UNIVERSIDAD INTERNACIONAL DE LAS AMÉRICAS

VICERRECTORIA ACADÉMICA

SCHOOL OF EDUCATION AND FOREIGN LANGUAGES

EFFECT OF THE PROCEDURES AND METHODS USED TO TRANSLATE THE DOCUMENTS *LA PODA DEL ALCORNOCAL (QUERUS SUPER L.). CUANTIFICACIÓN DE SUS PRODUCTOS* FROM SPANISH INTO ENGLISH AND *EXPERIMENTAL REARING OF NILE TILAPIA (OREOCHROMIS NILOTICUS) FOR SALTWATER CULTURE* FROM ENGLISH INTO SPANISH FOR UNIVERSIDAD NACIONAL DE COSTA RICA

Thesis Submitted to Obtain the Bachelor in English

STUDENT: VIAN NAZIRA BRENES ALEMÁN

THESIS MENTOR: M.Sc. CATALINA GUERRERO TROYO

SEDE ARANJUEZ

DICIEMBRE, 20

Contents

Tables

Abstract

The present study is derived from one stated problem which is, what is the effect of procedure and methods used to translate the documents *La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture* from English into Spanish for UNA? The National University is a public institution and the documents are part of their Natural and Exact Sciences Faculty, which currently has over 1000 students. This question will be answered by the translation of both documents into their respective target language, applying various techniques of translation, as well as using three different instruments of data collection, which include a table of text analysis, color-coding to mark those techniques and finally two glossaries, one for each document. These instruments are essential to evaluate the procedures and methods applied to translate these documents into the target language with naturalness and also for them to be communicatively accurate, in fact; with the instruments, it was found how useful and necessary this step is for the translation process. Related to the aforementioned, this project is based in the qualitative method rather than the quantitative.

Resumen

El presente estudio se deriva de un problema descrito el cual es, ¿cuál es el efecto de los procedimientos y métodos usados para traducir los documentos *La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos* de español a inglés para la UNA y *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture* de inglés a español para la UNA? La Universidad Nacional es una institución pública y los documentos son parte de su facultad de Ciencias Naturales y Exactas, el cual tiene más de 1000 estudiantes hoy en día. Esta pregunta será contestada con la traducción de ambos documentos a su idioma de llegada respectivo, aplicando varias técnicas de traducción, así como usando tres instrumentos diferentes de colección de datos los cuales incluyen una tabla de análisis de textos, una de códigos de colores para marcas estas técnicas y finalmente dos glosarios, uno para cada documento. Estos instrumentos son esenciales para evaluar los procedimientos y los métodos para traducir estos documentos al idioma término con naturalidad y también para que sean comunicativamente correctos; de hecho, con estos instrumentos se encontró lo útil y necesario que es este paso en el proceso de traducción. Relacionado a esto anteriormente mencionado, este proyecto está basado en el método cualitativo en vez de cuantitativo.

Chapter I

Introductory Framework

The introduction is an essential part for any investigation, which is going to be developed around one main topic of discussion. Without a proper introduction, the investigator will not be able to guide the potential readers into understanding what the whole research is going to be about. That means, the introduction is what presents to the readers everything they should know before dealing with the actual investigation. Meaning that it will state what is the problem that faces the investigator, and what are the instruments, methods, and procedures that the researcher is going to use to be able to solve that problem.

In addition, a second characteristic of the introduction is that it is the one that catches the attention and interest of the readers and pushes them into keep reading the whole investigation. It states the importance of what is going to be discussed, why it should be discussed, and also who is going to be benefited by the research. Then, when the introduction is completed, the readers should know exactly the most important points of the investigation, and they will also know in advance what is going to be discussed throughout the research. Furthermore, this part of the research should always be clear, so that the readers get to be as intrigued about the topic as the investigator is. Finally, the introduction should be informative for the readers.

1. Background of the Study

The investigator chose the translation subject because of its importance in the modern world and, related to that importance, the complexity of being able to produce a well-developed translation. It is known that translation is of great importance nowadays, for any public or private institutions. Those institutions usually interact with people from around the world, specifically the ones that are governmental. In this case, the investigator will deal with documents which belong to a public university. Those documents translated will be of great importance for foreign students and also for all national students, since the translations will be both, from English to Spanish, and for Spanish to English.

Along with the importance, the advances in technology play a significant role. What inexpert people would think is that a translator is not completely necessary nowadays, due to the fact that now there exist computer programs, applications, and cellphone dictionaries. However, this affirmation is totally untrue, since translation is a complex and long process, which cannot be done by computers or phone applications. In fact, House (2015), a linguist and translation scholar, states the following, "Translation is both a cognitive procedure which occurs in a human being's, the translator's, head, and a social, cross-linguistic and cross-cultural practice" (pp. 1.) This statement, without a doubt, reaffirms the need of human consciousness to develop a translation. Thus, the investigator is interested in demonstrating the importance of having a professional translator to be the one who manages the documents.

In addition, Bassnett (2014), a translation theorist and scholar of comparative literature states that, "The translator is a force for good, a creative artist who ensures the survival of writing across time and space, an intercultural mediator and interpreter, a figure whose importance to the continuity and diffusion of culture is unmeasurable" (pp. 5). This is a clear example of the importance of having a professional in charge of translating, and also that without the translator, the final result of the document will not be as accurate as it should be, and it might also not carry the real meaning that the original document wanted to emphasize.

Consequently, in order to be able to translate the documents accurately, the investigator, and also any translator, needs to analyze each text carefully. This means reading it to find any difficulty that might be present in the original text, like misspelled words, grammar errors, punctuation errors, and also, words which have no direct meaning in the target language. The analysis of text is one of the most essential steps to follow, even centuries ago when translation began to be a major. In summary, the analysis of texts is a crucial step because in this way the result of the translation will be done accurately and, most importantly, with naturalness for the target language. That means that the readers of the translations will have a clear understanding of the message that the original text wanted to convey.

2. Research Question

The research question is essential in all investigations, no matter the topic that the investigator chose to develop. It is important for the research because it allows the investigation to have meaning and follow a specific direction that sticks to the interest of the investigator. Furthermore, this research question should be clear and rather specific; the more specific the question is, the better for the investigation, because in that way the investigator will not be able to wander around other topics that are not important. In addition to what has been said, the research question should always be achievable. That means, the question should expose a situation or argument that is real and can be solved by genuine instruments or strategies.

Likewise, the research question functions as a guide for the readers to let them know what the purpose of the investigation is and what kind of investigation it will be. Another function is that it helps the investigator to state the objectives that are going to be accomplished throughout the research. In fact, most of the time the research question is the same general objective transformed into a question. This reaffirms the importance of having that question well-thought and developed.

As in any other aspect of investigation, there can be several problems rewarding the clearness of the topic and the solution the researcher must come across with. Andrews (2003), an English professor at the Institute of Education in London, states that “Problems can occur with the writing of a thesis or dissertation if research questions are not clear from near the start of the project” (p. 63) This is one of the main reasons that specify the importance of having a clear idea of what the whole investigation is going to be about, and surely this is accomplished by stating a research question.

In summary, a good research question should be the one that is specific enough and appropriately complex to state a real situation or problem that will be solved in an authentic amount of time and using the right instruments in order to accomplish its objectives. If the question is either too simple or unclear, this will probably bring difficulties to the investigator at the time of developing the entire work, and it can finally lead to the disorientation of the topic. This is something the investigator should, by all means, avoid.

Therefore, for this investigation the research question should be, What is the effect of the procedures and methods used to translate the documents *La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos* from Spanish into English for Universidad Nacional (UNA) and *Experimental rearing of Nile tilapia (Oreochromis niloticus) for saltwater culture* from English into Spanish for Universidad Nacional (UNA)?

3. Purpose and Significance of the Study

The procedures that will be discussed in this investigation will be both, the ones Peter Newmark, professor of translation at the University of Surrey in UK, and Gerardo Vázquez-Ayora developed and refined over the years to have a final result. According to Newmark (1988), there are twelve procedures, transposition, modulation, equivalence, adaptation, direct translation, extension or paraphrase, reduction, compensation, transference or naturalization, recommended translation or translation ethics, double and finally notes or additional.

However, for this investigation the procedures to be used are the ones from Vázquez-Ayora, author of "Introducción a la Traductología" Vázquez-Ayora (1977), who thought of nine procedures, which are transposition, modulation, equivalence, adaptation, amplification, omission, compensation, literal translation, and explicitation. Most of those procedures are basically the same from the ones of Newmark, some even have the same name and others have a different name, but serve the same function, with the exception of explicitation, which is exclusive from Vázquez-Ayora.

Nevertheless, the procedures of both professionals in the area, Newmark's and Vázquez-Ayora's, can also be combined and applied in the translations. Although Vázquez-Ayora's are the ones that will appear more often in the practical part, both sets of procedures will be studied in order to avoid the possible problems when translating the documents into the target language. It is important to state the practical uses of these procedures, since without them the investigator cannot be sure of the correct usage of words or phrases, not only relates to vocabulary, but also the way these procedures make the entire paragraph coherent.

Moving on, since this investigation evaluates the effects of procedures and methods used to translate the official documents stated before, it is an important research to remark the appropriate use of those procedures and why they are useful for the translations developed, as said before. Besides that, it is not only important to clearly comment the usage of those procedures and methods, but also the relevance of translating those documents for the public university. That is the main reason why the investigation is convenient and why it should be discussed.

Additionally, this investigation will be of immense value to all the students in the area of Biology at the public university chosen. Not only will they be able to access this information, which is necessary for their studies, but also, they will be able to have a clearer picture of the information provided for the ones that understand both, English and Spanish.

Every year this university admits new foreign students who usually only speak English, and most of the time they need to have access to some of the most important documents of the university or the faculty that they belong to. However, those documents are mostly written in Spanish. That means that translating those documents into English will be helpful for those foreign students, but not only for them. It will also be helpful for the national students, because those documents, which originally are written in English, will be translated into Spanish. Finding documents in English is common in the faculty of Biology since many of the magazines and manuals always come in this language. This can lead to difficulties to the University since most students are national citizens of Costa Rica, and not all of them master both languages.

This investigation will solve many of the problems that the university has had in some recent years in the matter of important documents, and the students' understanding if those documents belong to the Biology subject. Both, students and professors, will take advantage of this research and will definitely find the documents translated in both languages useful for their day to day work. From practical uses, like assigning homework or leaving the documents to further research in the area, to making exams based on the information provided among other important uses.

4. Objectives of the Investigation

In order to develop an accurate investigation, there always need to be objectives. These objectives help the investigator to have in mind what is the real goal of the investigation. The corporative investigator Ferraro (2006), states the importance of having clear objectives, as he says that, "Experience has shown that carefully crafting objectives at the onset of the investigation provides substantial dividends later. In addition to setting the project's course, carefully articulated objectives contribute substantially to one's ability to defend the process should it be later challenged" (p. 40).

Ferraro (2006) states the importance of having those objectives well thought out and make them be specific enough. The objectives will certainly help the investigator to follow and stick to the main points of importance to be developed in the research. In addition, Ferraro gives an important point of view, which is the fact that objectives not only help the investigator, but they will also, at some point in the final result of the research, provide essential summaries and conclusions regarding all of the work done.

More specifically, for any investigation it is not only necessary to have a general objective, but also specific objectives. The general objective is the one that exposes the main idea of the investigation, this is the one that helps the investigator. On the other hand, the specific objectives give more indispensable information for both, the researcher and the readers. Those specific objectives are specially the ones that draw a limit to the investigator to follow the main points of discussion. That means, all of the objectives combined give a clear idea of the main components of the investigation and also help the researcher keep a central topic.

Hence, the general and specific objectives for this investigation should be the ones mentioned below.

1.4.1 General objective

To analyze the effect of the procedures and methods used to translate the documents *La poda del Alcornocal (Querus Suber L.). cuantificación de sus productos* from Spanish into English and *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for saltwater culture* from English into Spanish for Universidad Nacional (UNA).

1.4.2 Specific objectives

- To translate the document *La poda del Alcornocal (Querus Suber L.). cuantificación de sus productos* from Spanish into English Universidad Nacional (UNA) and *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for saltwater culture* from English to Spanish for Universidad Nacional (UNA).
- To apply various translation techniques to the documents in order to achieve communicative texts.
- To evaluate the effect of the translation techniques applied on the documents.
- To create a glossary with the most relevant terminology found in both texts

5. Limitations of the Study

The limitations that the investigator will probably have to face relate to time, money, space, and linked to that, transportation. Since time is the most common of the limitations, it is important to mention that the investigator is still a student with other subjects to carry out at the university and, not only that, but also other responsibilities like work, personal situations and daily life. This takes plenty of the time that the researcher will need to accomplish the investigation.

Another limitation is regarding money, considering that the public university in which the investigator is basing the translation of the documents is far away from where the investigator is located. This directly connects to the limitation of space, again taking into account the distance that the investigator has to travel.

As stated before, since the university is far away from the location of the investigator, it means that the transportation will be an obstacle to the investigator, that also concerns money and the distance between the investigator's work, or house to the university. This is in turn linked to time, because getting to the university takes a long time and sometimes the transportation delays the arrival time.

In addition, talking about constraints regarding the documents, the investigator will have to face difficulties with specific vocabulary. In some cases, the vocabulary may be too technical and that will require the researcher to make further studies in the field at hand to have a clearer understanding of what the pages are referring to. Also, there will probably be phrases or words that will be difficult to translate into the target language since those words or phrases have no direct meaning in the other language.

In order to endure these limitations, the investigator will have to choose wisely the transportation to the places, and after that, the budget that will be necessary for getting there. The idea is for the researcher to not lose the estimated amount of money dedicated to the project in expenses of transportation. Besides that, when the budget and transportation are well organized, then the space limits will not be as relevant as the others. The vocabulary limits can be solved by conducting accurate investigations about the subject and its context. And finally, the words or phrases that cannot be translated into the target language can be explained using explicitations in the same translation. If the investigator manages to surpass these limitations, then the research will have no further difficulties to face.

Chapter II

Theoretical Framework

The theoretical framework is an essential part of the investigation since it gives all the support the research needs to have meaning. In this chapter, it will be provided all the theoretical evidence needed for the translator to apply in the documents. Without this, the investigation would not have enough proof to deliver the message the investigator wants to transmit. In addition, theories are meant to explain a topic, predict certain possible circumstances in investigations, and also help readers understand determined aspects of a specific subject. This aims to create critical thinking among readers and, finally, make the investigation a document well organized and understandable. This chapter will deal with text analysis, stylistic scales, text functions, translation types, translation techniques and, finally, the theories on translation. All of the elements mentioned are important steps to follow before actually dealing with the translation of the documents. In summary, the theoretical framework is significant because it introduces and gives a detailed explanation about the theory or theories that the research is going to discuss, and it gives the probable solutions for certain problems the investigation exposes.

2.1 Text Analysis

According to Vázquez-Ayora (1977), expert in translation, the acquired experience has shown that the most common errors in translation are due to the lack of text analysis. In addition, without proper previous analysis, there is no possibility of being able to translate it (p. 8). Furthermore, Vázquez Ayora explains that the text analysis is an essential step to follow and, in fact, it should be the first step that the translator does in order to have a clearer idea of what the text is about, which is its type, the scales of formality that it uses, its function, the type of translation, among other important aspects that the translator will be dealing with in this chapter.

Regarding the analysis of texts, there is a base of knowledge that the translator must be able to manage professionally, which is the reading comprehension. In addition, experts Di Jin and Nida (2006) state "The effectiveness of a message is also greatly influenced by the nature of the source. Is, for example, the source known or unknown to receptor? Is it a single person or a group?" (p. 34). These common questions will be important to answer, and in fact, the translator might answer these questions while first reading the text in general terms.

This rather basic step is crucial in the analysis for it helps the translator to first catch the message of the text, at first as a general message, but after reading carefully, the translator will be able to find other aspects of the text, for example; problems in punctuation, grammar errors, typos among others. In reading comprehension, the translator is able to divide the text into phases were each one will be analyzed carefully. In fact, according to Osimo (2002), expert in translation, any novice or professional translator should know seven basic steps when reading a soon to be translated text (p. 2). The first one is to read for essentials and main ideas, then read for details, after that, identify the meaning of certain words, expressions or phrases by using components of the same structural analysis, for example; prefixes, suffixes, roots, punctuation among others. Then identify the meanings of words and phrases by using the contextual analysis that means antonyms, synonyms and others of that kind. After this, identify the writer's style that is if the text is informative, persuasive, literary, scientific or other. Then, identify the scale of formality of the text, which could be, formal, slang, technical among many others. Finally, identify cultural terms difficult to translate.

2.1.1 Text Styles

When analyzing a text, the first element that the translator will notice is the text style. In order to understand this step of the analysis, it is useful to take into account the number of styles there exist. In fact, according to Newmark (1988) "the average text for translation tends to be for an educated, middle class, readership in an informal, not colloquial style" (p. 13). Not only should this be taken into account, but also the fact that there are other possibilities of text styles that might require translation. In fact, Newmark suggests only four possible text styles (p. 13).

The first style is Narrative text, as the name says it, a narrative text is the one that relates a story, the events are usually told in sequence, more specifically, chronological order is dominant in this style. Newmark (1988) states that a narrative text will always make emphasis in the verbs. That means, an example of this style would be a novel like the "Harry Potter" series, or even short stories like "The black cat" by Edgar Allan Poe, among others of this kind.

Then, there is the descriptive text, this text style emphasizes in linking verbs, adjectives, which are, in fact, key words in descriptive documents, and adjectival names and nouns. This style is often found in more literal works, sometimes in poems or sonnets, like Shakespeare and other writers of this type. In this specific style, the translator will find many elements, which might be challenging for the fact that, most of the time, the words or expressions used are cultural, that means there is no direct translation for most of them.

Another style is the discussion or argumentative, this one consists more on the expression of ideas, which includes abstract or subjective terms, verbs that note feelings or thoughts of oneself, that is phrases like “I think,” “I consider,” among others of this type. The emphasis is in logical and linking arguments from a specific person. That means, this style of text can be easily found in political speeches, debates and, in general, discussions of any type.

Finally, there is the dialogue style, this one, as the name says, relates to texts that are, partly or entirely, dialogue. Dialogues consist on chronological ideas and expressions, characters are important elements, and they normally emphasize the colloquial speeches, cultural terms and social interactions (Newmark, 1988, p. 13).

2.1.2 Stylistic Scales

The stylistic scales are other important aspects for the translation at the time of reading the original document. These characteristics of the text help the translator identify the community or group of readers to which the original document is addressed to, and with that information, the translator will know the vocabulary that needs to be implemented in the result of the document. Newmark (1988) reinforces the following regarding the stylistic scales, “The three typical reader types are perhaps the expert, the educated layman, and the uninformed. You then have to consider whether you are translating for the same or a different type of TL readership, perhaps with less knowledge of the topic or the culture, or a lower standard of linguistic education” (p. 15). This reaffirms the importance of each scale in the translation. There are three different stylistic scales proposed by Newmark.

2.1.2.1 Scale of Formality

The first scale to analyze is the formality of the source document. The formality directly links to the text styles, since according to the vocabulary of the text; it will fit one of the formality scales. In this area, Newmark (1988) evaluated eight different scales of formality, from extremely formal to slang. In fact, they are normally listed from higher formality to lower; in this case, they would be officialese, official, formal, neutral, informal, colloquial, slang and finally taboo (p. 14).

Starting with officialese and official formality scales, they both might be confused at first sight. However, they do have their differences, despite they might be slight from one to the other. In the case of officialese, it is often found in really formal texts which use solemn words or expressions. Normally, where this can be found is in antique and historical documents, such as the declaration of independence, the human rights declaration, among other related documents. On the other hand, official scale is slightly different from officialese; it still uses words that are really formal, but not as much as the officialese. Official scale is most commonly used in legal documents, like in court and laws, and also in any other authentic papers related to government and public institutions.

Then, there is the formal scale, although this can also be confused with the other two scales mentioned above, this particular scale is different among all of the scales. The documents written in this specific scale use vocabulary that is mostly serious, punctual and conventional, but also natural in terms of vocabulary. That is, this can be easily found in any regular document which only uses vocabulary that marks it as serious, not so official nor informal, it is right in the middle. After the formal scale, there is the neutral one, this scale uses mostly basic vocabulary and nothing else. There is a fine line between neutral and formal scales, in fact these two can often be confused, and there is no problem with it since they are both basically the same.

Informal scale is different among the rest discussed above, it uses simple and plain vocabulary. This scale is usually found in informal letters, and also in daily life dialogues, among others which do not have the need to use complicated words or expressions. The colloquial scale is in this case the one that is most alike to the informal one. Even though, the colloquial scale is more related to proper conversations among friends and family, and this would be the only difference that these two scales have. Besides that, both are really similar among each other.

Finally, there is the slang scale, which is a totally different level of formality. The slang is often used by people from low social environment, although this is not always the case. Slang can still be found in proper conversations from people who live in ghettos and other sections of minorities. Then, taboo scale is different from slang for the fact that taboo refers to topics which are forbidden in our society. For example, texts that expose topics like prostitution, pornography and more themes of that kind.

2.1.2.2 Scale of Generality or Difficulty

Newmark (1988) states six scales of generality or difficulty. These scales basically help the translator to, after analyzing the text and finding the scale of formality, find out the general difficulty level of the document. The six scales proposed by Newmark are simple, popular, neutral, educated, technical, and finally opaquely technical (p. 14).

First of all, simple texts are, as the name states it, texts that have no complexity in vocabulary and content. They are easier to understand, read and translate. An example of this type of text are the ones that are not technical at all, and use only the simplest of the words. The popular scale is as well, easy to understand and translate, the difference it has with the simple scale is that it uses more vocabulary that is part of a community and their traditions. That means, words can change from one another, Newmark (1988) gives two examples using the same basis, but changing some of the words to fit each scale. The example for simple scale is: “The floor of the sea is covered with rows of big mountain chains and deep pits”; on the other hand, the example for popular scale would be: “The floor of the oceans is covered with great mountain chains and deep trenches” (p. 14) These examples help to clarify the slight difference between these two scales of difficulty, noticing that there are just some changes in the selection of words of each statement.

Following these scales, there is the neutral one, which directly relates to the neutral scale of formality, which means this scale only uses basic vocabulary. Anyone can understand the text that is written in this form, the reader is not asked to have a higher level of education. However, the educated scale actually requires the reader to have some level of study. It deals with more complex vocabulary throughout the text. Newmark (1988) states two examples, one for the neutral and one for the educated, which are: “A graveyard of animal and plant remains lies buried in the earth's crust” this would be the neutral example; on the other hand: “The latest step in vertebrate evolution was the tool-making man” (p. 14). These two examples make the line clear about the differences between these scales.

Then, it comes the technical scale; certainly, this scale belongs to the areas of science, art, and even technology. That means the texts associated with this specific scale can only be found in documents of a specific area of study. These texts are more complicated to read and translate, since they convey complex terminology that is too specific from the subject of the text. Finally, the opaquely technical, which, in fact, is similar from the technical, deals with vocabulary, expression and terms that only experts can understand. The difference between these two scales is that the opaquely technical is even more complex than the technical.

Newmark (1988) again, gives two examples of each to better understand their difference. The technical example would be: "Critical path analysis is an operational research technique used in management", and the opaquely technical is: "'Neuraminic acid in the form of its alkali-stable methoxy derivative was first isolated by Klenk from gangliosides" (p. 14). It is clear to see the difference between both of them; one might not be as complicated as the other might be.

2.1.2.3 Scale of Emotional Tone

The scale of emotional tone refers to the amount of expressiveness that a text may contain. To clarify, the emotional tone deals with either subjective or objective terms present in a document, text or story. Newmark (1988) suggested four different scales of emotional tone. These scales will depend on the general words chosen by the author of a work. Those scales are intense, warm, factual or understatement (p. 14).

The first scale that appears in the list is intense. This one refers mostly to subjective terms; that is, intensifiers are clearly and abundantly present. Intensifiers are words that emphasize adjectives; this can be easily found in poetry and novels, such as Romeo and Julie from Shakespeare. An example of an intensifier would be "It is extremely beautiful," minding that extremely is the intensifier of this sentence. Whenever a text contains too many intensifiers like this, then, it can fall in the intense scale of emotional tone.

After this, there is the warm type of tone. This specific tone deals with friendly vocabulary, that is, the selection of words and expressions in this kind of scale are more likely to contain less intensifiers as the intense scale, but still it has some words that relate to the intense one. Newmark states an example for warm tone, which would be: "Gentle, soft, heart-warming melodies". This example does not contain intensifiers, but still it has that same feeling of warmth.

Then, there is the factual tone, also known as cool tone. This one is completely different from the intense and warm ones. According to Newmark (1988), the factual tone is completely exempt of partiality. That means it does not include any type of adjectives, intensifiers, subjective vocabulary or even abstract terms. The idea of texts that are factual is to deliver a plain message, with no space to make any comments that might end up being relative. In addition, cool toned documents are well judged and presentable in any serious type of institute.

Finally, there is the understatement tone. This tone specifically and most commonly connects with the officialese scale of formality. The understatement refers to texts that have no intention of delivering a message which might contain opinions, nor do they want to express any abstract concepts. The whole idea of this is to send specific information to a group of people. At the time of translating these types of text, they normally do not require any additions or explanations.

2.1.3 Text Function

The text function will usually be related to all of these scales mentioned before. There are six possible functions in a text according to Newmark (1988); however, in this chapter, only three of those functions will be explained. Those functions are, informative, expressive and vocative. The three of them are really different among each other, that means it is not difficult for the translator to categorize the documents to be translated. In some cases, it is important to know about the author, in fact; according to expert in linguistics Nida (2006), "If one is undertaking to translate an entire book or even a particularly complex poem, it is extremely advisable to have as much background information [about the author] as possible" (p. 186). In contrast, in some other circumstances it is not necessary to have any knowledge about the author. Additionally, knowing the function of a text is of great importance for the translator, because it helps to clarify and identify the other scales.

2.1.3.1 Informative

According to Newmark (1988), "For the purposes of translation, typical informative texts are concerned with any topic of knowledge" (p. 40). That is, informative function deals with facts of a particular subject and even proven theories. This function usually does not have any emphasis on the author, since the main idea of it is to inform and nothing else. Newmark states "Informative texts constitute the vast majority of the staff translator's work in international organizations, multi-nationals, private companies and translation agencies" (p. 40). In addition, nowadays this type of texts cannot only be found in these examples given, but also in newspapers, scientific magazines, many textbooks and even thesis. Finally, the core of an informative text will always be the truth, that is, to state the truth about a topic giving the support it needs to prove its validness.

2.1.3.2 Expressive

Differently from the informative function, in the expressive text the author does matter. This happens because the translator actually has to stick to the author mind and perspective, and in that way, deliver the message, as the writer would have wanted. In addition, Newmark (1988) states that the core of any expressive text would be the mind of the speaker or writer.

Besides, Newmark specifies three different types of expressive texts, which are serious imaginative literature, this one relates to lyrical works, and plays that contain cultural expressions. Then the authoritative statements, which are texts that have the total copyright of an author, such as political speeches or official documents by ministers. Finally, the autobiography, essays and personal correspondence deal with emotions belonging the authors (p. 39).

2.1.3.3 Vocative

In this type of text, the main idea is to persuade the readers into reacting to a situation or case. In fact, Newmark (1988) calls vocative the act of calling the attention of the readership in order to think or feel the way the text wants them to feel or react (p. 41). That means the core of this text would certainly be the readers. That leads to where it is often found a vocative text, which is usually in publicity, instructions of any kind among others of this type.

2.1.4 Type of Translation

Newmark (1988) states**,** "The central problem of translating has always been whether to translate literally or freely" (p. 45). This has been a discussion throughout the years for professional translators. However, Newmark suggested several types of translations, which are word-for-word, literal translation, faithful, semantic, adaptation, free translation, idiomatic and communicative. In this chapter, the investigator will only deal with semantic and communicative type of translations.

In addition, nowadays, applying translation methods to the actual documents will for sure expand the possible readership of the final result of the translation. The translator should accommodate to the best option, which is, either semantic or communicative translation, in order to fit the needs of the readers. Although there are other methods of translation, in this chapter they will be narrowed to only two possibilities.

2.1.4.1 Semantic Translation

The semantic translation fits the author's expressiveness, that is, when translating a semantic text, the translator should, at all times, stick to the author's message. These texts are usually esthetic; in fact, Newmark (1988) states that the "Semantic translation differs from 'faithful translation' only in as far as it must take more account of the aesthetic value (that is, the beautiful and natural sounds of the SL text, compromising on 'meaning' where appropriate so that no assonance, word-play or repetition jars in the finished version" (p. 46). This clarifies the principal function regarding semantic translation and its particularity of sticking to the author's expressions.

2.1.4.2 Communicative Translation

The communicative translation, on the other hand, emphasizes in the readership. Not only that, but also the idea that the readers must understand the message. In order to accomplish this, the translator may modify certain aspects and elements of a text, adding information to clarify a concept and making adjustments so that readers will easily and more quickly understand what the text is about. Newmark (1988) states that the, "Communicative translation attempts to render the exact contextual meaning of the original [text] in such a way that both content and language are readily acceptable and comprehensible to the readership" (p. 41).

2.2 Translation Techniques

Translation techniques are complex tools used by translators in order to produce a higher quality final work. These techniques cover several situations when translating, and help the translator to develop a more natural translation. In this part of the chapter the authors that will be mentioned are Newmark and Vázquez-Ayora, these experts give a clear and concise definition of each technique, the types that a translator might encounter at the time of actual dealing with the documents and the importance of each one.

2.2.1 Transposition

Vázquez-Ayora (1977) affirms that transpositions are meant to improve the naturalness of a single sentence from the source language to the target language (p. 248). Newmark (1988) takes this statement from Vázquez-Ayora, and adds that there should be several shifts related to transposition (p. 85). This nowadays adds even more help to the translator since there are many examples given to improve the translation's naturalness.

As a matter of fact, if both Vázquez-Ayora's (1977, p. 248-250) and Newmark's (1988, p. 85-86) examples of transpositions are joined together, the final number of transposition variety would be thirty-five different variations. Each really different among each other, the list of transpositions is; adverb to verb, adverb to noun, adverb to adjective, verb or past participle to noun, verb to adjective, verb to adverb, noun to verb or past participle, adjective to noun, adjective to verb, past participle to adjective, indefinite article to definite article, possessive to definite article, other particularities, transposition of the word 'that', double transposition of adverb and adjective to noun and adjective, transposition of adjectival group and noun, crossed transposition, second version of crossed transposition, this latter refers to the configuration of simple verb and gerund.

Other models of crossed transposition, with the combination of abstract noun, preposition and quantifiable noun, the one where the adjective assumes the action instead of the verb, a noun takes the place of a preposition and an adjective in order to express the main action, the reflexive grammatical constructions with intransitive verbs, crossed transposition with verb plus ‘again’ to ‘volver a’ plus verb, change from singular to plural, when a grammatical structure from the source language does not exist in the target language, the gerund in English to a verbal, relative or noun construction, from preposition in source language to prepositional construction in target language, from adverb in SL to adverbial construction in TL, noun plus noun in SL to noun plus adjective, descriptive verb plus preposition in SL to verb of movement and gerund in TL, linking verb plus noun in SL to verb in TL; noun, preposition and noun to noun, past participle or adjective subordinate plus noun in TL, subordinate sentence or adverbial syntagms in SL to participial construction in TL, to fill a lexical emptiness with grammatical structure, and finally; transposition of simple sentences or coordinated into subordinated in Spanish.

2.2.2 Modulation

Newmark (1988) supports the statement by Vinay and Darbelnet “coined the term 'modulation' to define a variation through a change of viewpoint, of perspective and very often of category of thought'” (p. 88). In this statement, the experts affirm that modulation should be a tool given to the translator, in which he or she has the freedom to change some parts of the text by only using the linguistic knowledge. Taking into account that the original message should not be disturbed during these changes. Newmark adds that modulation is necessary when the target language does not accept literal translations. That means, modulation is a free type of procedure which can be used in any form; verbs, adjectives or adverbs (p. 88).

In this case, Newmark (1988) is the one who states the varieties of modulations there should be, which for him there are only seven of them. The modulations suggested by Newmark are; abstract to concrete, cause for effect, one part for another, reversal of terms, active for passive, intervals and limits and lastly change of symbols. (p. 89) However, Vázquez-Ayora's (1977) suggestions of modulations have some similarities to the Newmark's, for example; abstract to concrete is the same for both experts. Still, Vázquez-Ayora proposes other possibilities that would be, explanatory, from general to specific and from specific to general, from one part to another, term inversion, from positive to negative and from negative to positive, modulation of form, aspect and use, change in comparison or symbol, modulation of the great signs, this latter would be the most complex one; from figurative vision to direct and from figurative to figurative, from direct to figurative vision and finally, from animism to inanimism (p. 294-313).

2.2.3 Omission and Amplification

The translator should always accommodate to the target language and aim to produce a translation, which would be communicative and natural for the language. In some cases, the target language would need the omission either of certain words in order to have meaning or, in other cases, the translator should add words to develop the same idea. Vázquez-Ayora (1977) believes that omissions are essential for the fact that language saving is the most adequate tool to accomplish naturalness.

In addition, Vázquez-Ayora (1977) proposed ten common situations where omissions aid translators to choose which would be the best case where it can take place in a paragraph or sentence. Those suggestions are, omission of abusive redundancies, omission of repletion, omission of the auxiliary 'can', of the present participle in 'to use', of some prepositions, articles and other determinants, pronominal subjects and the pronoun 'it', some adverbs and other words, 'there' plus verb that is not 'to be', and finally other different cases (p. 367-372).

Furthermore, additions, for sure; opposes the principle of saving language. Vázquez-Ayora (1977) suggests several variations as well. These variations are adverb addition, verb addition and adjective addition, pronoun addition, other pronouns; such as 'either', addition of demonstratives, and addition of prepositions (p. 337-342). The idea of this technique is for the result of the translation to fit the correct meaning of the original text.

2.2.4 Explicitation

Explicitations are used by the translation in order to clarify certain vocabulary or expressions that might not be easy to understand for the reader at first glance. They are usually used with cultural bound terms, and concepts that cannot be translated into the target language. According to Vázquez-Ayora (1977), the main idea of this technique is for the final result to be specific enough; however; the translator should never overuse explicitations since the final translation would indeed loose its accuracy (p. 349). One example of explicitation can be: "Harry shook his head", shook can have several meanings in this context the best option to translate it is to say: "Harry movió su cabeza en modo de negación."

2.2.5 Literal Translation

Newmark (1988) affirms that literal translation is a technique that can be used in order to translate names of international companies "which often consist of universal words which may be transparent for English and Romance languages" (p. 84), or even in well-known phrases. He adds that literal translation can also be called as calque, since the idea is to translate in the same word order and the same meaning that each word provides. Ayora, in other instance, believes that literal translation should deal with parallel concepts, but no word for word translation. In this case, the translator can stick to Newmark's theory, an example of literal translation can be: "él vino a decir lo que piensa", which would be translated to: "he came to say what he thinks".

2.2.6 False Cognates

The last technique discussed in this chapter is the false cognates. First of all, the MacMillian Dictionary (2002) explains this technique as "a word in one language that has a different meaning from a similar-sounding word in another language" adding, "These similarities can confuse language learners and often cause errors." In this case, Spanish and English have a great amount of words with similarities in pronunciation, this can deceive even the most expert of the translators, that is why they must be really careful at all times to avoid this type of errors. When having a doubt of a meaning of certain word in the source language, which might sound alike to other in the target language, it is better to analyze and consult a dictionary before actually translating the word. An example of a false cognate would be: "dependent", which in English means relying on someone or something in order to survive, and: "dependiente" in Spanish which means, an employee or a store.

2.4 Glossaries

First of all, glossary is defined by the Cambridge Dictionary (1995) as “an alphabetical list, with meanings, of the words or phrases in a text that are difficult to understand.” Lionbridge (2013) adds to this definition the following, “You may also hear it referred to as a lexicon, term base, and terminology collection. For smaller companies or projects, it may be as simple as a spreadsheet; larger multinationals and broad product lines require more automated or sophisticated tools to manage all their terms and translations” (p. 2). That is, the complexity of the glossary will depend on the type of company where the document to be translated belongs to.

The glossaries need to be done in the readers’ language and in the source language as well, this is essential to both, the translator and the future readers. The glossary is, in fact, a crucial part of any translated document, in order to complement it with further vocabulary analysis. This element of a document is especially important for technical papers, since not every reader will understand the vocabulary used in this type of texts. Translators will usually have to deal with terminology, that is according to Cambridge Dictionary (1995) “special words or expressions used in relation to a particular subject or activity,” the terminology is often part of a company or institution where one single main subject of study is learned. This cannot only include words, but also abbreviations, technical expressions and phrases among others.

Lionbridge (2016) conceptualizes and gives the importance of a glossary, “The glossary helps translators ensure that each time a defined key term appears in a corresponding language, it is used consistently and correctly” (pp. 4). This affirms the fact that the terminology placed in glossaries should be made really clear to avoid misunderstandings. In addition, a glossary can be made from simple shape, like the one that only contains the definition of each word, to a more complex one, which may include pictures, pronunciation of the words, examples among others.

2.4.1 The Relevance for the Translator

Translators have no power to have in their mind every single concept in this world. It would be certainly impossible for a human being to manipulate each and every possible definition of terms. That is the main reason why glossaries are of great importance for the translator. Additionally, the glossary will be increasing the vocabulary each time the translator develops a new one, which, in fact, can improve the production of accurate and coherent translations. This will directly aid the translator because of the professionalism he or she will acquire throughout the time.

2.4.2 Relevance for the Translation Process

Each company or institute has its own set of vocabulary, it is important for the translation process to make the vocabulary clear. Lionbridge (2016) states one example of this, "Every business has its own language. For example, consider the term "drive." As a verb, it can describe several different actions, such as operating a motor vehicle. In many companies, however, it is used as a noun to describe a computer device that stores data" (pp. 2).

Since it is made clear throughout this chapter that the main goal of the final translation is to be accurate, natural and communicative to the readers, it is understood that adding a glossary to the translation will, for sure, increment the velocity of actual dealing with the process of translating and the techniques used. The specific relevance of glossaries for the process of translating is that they will help the translation to have a higher quality, and also the amount of time it will save to only look up for the term on the glossary and quickly add it in the work. Avoiding over thinking and analyzing a specific concept that has already been found and determined in a different sheet of paper.

2.4.3 How to Create a Glossary

Lionbridge (2016) explains a basic and first characteristic that a glossary must have in order to be clear and effective. The characteristic is that it should be an organized reference; this means that each term should be included only once, although the term might be composed by several different words. The ideal glossary will give a definition for each single concept. For example, if the translator wants to include 'car parts' in the glossary, then it should be divided into 'car' and 'parts' not the two words joined together.

Glossaries are meant to be in the final pages of the document translated. The first step to create a glossary is to define the best vocabulary that fits in the glossary. This will greatly depend on the receptors, that is, if it will be used by an institution, which kind of institution it is, and how that institution will be benefited with the glossary. Other elements include the type of document that will be translated, if it is a technical type of text, it is recommendable to choose the most technical words of the text to include in the glossary. The more words the translator includes in the glossary, the better.

If it is not the case that the source text is not technical, then the translator must choose which would be the best option. Including uncommon words or important concepts would be the two options in this case. When the translator has already chosen the vocabulary, then the next step is to deliberate the possible readers of the entire document and the glossary. This means that, the format of the glossary should fit the necessities of the readership. If the readers are going to be people with no high education, then the definitions in the glossary should be simple and made clear. However, if the readers will be educated people, then the translator can provide more complex information and definitions. Of course, this will only depend on the preference and judgment of the translator.

When these steps are done, the next movement would be to think of the elements that the glossary will contain. Normally, the more elements the glossary has, the better for both, the translator and the readers. Likewise, this will depend greatly in the type of document it is and the readers. The glossary can contain several elements; the first and most important element is the clear dictionary definition of each word in both, source and target languages. This element is essential and should not be taken for granted.

After that, all of the other elements will be chosen depending on the preference of the translator, those elements can include the pronunciation of the word; in phonetic symbols, images of some of the vocabulary; that clearly fit the definition of the word, examples in sentences, the direct meaning in the target language, among others.

When the translator has defined all of these characteristics, then it is time to accommodate them in the best and most organized way possible. Whether beginning with the source language word and organizing it in a kind of list, to creating tables where the words will be found. When the translator has already defined how he or she will accommodate each word in the glossary, then the glossary can be created. Once it has been created the final step is to verify the correct definition of each word to make sure that the glossary has been made only with correct concepts and definitions.

In this investigation, the researcher will use a list in dictionary form to illustrate each word in the glossary. The elements that it will carry are first of all, the word in the source language followed by the direct definition in the target language, then the pronunciation of the word in the International Phonetic Alphabet (IPA). After that, two dictionary definitions on each language, Spanish and English. Finally, if the word is a particular concrete concept then, a small picture representing the word will be placed.

Since the readership of these glossaries and documents will be students of the Biology area, then the addition of pictures is of great importance to illustrate some of the concepts. Students will use the glossaries when they find some difficult terms, and in there some of the most common words used in the document will be represented as a picture and definition, for students to have a clearer idea about the concept. This will certainly help greatly to each of the readers so that the documents will be even more useful than before.

Chapter III

Methodological Framework

In this chapter, the research method, which will be used by the investigator, is going to be discussed. The research method is, as well as the other elements of the project, an essential part of the investigation to be able to accomplish the described objectives that the researcher chose to explain widely in this specific project. Furthermore, it is important to analyze this step of the investigation because of the fact that there are several research methods that could be used in order to accomplish such objectives. Sometimes a combination of methods is the best way to go, while in other cases it is advisable to choose one method and follow it. If the method that least favors the investigation is chosen, then a series of problems would take place at the time of synthetizing the collected data. This is why it is really important to pay close attention to what the investigator wants to achieve in the research. There are only three options to choose from the existing methods. It is either qualitative, quantitative or a mixture of both. However, for this investigation it is more advisable to only stick to one method.

3.1 Research Method

The investigator should ask first of all, what is a method? According to the Merriam Webster Dictionary (1979), a method is "A procedure or process for attaining an object such as (1) a systematic procedure, technique, or mode of inquiry employed by or proper to a particular discipline or art, (2) a systematic plan followed in presenting material for instruction the lecture method; (3) a way, technique, or process of or for doing something." As it can be observed in this definition, the word "method" refers to several concepts, and that is one of the main reasons why this question should be asked, so that the investigator can have a clear idea of what is coming next; in this case the definition number 3 is the best one that fits what a method is. Once the definition is discussed, the thought of its importance raises. Therefore, a method helps the researcher to have an unambiguous study, it establishes one specific way of observing and processing the information; consequently, the researcher will not lose time and effort analyzing all of the data in the wrong way and coming to unclear conclusions.

On top of that, this investigation is one hundred percent qualitative due to the nature of its information, which is literally all related to quality or kind rather than quantity or just numbers. Quality referring to the strategies which will take place in the translation of the selected documents and the analysis of these texts, as well as the translation techniques that are going to be used such as transposition, modulation, omission, amplification, explicitation, and finally literal translation.

3.2 Selection and Description of Population and Sample

In order to achieve the objectives of this project, there were chosen two different documents, one in English and one in Spanish to be translated by the investigator. These documents belong to the Universidad Nacional of Costa Rica and are part of the Faculty of Natural Sciences. In addition, as these mentioned documents belong to a specific area of study, a research regarding the vocabulary used and a measurement of the difficulty of the terms had to be made; therefore, the final results would be the best in each case.

3.2.1 Description of the Institution

The institution to which both documents belong is the Universidad Nacional de Costa Rica (UNA). This university is located in the province of Heredia near the capital of the country, San José, and was founded in 1973 thanks to the then president of the country, José

Figueres Ferrer and the Minister of Education. It has five different headquarters around the country so that everyone has access to it. The main headquarters is located in Heredia and is the biggest of all. It has access to every career, unlike the other headquarters, which are located in Alajuela, Liberia and Nicoya, Perez Zeledón, Coto and Sarapiquí, and do not provide all the careers available.

According to UNA's website (2017), the main headquarters provides all of the careers because it is the one that contains all five faculties of the university, which are Philosophy and Letters, Social Sciences, Land and Sea, Natural Sciences, and Health Sciences. Besides in those faculties, this university has specialized centers such as General Studies, Investigation and Teaching in Education and finally Investigation, Teaching an Artistic Extension.

According to UNA's website (2017), their mission is to generate, share and communicate knowledge, also to form humanistic professionals with critic and creative attitude, consequently, transforming democratically and progressively the society of this country to benefit the people of all classes. Besides that, it wants to create a community of people who respect each other and give special attention to those areas which are in danger of exclusion or people that are less favored. Moreover, its vision is directed towards the academic excellence, which will represent the exercise of its autonomy, innovation and social compromise in the regional and national sense, as well as international acknowledgement in Latin America and the Caribbean. Furthermore, it concentrates in the fomentation of sustainable and integral human development, which will be achieved by the practice of the respect of human rights inside and outside classrooms.

3.2.3 Description of the Sample

As mentioned before, two documents were chosen to accomplish the objectives selected by the investigator. One in English with the name of “Experimental Rearing of Nile Tilapia Fry (Oreochromis Niloticus) for Saltwater Culture,” which was written in 1984, and one in Spanish named “La poda del alconocal (Quercus Suber L.). Cuantificación de sus productos” written in 1991. Both original texts belong to the Universidad Nacional of Costa Rica.

The document in English was written by three Taiwanese scientists, whose names are Wade O. Watanabe, Ching-Ming Kuo and Mei-Chan Huang. These scientists were researching the Nile tilapia for its culture in saltwater. The whole text is written in English with the exception of certain names, which were written in Latin for the scientist to recognize the species of fish they were referring to. The situation of investigation of the text takes place in a laboratory where the scientists are carrying out the experiments which consist on the acclimation of tilapias in saltwater, it also contains information of the anatomical and behavioral aspects of other fish, not only about the Nile tilapia. It is important to mention that this document contains vocabulary specific to this area of investigation; therefore, a research on the vocabulary had to be made to effectively translate the text.

The second document which is completely written in Spanish, with the exception of certain names of trees in Latin, by two biologist researchers based in Spain whose names are Gregorio Montero Gonzalez and Rafael Curras Cayon. This text is related to the pruning of the cork oak and how the extracted cork benefits the owners of the cork oak fields. In addition, this text almost in its entirety gives advice to the owners of the cork oak fields on how to perform the necessary pruning of the trees so that they can profit from it the best way possible without degrading the ecosystem or killing the trees. This document contains several words which are proper from the Spanish biologists and scientists. That is why sometimes they do not have an exact or literal translation in English, which can turn to a challenge for the translator to achieve the ultimate goal, which is effectively translating and elaborating a final result of the text.

3.3 Implemented Strategies

First of all, the general objective which the investigator chose is to analyze the effect of procedure and methods used to translate the documents “La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos” from Spanish into English for UNA and “Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture” from English into Spanish for UNA. This objective helps the investigator to stick to the main topic of discussion of this project, which surrounds all that has to do with procedures and methods, as it was explained before, used at the time of translating the described objectives.

The first specific objective chosen by the investigator is to translate the aforementioned documents. This objective involves certain steps particular from the translation process, which guide the translator into developing a complete and well-done final draft or translation. The second specific objective is to apply various translation techniques to the documents in order to achieve communicative texts, and this objective describes one of the steps mentioned in the first one. Translation techniques are essential for the translator at the time of taking part of the translation process. The third objective is, to evaluate the effect of the translation techniques applied on the documents, after finding these techniques, there should be an analysis or evaluation, as the objective says, of each one of them. The last specific objective is, to create a glossary with the most relevant terminology found in both texts, this step is crucial for future readers of the text to have a quick place to look up terms they might have trouble with, and also to have a picture, if possible, of that same term. This way is faster for readers to follow these documents.

As said before, the investigator has to follow steps before, during and after the translation process. The first step in this process is to make a general analysis of the text and decide which text style the document is, whether it is narrative, descriptive, argumentative, or dialogue. Next is to find what is the function of such text, it could be informative, vocative or expressive. Then, stylistic scales such as formality, scale of difficulty and finally the emotional tone. Once this has been done the translator has a basis to begin the research of terms, because this greatly depends on all of these previously mentioned aspects or elements of the original document.

After this step, the translator can start carefully reading the document to find all of the troublesome terminology of the text, like words that are proper to a specific area of study. For example, in the text "Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture", the translator should expect to find vocabulary regarding fish species, chemistry or environmental conditions among other terms of this kind. On the other hand, in the text "La poda del alcornocal (Quercus Suber L, cuantificación de sus productos," the translator might come across with terms related to trees' species or specific locations and names related to those locations.

Then, when the research of terms has finalized, the translation process can start. With the researched information in hand, the translator should not have any problems at the time of encountering the translation. This is one of the main reasons why those previously mentioned steps are essential for this process, they help the translator to create a final result that is meaningful and is not difficult for others to read.

Once the all the original document has been finished, that is translated, then the translator can start to reread the final result to find any grammar or spelling errors, correct any typo or other mistakes of that kind. Finally, when this has been achieved, then the translator, as an advisable extra step, should give the final result to a specialist, teacher or another translator for them to check everything that might have been missed, such as other errors or suggestions they might have regarding terms or grammatical structures, etc.

With this final step completed, the translator now can simply print and hand in the final translated document with no difficulty to the institute or person that belongs to.

3.4 Data Collection Instruments

It is crucial for the investigator to choose specific and strategic instruments that help the investigation to drag clear conclusions and even correctly measure the variables that the research question and objective state. Here are some examples of the instruments the translator chose to use.

3.4.1 Text Analysis

Text analysis, as explained before, with all of its characteristics and elements, is necessary to understand the original text.

Elements to analyze	Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture	La poda del alcornocal (Quercus Suber L.). cuantificación de sus productos
Text Style		
Text function or intention		
Intention of the translator		
Stylistic scale		
Formality		
Generality or difficulty		
Emotional Tone		
Translation Method		

Table 1 shows the aspects to be analyze in the text analysis.
Source: Researcher's own creation.

3.4.2 Color-coding

Color coding is the next instrument, this one will find all the translation techniques used in the documents with a sample of fifteen paragraphs of each document, original and translated, where those techniques will be underlined with different colors as it is seen in the next example.

Transposition
Modulation
Omission
Amplification
Explicitation
Literal Translation

Table 2 shows the translation techniques to be taken into account by the translator.
Source: Researcher's own creation.

3.4.3 Glossaries

Glossaries are another instrument to be used by the investigator. This instrument is going to be divided into two, meaning there will be one glossary for one document and one for the other. These glossaries will contain all of the terms which the translator found to be either difficult to understand, or important to have in mind at the time a student is reading the translated document. These glossaries will follow a structure as the one given bellow.

English Term	Spanish Term	Grammatical Category	Definition

Spanish Term	English Term	Grammatical Category	Definition

Table 3 and 4 contain the elements of the glossaries.
Source: Researcher’s own creation

Chapter IV

English to Spanish Translation

Crianza experimental de pececillos de tilapia provenientes del Nilo

(Oreochromis Niloticus) para la acuicultura de agua salada

Wade O. Watanabe

Ching-Ming Kuo

Mei-Chan Huang

Consejo para el Planeamiento de la Agricultura y el Desarrollo

Taiwán

Centro Internacional para el Manejo de Recursos Vivos Acuáticos

Manila, Filipinas

Crianza experimental de pececillos de tilapia provenientes del Nilo (Oreochromis Niloticus) para la acuicultura de agua salada

Wade O. Watanabe

Ching-Ming Kuo

Mei-Chan Huang

1984

Publicado conjuntamente con el Consejo para el Planeamiento de la Agricultura y el Desarrollo, Ejecutivo Yuan, Calle 37 Nan Hai, Taipei, Taiwan y el Centro Internacional para el Manejo de Recursos Vivos Acuáticos, apartado postal MCC 1501, Makati, Metro Manila, Filipinas

Watanabe, W.O., C-M Kuo y M-C. Huang. 1984. Crianza experimental de pececillos de tilapia provenientes del Nilo (Oreochromis Niloticus) para la acuicultura de agua salada. ICLARM Reportes Técnicos 14, 28p. Consejo para el Planeamiento de la Agricultura y el Desarrollo, Taipei, Taiwán y el Centro Internacional para el Manejo de Recursos Vivos Acuáticos, Manila, Filipinas.

Portada: Una incubadora del tipo utilizado en la crianza experimental de *O. niloticus* en varias salinidades

ISSN 0115-5547

ISBN 971-1022-11-7

ICLARM Contribución número 208

Tabla de Contenidos

Crianza experimental de pececillos de tilapia provenientes del Nilo

(Oreochromis Niloticus) para la acuicultura de agua salada

Wade O. Watanabe

ICLARM miembro de investigación posdoctorado

1439-B calle Alewa

Honolulú, Hawái 96817, USA

Ching-Ming Kuo

Científico experimental

Centro Internacional para el Manejo de Recursos Vivos Acuáticos

MCC apartado postal 1501, Makati, Metro Manila

Filipinas

Mei-Chan Huang

ICLARM Asistente de investigación

Universidad Nacional Sun Yat-sen

Kaohsiung, Taiwán

Watanabe, W.O., C-M Kuo y M-C. Huang. 1984. Crianza experimental de pececillos de tilapia provenientes del Nilo (Oreochromis Niloticus) para la acuicultura de agua salada.

ICLARM Reportes Técnicos 14, 28p. Consejo para el Planeamiento de la Agricultura y el Desarrollo, Taipei, Taiwán y el Centro Internacional para el Manejo de Recursos Vivos Acuáticos, Manila, Filipinas.

Resumen

Los huevos fertilizados de la tilapia del Nilo (Oreochromis niloticus L.) desovados en agua dulce fueron removidos de las hembras con incubación bucal un día después del desove y artificialmente incubados en salinidades elevadas. La mortalidad durante la incubación artificial ocurrió principalmente en el desarrollo prematuro y generalmente incrementaba con el aumento en la salinidad de la incubación. A los seis días luego de la eclosión, los promedios de supervivencia del 85.5, 84.4, 82.5, 56.3, 37.9, 20.0, y 0% fueron registrados para crías incubadas en salinidades del 0, 5, 10, 15, 20, 25 y 32 ppm, respectivamente. Los huevos fertilizados mostraron un promedio letal de salinidad a las 96 horas (SLM-96) de 18.9 ppm, idéntico al de pececillos y alevines de 7 a 120 días de edad. Sin embargo, los huevos fertilizados mostraron un tiempo de supervivencia media mucho más alto (TS_{50}= 978 min) que los pececillos y alevines de 7 a 395 días de edad (TS_{50} = 28.8 – 179.0 min), lo cual refleja la habilidad de los huevos para sobrevivir a la transferencia directa al agua salada por periodos más largos que los pececillos y alevines.

El rendimiento de la población reproductora de *O. niloticus* de un año de edad fue monitoreado bajo condiciones de laboratorio en varias salinidades y fue comparado con los resultados del rendimiento de la población reproductora de mayor edad (de dos a tres años) en agua dulce. El desove fue observado en salinidades que oscilan desde agua dulce hasta agua de mar (32 ppm.). El promedio de éxitos en la eclosión fue similar al de los huevos desovados por hembras de un año de edad en agua dulce (30.9%), en 10 ppm (32.7%) y en 15 ppm. (36.9%). Un éxito extremadamente bajo en la eclosión fue obtenido con huevos desovados en agua de mar. El promedio de éxito en la eclosión fue considerablemente más alto para huevos desovados en 5 ppm (51.6%) y fue comparado con el obtenido en huevos desovados por

hembras de mayor edad en agua dulce (54.2%). La producción estacional de pececillos y huevos por hembra fue mucho más alta en la población reproductora de mayor edad en agua dulce que la de hembras de un año de edad bajo cualquier salinidad. Sin embargo, la producción estacional de pececillos y huevos por peso unitario fue mayor en las hembras de un año de edad en salinidades de 5 a 15 ppm que en hembras de mayor edad en agua dulce.

La tolerancia a la salinidad de pececillos desovados en varias salinidades y pececillos desovados en agua dulce, pero eclosionados en varias salinidades, fue determinada usando los índices de: el tiempo medio de supervivencia (TS_{50}), el tiempo de supervivencia promedio (TSP) y la salinidad letal mediana de 96 horas (SLM-96). Para fines comparativos, los pececillos desovados y eclosionados en agua dulce fueron aclimatados a varias salinidades y su tolerancia a la salinidad, también, fue determinada. La tolerancia a la salinidad de los pececillos incrementó progresivamente con la creciente salinidad de desove, eclosión y aclimatación. Sin embargo, en una salinidad equivalente, la exposición temprana (el desove) produjo una descendencia de comparativamente mayor tolerancia a la salinidad que la de los desovados en agua dulce y eclosionados en una salinidad elevada. En forma similar, en una salinidad equivalente, la descendencia desovada en agua dulce, pero eclosionada en una salinidad elevada mostró una mayor tolerancia a la salinidad que la descendencia desovada y eclosionada en agua dulce y luego aclimatada en una salinidad alta.

La utilidad de estos métodos de temprana exposición a la salinidad para la crianza de tilapia en agua salada es discutible.

Introducción

Aunque la crianza de tilapia en el presente es primariamente limitada al agua dulce y al agua salobre de baja salinidad, ha sido ampliamente sugerido que las tilapias eurihalinas pueden ser criadas en mayores niveles de salinidad (agua salobre y sistemas marinos), permitiendo de este modo su explotación en tierras áridas y áreas costeras. Una investigación inadecuada, basada en su biología y crianza con respecto de su tolerancia a la salinidad, ha impedido la realización de estos importantes objetivos. Para reseñas recientes pueden consultarse Chervinski (1982) y Payne (1983).

El enfoque general hacia la crianza de tilapia en agua salada tiene como propósito el producir descendencia y alevines en agua dulce, seguido de criaderos en agua salobre o agua de mar. En un estudio previo (Watanabe et al., 1984) se observaron cambios ontogénicos en la tolerancia a la salinidad en varias especies de tilapia. En Oreochromis niloticus y O. aureus, la tolerancia a la salinidad incrementó desde valores relativamente bajos sobre la posteclosión inicial de 45 a 60 días, a valores máximos desde 150 a 180 días posteclosión. La descendencia híbrida del O. mossambicus (♀) y el *O. niloticus* (♂) mostraron una velocidad creciente de tolerancia, comparativamente más rápida con la edad. Estos cambios ontogénicos en la tolerancia a la salinidad fueron determinados al estar más estrechamente relacionados con el tamaño del cuerpo que con la edad cronológica. Se asume que la supervivencia máxima y el crecimiento en agua de mar podrían resultar si la transferencia desde agua dulce fuera implantada en el tamaño de máxima tolerancia a la salinidad, estos resultados han proporcionado una base racional para seleccionar un tiempo óptimo para la transferencia desde el desove en agua dulce y las poblaciones criadas en agua de mar para su crecimiento.

El conocimiento del tamaño de transferencia óptimo también minimiza los requisitos del agua dulce, lo cual le permite al acuicultor implantar la transferencia lo más antes posible.

Sin embargo, cuando el agua dulce es seriamente limitada, los costos asociados con el desove y la crianza temprana en agua dulce pueden superar los beneficios de la supervivencia mejorada y el crecimiento atribuible a este enfoque. Además, la cantidad de peces que pueden ser producidos en agua dulce puede limitar la producción total, como ha sido demostrado para el salmón (Landless y Jackson 1979).

Un enfoque alternativo para el problema de la crianza de tilapia en agua de mar es exponer a los peces a bajas concentraciones de agua de mar en etapas muy tempranas de sus ciclos de vida, para así preadaptarlos a la posterior crianza en salinidades altas. Este enfoque puede involucrar, por ejemplo, la exposición de la descendencia desovada y eclosionada a salinidades elevadas poco después de la eclosión. La exposición puede ser ejecutada en una etapa de desarrollo, incluso más temprana, removiendo los huevos fertilizados de la boca de la madre para su incubación artificial y eclosión en salinidades elevadas. Opcionalmente, si el desove es logrado con éxito en salinidades elevadas, los huevos son expuestos a un ambiente salino inmediatamente después de la oviposición, cuando dejan el fluido ovárico. El conocimiento de los efectos relativos de estos métodos de exposición temprana en la tolerancia a la salinidad de la descendencia resultante será de considerable importancia práctica para el acuicultor de tilapia en agua de mar.

Este estudio representa una evaluación preliminar de las utilidades de estos enfoques de exposición temprana a la salinidad para la crianza de tilapias en agua de mar. El rendimiento reproductivo de la tilapia del Nilo (Oreochromis niloticus L.) fue monitoreado en condiciones de laboratorio en varias salinidades y la tolerancia a la salinidad de la descendencia fue determinada. La supervivencia de los huevos fertilizados desovados en agua dulce, pero removidos de la boca de la madre e incubados artificialmente en varias salinidades también fue evaluada y la tolerancia a la salinidad de los pececillos resultantes fue determinada. La tolerancia a la salinidad de los pececillos desovados y eclosionados en agua dulce, pero posteriormente aclimatados a varias salinidades, igualmente fue establecida. Finalmente, las tolerancias a la salinidad de pececillos sometidos a estos métodos de exposición temprana se compararon.

Materiales y Métodos

Los experimentos descritos en este reporte se llevaron a cabo en la Universidad Nacional Sun Yat-sen, Instituto de Biología Marina, Kaohsiung, Taiwán, desde marzo hasta diciembre de 1983.

Desove en agua dulce en el acuario del laboratorio

La población adulta reproductora de tilapia del Nilo utilizada fue originada de una población reproductora en cautividad experimental mantenida en agua dulce en el Instituto de Investigación Pesquera de Taiwán (Lukang y Tainan Branches). Los individuos fueron examinados para asegurar la conformidad con las características morfológicas específicas de especies conocidas, incluyendo la configuración de la cabeza, la coloración madura, restricción de la aleta caudal (Lee, 1979). Descripciones más completas fueron publicadas en Trewavas (1983). Los reproductores oscilaban en tamaño desde los 99 hasta los 227 g en el peso corporal inicial.

Los desoves fueron conducidos en agua dulce en un acuario de vidrio de 120 litros bajo techo (60 x 60 x 40 cm) en temperaturas de 24º a 31º C, bajo fotoperiodo natural con luz solar difusa a través de varias ventanas de laboratorio. Un sistema de recirculación semicerrado fue empleado con agua constantemente recirculada por un puente aéreo a través de filtros de grava de tipo caja, situados dentro de cada acuario. Las heces fueron sacadas periódicamente, y aproximadamente la mitad del volumen del tanque fue reemplazado por agua del grifo cada semana.

Los peces fueron alimentados dos veces al día ad libitum con una dieta granulada de tilapia comercial (Compañía Tong Bao, Tainan, Taiwán) que contiene un 24% de proteína.

En cada acuario, un macho fue juntado con una o tres hembras etiquetadas individualmente. El premaxilar fue removido de todos los machos para reducir la mortalidad de las hembras debido a mordeduras agresivas (Lee, 1979). Los acuarios se revisaron diariamente en caso de cualquier actividad de desove, así como el desovador y la fecha de observación de cada desove se registraron al percibirse una incubación bucal.

Éxito en la eclosión de huevos fertilizados desovados en agua dulce pero artificialmente incubados en varias salinidades

Los huevos fueron removidos de las hembras con incubación bucal aproximadamente un día después del desove. Estos fueron contados y distribuidos equitativamente en incubadoras artificiales en varias salinidades (0, 5, 10, 15, 20, 25 y 32 ppm). El número de huevos oscilaba desde los 164 hasta los 224 por incubadora. Los huevos se transfirieron directamente desde el agua dulce hacia la salinidad de la incubadora. Se preparó el agua de salinidades variadas al diluir el agua de mar obtenida de la playa Hsitzewan en Kaohsiung con agua del grifo. El agua de mar y el agua de grifo fueron condicionadas por la recirculación de puentes aéreos a través de una cama de ostras de 6cm por varios días antes de su uso.

Las incubadoras artificiales se elaboraron con botellas de plástico transparente de 1.2l que tienen una base cilíndrica y una sección en forma de copa cerca de la boquilla (ver lámina 1). Media sección de la base de la botella fue removida para crear una abertura para la colocación y remoción de los huevos y pececillos y un disco perforado en forma cóncava se montó cerca de la boquilla para que funcione como un dispositivo de ducha. La incubadora se suspendió (con la boquilla hacia abajo) con un soporte de tubería de PVC en un tanque de 100l que contenía aproximadamente 80l de agua y una salinidad apropiada. Una corriente continua de agua filtrada y recirculada de un filtro de acuario externo operado con electricidad se le dio a la incubadora a través de un tubo Tygon conectado a la boquilla de la botella por medio de un tapón de caucho. La velocidad del agua hacia la incubadora se ajustó a aproximadamente 1.75l/min, nivelando el grado de sumersión de la incubadora, de este modo que se pudiese regular el agua que entra a través de puertos que preceden al punto de entrada de la incubadora. Esto se logra, ya sea ajustando el largo del cable de suspensión o el nivel de agua

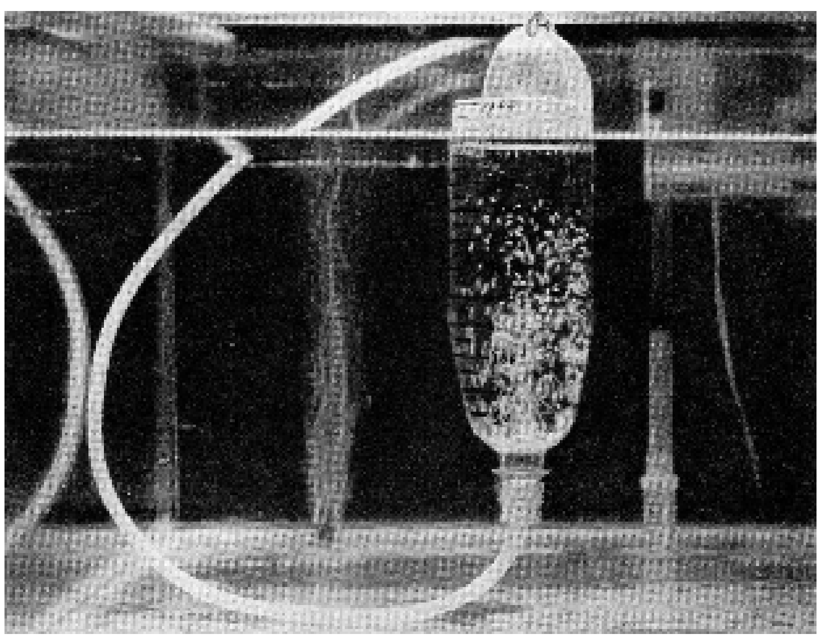


Lámina 1. Incubadora utilizada para la crianza experimental de O. niloticus, como fue descrita en el texto.

del tanque. El flujo constante de agua a través de la incubadora mantuvo a los huevos incubados en suspensión.

La incubación se llevó a cabo con temperaturas de 27.2 a 31.5º C. Los embriones muertos y las larvas fueron contados y removidos diariamente. El oxígeno disuelto (OD), el pH, NH_4 –N total y NO_2 –N total, fueron monitoreados en cada incubadora en días alternos. Los niveles de oxígeno disuelto (OD) se mantuvieron cerca de la saturación de aire (6.3 a 8.5 ppm) y el pH oscilaba desde 8.0 a 8.5 durante la incubación en todas las salinidades. Las concentraciones totales de NH_4 –N total y el NO_2 –N no excedieron los 0.06 y los 0.02 mg/l, respectivamente, en cualquier salinidad durante la incubación.

La eclosión ocurrió aproximadamente tres días luego del desove. A las larvas eclosionadas se les permitió permanecer en las incubadoras hasta que la absorción del saco vitelino estuviese completada en aproximadamente seis a siete días luego de la eclosión. La tolerancia a la salinidad de los pececillos de siete días de edad fue determinada usando los índices de TSP, TS_{50} y SLM-96 descritos en la siguiente sección.

Rendimiento reproductivo de los *o. niloticus* de al menos un año de edad en el acuario del laboratorio en varias salinidades

Veinticinco individuos *O. niloticus* (longitud media inicial, peso: 7.2cm, 6.2g) de una misma población de crías, desovadas y criadas en agua dulce hasta los 232 días luego de la eclosión, fueron aclimatados en agua de mar (32 ppm) en un periodo de seis días, a un ritmo de aproximadamente 5 ppm al día. Un grupo controlado que consiste de 25 individuos (longitud media inicial, peso: 6.9cm, 5.3g) de la misma población de crías fueron conservados en agua dulce. Los grupos controlados y aclimatados a agua de mar se llevaron a cabo en acuarios de plástico blanco de 100l bajo sistemas de condición semicerrados como fue descrito anteriormente.

A los 40 días posteriores a la iniciación de la aclimatación (272 días luego de la eclosión), se observó a una hembra en el grupo de aclimatados en agua de mar (longitud, peso: 9.6cm, 12.6g) incubando huevos bucalmente. Los huevos fueron removidos de la boca de la hembra y se incubaron artificialmente en agua de mar (32 ppm), a pesar de que ningún desarrollo embrionario se observó. A los 118 días luego de la iniciación de la aclimatación (350 días luego de la eclosión), otra hembra en el grupo de aclimatados en agua de mar (longitud, peso: 10.0cm, 16.0g) fue observada incubando bucalmente. Ningún desarrollo embrionario fue observado durante la incubación artificial. Una hembra en el grupo de control de agua dulce (longitud, peso: 11.0cm, 18.8g) fue vista incubando huevos bucalmente a los 312 días luego de la eclosión, aunque los huevos no fueron removidos para su incubación artificial. Esta actividad reproductora en agua de mar sugiere la factibilidad de comparar el rendimiento reproductivo de los individuos aclimatados en agua de mar siguiendo la reaclimatación en salinidades reducidas.

Los individuos aclimatados en agua de mar (longitud media inicial, peso: 9.9cm, 16.6g) fueron distribuidos posteriormente a salinidades de 32, 15,10 y 5 ppm y su desempeño reproductivo fue monitoreado paralelo al de los grupos de control de agua dulce. Los desoves fueron llevados a cabo en acuarios de vidrio de 120l bajo techo a 27.0-30.2Cº, bajo condiciones de fotoperiodo natural. Se emplearon los sistemas semicerrados descritos anteriormente. Aproximadamente, un tercio del volumen del tanque fue reemplazado cada semana con agua condicionada de la misma salinidad. Tres hembras y tres machos etiquetados individualmente fueron mantenidos en cada acuario. Cada tanque se observó diariamente, en caso de cualquier actividad de desove. Cuando una hembra fuese observada incubando bucalmente, se registró el desovador y la fecha de desove. Los huevos fueron removidos de la boca aproximadamente un día después del desove e incubados artificialmente en salinidades equivalentes. Las incubadoras fueron monitoreadas diariamente a fin de establecer una fecha para su eclosión (edad, 0 días). Se les permitió a las larvas eclosionadas permanecer en las incubadoras hasta que la absorción del saco vitelino estuviese completa, aproximadamente de seis a siete días después de la eclosión. La tolerancia a la salinidad de los pececillos de seis a nueve días de edad fue determinada usando los índices de TSP, TS_{50} y SLM-96 que a continuación se discuten.

Tolerancia a la salinidad de pececillos desovados y eclosionados en agua dulce aclimatados a varias salinidades

Los pececillos *O. niloticus* (4 a 10 días luego de la eclosión) de una misma población de crías desovada y eclosionada en agua dulce fueron transferidos directamente a aclimatación de salinidades de 5, 10 y 15 ppm. De siete a ocho días después de la transferencia, la tolerancia a la salinidad de los pececillos fue establecida utilizando los índices de TSP, TS_{50} y SLM-96, que a continuación se discuten. Los peces fueron alimentados diariamente ad libitum con una dieta granulada de tilapia comercial durante la etapa de aclimatación. La alimentación se descontinuó el día de prueba de tolerancia.

Índices de tolerancia a la salinidad

El agua de mar fue obtenida de la playa de Hsitzewan en Kaohsiung y filtrada por recirculación a través de una cama de conchas de ostra de 6cm durante varios días antes de su uso. El agua de varias salinidades se preparó al diluir el agua de mar filtrada con agua del grifo condicionada, similarmente por la recirculación a través de conchas de ostra.

Toda prueba de tolerancia a la salinidad se llevó a cabo en acuarios de plástico blanco de 20l, con condiciones de sistema cerrado. En cada acuario, el agua fue recirculada por transporte aéreo a través de un filtro interno de grava tipo caja.

Se emplearon varias pruebas como índices prácticos de tolerancia a la salinidad:

(1)Salinidad Letal Mediana-96 horas (SLM-96), definida como la salinidad a la que la supervivencia cae a un 50% a las 96 horas luego de la transferencia directa a la salinidad a la que la población de crías había sido previamente expuesta (durante el desove, eclosión o aclimatación) a varias pruebas de salinidad (0, 7.5, 15, 17.5, 20, 22.5, 25, 27.5, 30 y 32 ppm). Una muestra de 25-30 individuos fue pesada y medida a fin de establecer la longitud media del cuerpo, el peso y el factor de condición de la población de crías experimental. Cada pez se secó con pañuelos de papel antes de pesarse. La longitud total fue determinada al 0.01cm más cercano. El factor de condición (K) fue calculado con la fórmula ($K=P/L^3 \times 100$), donde P denota el peso en gramos y L la longitud total en centímetros. De diez a veinte individuos fueron transferidos de preexposición de salinidad directamente a cada prueba de salinidad. Los individuos fallecidos se contaron y se removieron cada día por un periodo de cuatro días (96 horas). La supervivencia final (porcentaje) en cada prueba de salinidad fue calculada con la suma del número de días de supervivencia de cada individuo, dividido entre el producto del total de días experimentales (4) y el número inicial de peces. El porcentaje total de supervivencia fue trazado luego contra la transferencia de salinidad y el SLM-96 fue determinado con la salinidad en la que la supervivencia cayó a 50%.

(2) Tiempo de Supervivencia Promedio (TMS) definido como el tiempo medio de supervivencia de todos los individuos en un grupo experimental a través de un periodo de 96 horas luego de la transferencia directa de la preexposición de salinidad a agua de mar (32 ppm). Veinticinco individuos fueron utilizados para cada prueba. Los individuos fallecidos se

removieron tan pronto sucumbiesen al estrés salino y al tiempo de muerte asimismo longitud y el peso corporal se registraron. El cese de los movimientos operculares y la falta de respuesta a los estímulos suaves fueron los criterios usados para la muerte.

(3) Tiempo Medio de Supervivencia (TS_{50}) definido como el tiempo en el que la supervivencia cae al 50% luego de la transferencia directa de la preexposición a la salinidad a agua de mar.

Las transferencias directas entre la preexposición de salinidad y las pruebas de salinidad fueron realizadas en condiciones isotérmicas. Los experimentos se llevaron a cabo en temperaturas de 27 a 30.2º C. Las temperaturas se registraron diariamente durante las pruebas de tolerancia. Los niveles de oxígeno disuelto fueron mantenidos cerca de la saturación de aire (6.0-8.6 ppm) en todas las temperaturas y salinidades.

Resultados y Discusión

Éxito en la eclosión de huevos fertilizados y desovados en agua dulce pero artificialmente incubados en varias salinidades

La figura 1 presenta el patrón de supervivencia generalizada para los huevos fertilizados de *O. niloticus* luego de 96 horas de la transferencia directa desde el medio de desove de agua dulce a incubadoras artificiales en varias salinidades. Los huevos fueron removidos de la boca de la madre aproximadamente un día después del desove. Este patrón de supervivencia resultó en un SLM-96 de 18.9 ppm (intervalo = 16.0 – 27.6 ppm, n = 4). Para propósitos comparativos, un patrón de supervivencia generalizada por 7 a 120 días de edad de los pececillos *O. niloticus* y los alevines desovados y criados en agua dulce, luego de 96 horas de la transferencia a varias salinidades, es superpuesto en la figura 1.

Aunque los dos patrones muestran un valor de SLM-96 idéntico del 18.9 ppm, algunas diferencias importantes en estos patrones son evidentes. Las variaciones entre las poblaciones con respecto de la supervivencia en cualquier salinidad dada, fueron más pronunciadas en los embriones en desarrollo (es decir, huevos fertilizados) que en los pececillos y los alevines. La mortalidad visible de embriones ocurrió en todas las salinidades, incluyendo el agua dulce. Sin embargo, los embriones fueron más capaces de tolerar la transferencia directa a salinidades de 20 ppm o más altas. Por ejemplo, ningún pececillo ni alevín de 7 a 120 días de edad sobrevivió a las 96 horas luego de la transferencia directa a 25 ppm. En comparación, una supervivencia media del 20.5% fue registrada para embriones 96 horas luego de la transferencia directa a esta salinidad. Ningún embrión sobrevivió a las 96 horas luego de la transferencia directa a agua de mar (32 ppm). No obstante, es evidente por el patrón de supervivencia diaria de embriones transferidos directamente a agua de mar (Fig. 2) que hubo alguna supervivencia durante 48 horas luego de la transferencia. Los embriones sobrevivieron a la transferencia directa a agua de mar por periodos mucho más largos que los pececillos y alevines de 7 a 395 días de vida, los cuales sobrevivieron por un máximo de cinco horas luego de la transferencia directa a agua de mar en temperaturas comparables. El patrón de supervivencia para embriones transferidos directamente a agua de mar (Fig. 2) resulta en un tiempo de supervivencia media (TS_{50}) de 978 minutos, un valor mucho mayor que los observados en pececillos y alevines *O. niloticus* de 7 a 395 días de edad, los cuales oscilan de 28.8 a 179.0 minutos (Watanabe et. al. 1984).

E la tabla 1 se presenta la supervivencia diaria de huevos *O. niloticus* desovados en agua dulce durante la incubación artificial en varias salinidades. Estos patrones de supervivencia se ilustran en la figura 2. Como lo muestran estos resultados, la mortalidad durante la incubación artificial ocurrió principalmente durante el desarrollo prematuro desde el día de la remoción hasta un día después de la eclosión. La mortalidad generalmente incrementó con el aumento de la salinidad y fue particularmente abundante en las salinidades más altas de 20 a 32 ppm. En agua de mar (32 ppm.), no hubo supervivencia durante esta etapa. Luego del primer día de incubación (un día de edad), la supervivencia permaneció relativamente alta (oscila entre 85.4-94.0%) en todas las salinidades hasta 25 ppm. En agua de mar, sin embargo, la supervivencia media cayó a 25.5% durante esta etapa. La mortalidad diferencial en varias salinidades se tornó gradualmente más pronunciada sobre el segundo y tercer día de incubación de modo que las diferencias en los valores de supervivencia entre salinidades fueron observados por un día después de la eclosión. Luego de esta etapa de mortalidad prematura, la supervivencia generalmente se estabiliza hasta seis días después de la eclosión, aunque cierta mortalidad continuó a los 15 ppm. Los patrones de supervivencia para huevos incubados en salinidades de 5 y 10 ppm fueron muy similares al patrón observado en huevos incubados en agua dulce. A los seis días luego de la eclosión, los valores medios de supervivencia del 82.5, 84.4 y 88.5%, respectivamente fueron registrados en estas salinidades. Una mayor mortalidad ocurrió en forma progresiva con el aumento de la salinidad en la incubación. A los seis días luego de la eclosión, los valores medios de supervivencia del 56.3, 37.9 y 20.0% fueron registrados para salinidades en la incubación de 15, 20 y 25 ppm, respectivamente. Sin embargo, como los errores estándar e intervalos de la Tabla 1 lo demuestran, la supervivencia varió en forma considerable entre crías incubadas en salinidades de 15 ppm y por encima. Por ejemplo, en las salinidades de incubación de 15 y 20 ppm, los valores de supervivencia a los seis días luego de la eclosión oscilaron de 0 a 92.9% y de 0 a 89.7%, respectivamente.

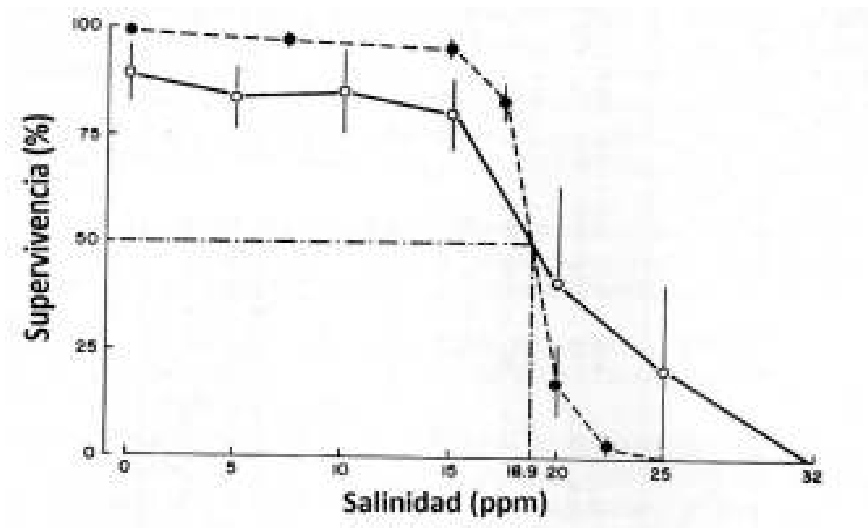


Fig. 1 Supervivencia de huevos desovados en agua dulce (○) y pececillos y alevines O. niloticus de 7 a 120 días de edad desovados y criados en agua dulce (•), 96 horas luego de la transferencia directa a varias salinidades. Los huevos se removieron de las bocas de sus madres aproximadamente un día postdesove. Cada punto trazado representa el valor medio para cuatro determinaciones para huevos y 20 determinaciones para pececillos y alevines. Las barras verticales representan el ± Error Estándar de la Media (EEM). Ambos patrones de supervivencia resultan en un SLM-96 de 18.9 ppm.

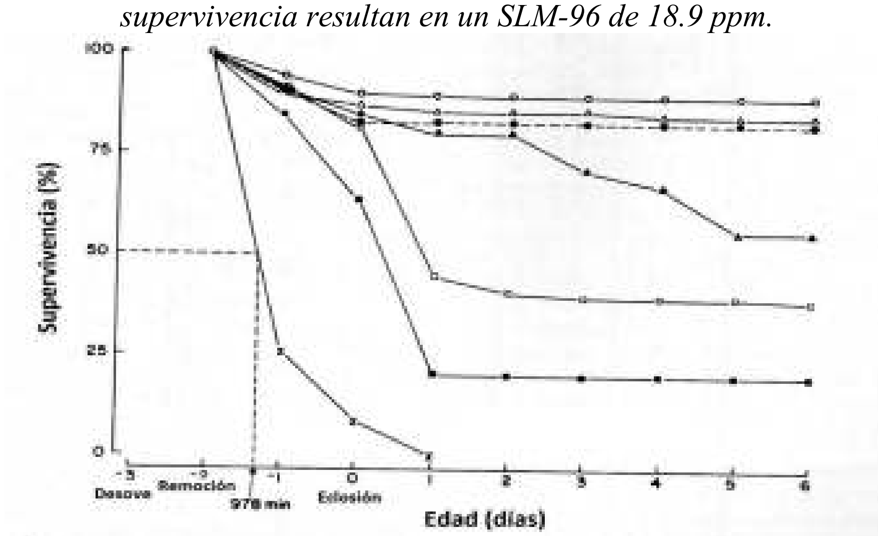


Fig. 2 La supervivencia de huevos O. niloticus desovados en agua dulce, incubados artificialmente en varias salinidades (agua dulce (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲), 20 ppm (□), 25 ppm (▪), 32 ppm (X)). Los puntos trazados representan los valores medios de la Tabla 1.

Tabla 1. Porcentaje diario de supervivencia de los huevos O.niloticus desovados en agua dulce, incubados artificialmente en varias salinidades.

					Edad: (días post-eclosión)						
Salinidad de incubación (ppm)	Edad (Días post-eclosión)	−3 Desove	−2 Eliminar e incubar	−1	0 Eclosión	1	2	3	4	5	6 Saco de yema absorbido
0			100	94.0 ± 4.7[a] (80.0 – 99.4)[b]	90.3 ± 6.5 (70.8 – 98.8)	89.4 ± 6.3 (70.8 – 98.2)	89.2 ± 6.3 (70.8 – 98.2)	89.0 ± 6.2 (70.8 – 97.6)	88.6 ± 6.3 (70.0 – 97.6)	88.6 ± 6.3 (70 – 97.5)	88.5 ± 6.3 (70 – 97.6)
5			100	92.0 ± 5.8 (74.8) – 99.4)	83.3 ± 7.5 (62.3 – 96.3)	83.1 ± 6.9 (63.9 – 94.5)	83.0 ± 6.9 (63.9 – 94.5)	82.6 ± 7.1 (63.1 – 94.5)	82.5 ± 7.0 (63.1 – 94.5)	82.5 ± 7.0 (63.1 – 94.5)	82.5 ± 7.0 (63.1 – 94.5)
10			100	91.0 ± 7.5 (68.5 – 99.4)	87.4 ± 8.9 (60.8 – 98.8)	85.9 ± 9.2 (56.9 – 98.2)	85.5 ± 9.6 (56.9 – 98.2)	85.5 ± 9.6 (56.9 – 98.2)	84.4 ± 9.3 (56.9 – 98.2)	84.4 ± 9.3 (56.9 – 98.2)	84.4 ± 9.3 (56.9 – 98.2)
15			100	90.9 ± 5.8 (74.6 – 98.8)	84.7 ± 6.4 (67.7 – 95.1)	80.8 ± 7.9 (62.3 – 95.1)	80.6 ± 8.0 (62.3 – 95.1)	72.2 ± 7.3 (61.6 – 92.9)	64.2 ± 12.9 (30.8 – 92.9)	56.3 ± 19.9 (0 – 92.9)	56.3 ± 19.9 (0 – 92.9)
20			100	92.2 ± 4.9 (78.5 – 98.8)	82.4 ± 8.7 (57.7 – 98.3)	45.2 ± 22.2 (0 – 91.6)	41.1 ± 22.4 (0 – 90.7)	39.2 ± 23.1 (0 – 89.7)	38.9 ± 23.0 (0 – 89.7)	38.9 ± 23.0 (0 – 89.7)	37.9 ± 22.6 (0 – 89.7)
25			100	85.4 ± 11.8 (50.0 – 99.4)	63.5 ± 18.4 (20.8 – 90.3)	21.5 ± 20.2 (0 – 82.1)	20.5 ± 19.8 (0 – 79.9)	20.0 ± 20.0 (0 – 79.9)	20.0 ± 20.0 (0 – 79.9)	20.0 ± 20.0 (0 – 79.9)	20.0 ± 20.0 (0 – 79.9)
32			100	26.6 ± 14.6 (0 – 51.2)	7.9 ± 4.0 (0 – 31.7)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

aMedio ± E.E.M. (Error Estandar de la Media) para cuatro pruebas de incubación.

bRango

Ninguna relación consistente fue observada entre la salinidad de incubación y el tiempo de eclosión. La poca supervivencia y eclosión de huevos incubados en las salinidades más altas se asociaron con anormalidades estructurales generalmente caracterizadas por un subdesarrollo de los órganos.

Tolerancia a la salinidad de pececillos eclosionados en agua dulce- desove de huevos incubados artificialmente en varias salinidades (pececillos desovados en agua dulce y eclosionados en agua salada)

El peso corporal medio, longitud media y factores de condición de los pececillos de siete días de edad desovados en agua dulce y los pececillos eclosionados en agua salina se presentan en la Tabla 2. La única población de crías eclosionada exitosamente en una salinidad de 25 ppm, tenía una longitud y peso corporal medio, el cual fue notablemente mayor que el de las poblaciones incubadas y eclosionadas en salinidades más bajas. No obstante, no hubo ($P>0.05$, prueba-t) diferencias importantes entre pececillos eclosionados en cualquier salinidad y los eclosionados en agua dulce con respecto de estos parámetros.

Los valores correspondientes de TS_{50}, TMS y SLM-96 de los pececillos de siete días de edad eclosionados en varias salinidades también se presentan en la Tabla 2. Debido a que la máxima salinidad empleada durante la indexación del SLM-96 fue 32 ppm, un valor de tolerancia relativo no fue previsto cuando la supervivencia excedió un 50% en todas las salinidades 96 horas seguido a la transferencia desde la salinidad de eclosión (SLM-96 > 32 ppm). Por consiguiente, a fin de obtener un valor de SLM-96 representativo para los pececillos eclosionados en una salinidad dada, la supervivencia media sobre todos los ensayos fue calculada para cada transferencia a la salinidad y el SLM-95 fue determinado del patrón de supervivencia generalizado resultante. La figura 3 ilustra estos patrones de supervivencia generalizados para los pececillos de siete días de edad desovados en agua dulce y los pececillos eclosionados en agua salina 96 horas después de la transferencia directa a varias salinidades. Como la figura 3 lo muestra, la progresión de SLM-96 incrementó de 19.2 ppm para los pececillos eclosionados en agua dulce a más de 32 ppm para los pececillos eclosionados en 20 ppm o niveles mayores. Los patrones de supervivencia de la figura 3 revelan que el SLM-96 creciente con la salinidad de eclosión creciente fue relacionado con una elevación de la mortalidad en salinidad incipiente. Con cada incremento de 5 ppm en la salinidad de eclosión, la salinidad de la mortalidad incipiente se elevó de 2.5 a 5 ppm. La mortalidad incipiente para los pececillos eclosionados en 0, 5, 10, 15, 20 y 25 ppm ocurrió en aproximadamente 17.5, 20, 22.5, 27.5, 30 y 32 ppm, respectivamente. El incremento de la salinidad en la eclosión también expandió la línea entre mortalidad incipiente y final. Por ejemplo, las mortalidades incipientes y finales para las poblaciones de eclosión en agua dulce ocurrieron dentro de un rango de salinidad relativamente estrecho de 17.5 a 22.5 ppm. A diferencia de las poblaciones eclosionadas en 10 ppm, la mortalidad incipiente ocurrió en los 22.5 ppm y la mortalidad todavía no estaba completada a los 32 ppm. Por lo tanto, mientras la supervivencia disminuía rápidamente cuando la salinidad excedía los niveles de mortalidad incipiente para los pececillos eclosionados en agua dulce, una disminución progresivamente más gradual en la supervivencia fue observada cuando la salinidad excedía los niveles de mortalidad incipiente para los pececillos eclosionados en salinidades elevadas.

Dado que el periodo empleado para la prueba de tolerancia a la salinidad fue de 96 horas, un valor relativo de TS_{50} no fue proporcionado cuando la supervivencia no cayó al 50% a las 96 horas después de la transferencia directa de la salinidad de eclosión hacia el agua totalmente salina ($TS_{50} > 5,760$ min). Por consiguiente, a fin de obtener un valor de TS_{50}

representativo para los pececillos eclosionados en una salinidad dada, la supervivencia media en todas las pruebas se calculó en periodos sucesivos luego de la transferencia, y la TS_{50} fue derivada del patrón de supervivencia generalizado resultante. La figura 4 ilustra los patrones de supervivencia generalizada en función del tiempo, para los pececillos de siete días de vida desovados en agua dulce y para los pececillos eclosionados en agua salina luego de la transferencia directa desde la salinidad de eclosión a agua de mar (32 ppm). Como la figura 4 muestra, la TS_{50} incrementó del 51,0 min para los pececillos eclosionados en agua dulce, a mayor que 5.760 min para los pececillos eclosionados en 20 ppm o más. La mortalidad ocurrió especialmente durante las ocho horas iniciales luego de la transferencia desde la salinidad de eclosión hacia el agua de mar (32 ppm) y estabilizada luego de esto a través de 96 horas. El aumento de la salinidad de eclosión resultó en un incremento progresivo en el porcentaje de individuos supervivientes a las 96 horas después de la transferencia directa de la salinidad de eclosión a agua totalmente de mar (32 ppm). Los pececillos eclosionados en agua dulce o en 5 ppm mostraron una mortalidad total dentro de las dos o cuatro horas iniciales, respectivamente, luego de la transferencia. A diferencia de los pececillos eclosionados en 10, 15, 20 y 25 ppm, los cuales mostraron valores de supervivencia media de 28.7, 51.3, 69.3 y 100%, respectivamente, 96 horas luego de la transferencia.

Rendimiento reproductivo de los o. niloticus de al menos un año de edad en el acuario del laboratorio en varias salinidades

Los resultados de los estudios en el rendimiento reproductivo de la población reproductora de *O. niloticus* de al menos un año de edad en el acuario del laboratorio en

Tabla 2. El tiempo medio de Supervivencia (TS50), Tiempo Promedio de Supervivencia (SMT) y Salinidad Media Letal (SML-96) de pececillos O. niloticus de siete días de edad eclosionados de huevos desovados en agua dulce e incubados artificialmente en varias salinidades.

Incubation salinity (ppt)	Body weight (mg)[a]	Body length (mm)[a]	Condition factor[a]	ST_{50} (min)[b]	MST (min)[a]	MLS-96 (ppt)[b]	Assay temperature range (°C)
0	7.8 ± 0.4 (6)	8.9 ± 0.3 (6)	1.14 ± 0.06 (6)	51.0 (6) 42.0 – 71.0	51.0 ± 4.7 (6) 4.20 – 73.4	19.2 (4) 18.5 – 22.0	27.2 – 29.8
5	8.1 ± 0.8 (5)	9.1 ± 0.2 (5)	1.07 ± 0.05 (5)	69.0 (5) 46 – 150	86.2 ± 27.5 (5) 45.1 – 193.3	21.2 (4)	27.4 – 30.5
10	8.2 ± 0.5 (6)	9.0 ± 0.2 (6)	1.14 ± 0.07 (6)	90.0 (6) 64 – >5,760	1,097.0 ± 934.5 (6) 65.3 – 5,760	26.0 (4) 23.8 – >32	27.4 – 29.8
15	8.0 ± 0.9 (5)	9.1 ± 0.2 (5)	1.05 ± 0.06 (5)	4,320 (5) 147 – >5,760	3,411.2 ±1,073.8 (5) 154.6 – 5,760	30.2 (4) 26.5 – >32	27.3 – 30.5
20	7.7 ± 1.4 (3)	9.0 ± 0.3 (3)	1.03 ± 0.09 (3)	>5,760 (2) 1,402 – >5,760	4,069.5 ± 847.6 (3) 3,005 – 5,760	>32 (2) >32	27.3 – 29.8
25	9.8 (1)	9.8 (1)	1.04 (1)	>5,760 (1)	5,760 (1)	>32 (1)	28.4

[a]Medio ± E.E.M. (número de determinaciones). Los rangos de valores se presentan para el SMT.

[b]Derivado de los patrones de supervivencia generalizada como fue descrito en el texto. El rango se da debajo del punto medio; número de determinaciones en parentesis.

varias salinidades se resumen en la Tabla 3. Los datos representan desoves registrados desde el 30 mayo de al 18 de octubre de 1983. Para propósitos comparativos, la Tabla 3 también presenta los resultados de un estudio por separado sobre el rendimiento reproductivo de los *O. niloticus* en un acuario de laboratorio en agua salada, el cual empleó una población reproductora más avanzada en edad (dos a tres años) y (peso/ longitud corporal medio estacional: 203.9g, 21,5 cm) y una población reproductora mucho más grande que consistía en 16 hembras. Para la población reproductora de mayor edad, los datos representan desoves registrados desde el 26 de marzo al 18 de octubre de 1983.

Para las hembras de un año de edad, el número total de desoves fue más alto en las aguas salobres de 5 a 15 ppm que en agua de mar (32 ppm) o en agua dulce. Una frecuencia baja del desove en agua de mar puede, en parte, explicarse por una tendencia del intervalo medio entre desoves para que se alargue en las salinidades más altas de aproximadamente 18 días en 5 y 10 ppm, a 22.9 días en 15 ppm, y a 32.0 días en 32 ppm. Sin embargo, así como los intervalos entre desoves sucesivos variaron sobre un rango considerable en cualquier salinidad dada, estas diferencias no fueron estadísticamente significantes ($P > 0.05$, prueba-t). El número total de desoves en cada salinidad también fue influido por las veces en que cada hembra en un grupo de salinidad desovaba durante el periodo de observación. Por ejemplo, se registraron más desoves en 15 ppm que en 10 ppm o 5 ppm, a pesar del hecho de que el intervalo medio entre desoves fue más largo en 15 ppm. Esto sucedió porque durante el periodo de observación, cada hembra en el grupo de 15 ppm desovó un promedio de 6.7 veces, mientras que cada hembra en los grupos de 10 ppm y 5 ppm lo hizo con un promedio de solo cinco veces. Solo se observaron desoves únicos en cada hembra en el grupo de control de agua dulce. En comparación, cada hembra en la población reproductora de edades mayores en agua dulce desovó un promedio de 3.8 veces y el intervalo medio entre desoves cuando los huevos fueron removidos fue de 19.7 días, muy similar al observado en las hembras de un año de edad, que desovaron en salinidades de 5 a 15 ppm.

Para las hembras de un año de edad, el número medio de huevos liberados por desove fue más o menos equivalente en todas las salinidades, aunque de cierta manera más bajo en 15 ppm. Cuando los datos se expresan como el número medio de huevos liberados por gramo de peso corporal (promedio estacional), los resultados de 15 ppm fueron muy parecidos a aquellos observados en las otras salinidades, esto indica que un número medio más bajo de huevos liberados por desove en 15 ppm estaba relacionado con las hembras de menor tamaño en esta salinidad. El número medio de huevos desovados por gramo de peso corporal bajo condiciones salinas no difirió significativamente ($P > 0.05$, prueba-t) del valor medio para hembras de un año de edad que desovaron en agua dulce. En comparación, las hembras de las poblaciones de mayor edad en agua dulce, liberaron un número medio de 961.3 huevos por desove, el cual superaba grandemente a los valores obtenidos por hembras de un año de edad. Sin embargo, cuando estos resultados se expresan como el número de huevos liberados por gramo de peso corporal (promedio estacional), las hembras mayores en edad y más grandes liberaban un número medio de solo 5.2 huevos por gramo de peso corporal, un valor considerablemente menor que el observado en hembras de un año de edad, independientemente de la salinidad. El número medio de huevos liberados por gramos de peso corporal por las hembras de mayor edad fue significantemente ($P < 0.001$, prueba-t) menor a aquellos de las hembras de un año de edad que desovan en salinidades de 5 a 32 ppm.

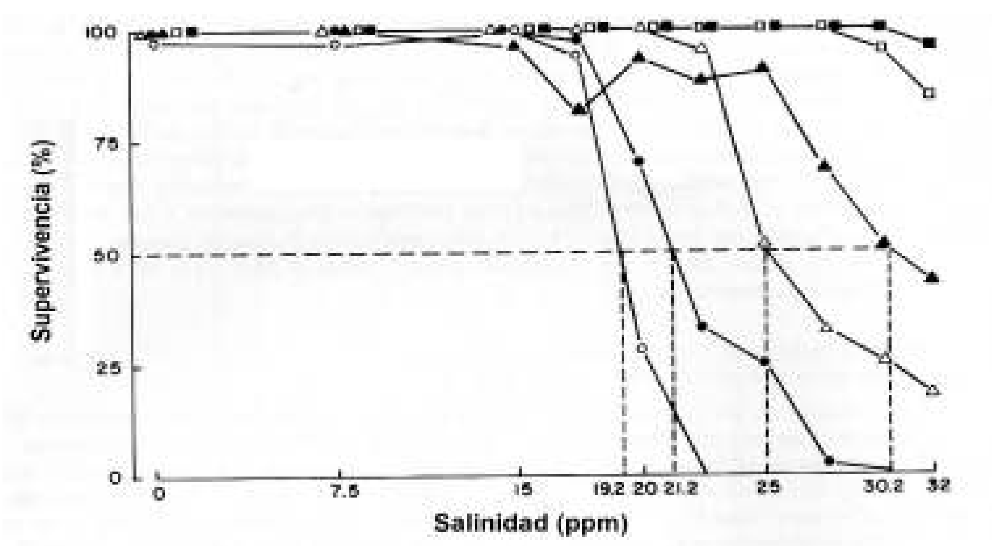


Fig. 3 La supervivencia de los pececillos O. niloticus de siete días de edad desovados en agua dulce y eclosionados en agua salina, 96 horas luego de la transferencia directa de la salinidad de eclosión a varias salinidades. Las salinidades de eclosión fueron: Agua dulce (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲), 20 ppm (□), y 25 ppm (■). Cada punto trazado representa el valor medio de supervivencia para determinaciones repetidas. El número de determinaciones para cada salinidad de eclosión se muestra en l Tabla 2. Los valores de SLM-96 de la Tabla 2 se derivaron de estos patrones generalizados.

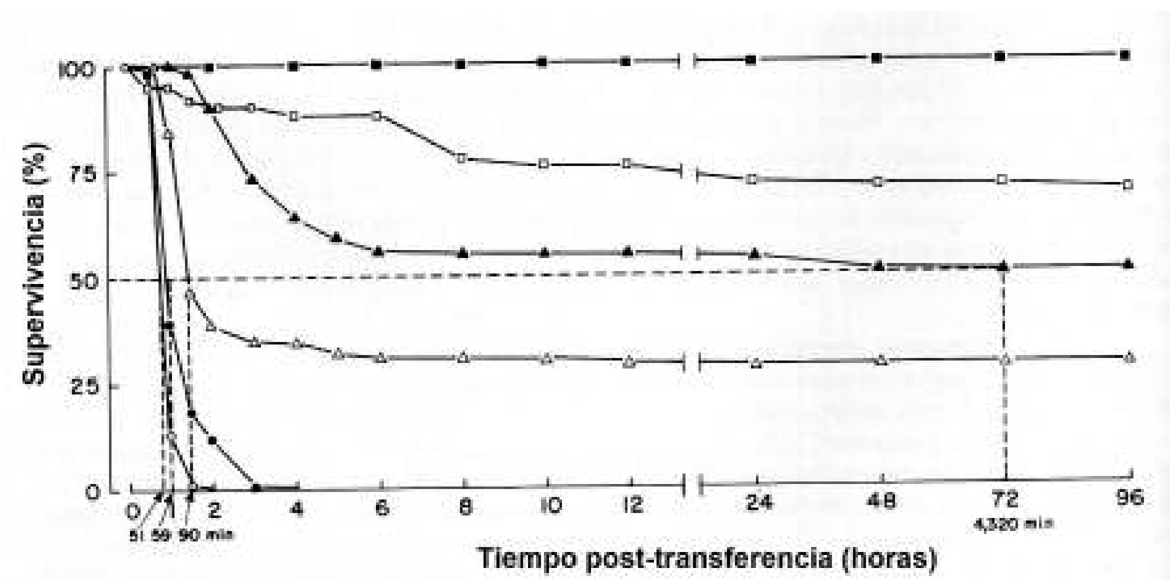


Fig. 4 Supervivencia en función del tiempo para pececillos O. niloticus de siete días de edad desovados en agua dulce y eclosionados en agua salina, luego de la transferencia directa de la salinidad de eclosión a agua de mar (32 ppm). Las salinidades de eclosión fueron: agua dulce (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲), 20 ppm (□), y 25 ppm (■). Cada punto trazado representa el valor medio de supervivencia para determinaciones repetidas. El número de determinaciones para cada salinidad de eclosión se demuestra en la Tabla 2. Los valores de TS50 de la tabla 2 fueron derivados de estos patrones generalizados.

Tabla 3. Desempeño reproductivo de la población reproductora de tilapia del Nilo (*Oreochromis niloticus*) de un año de edad en el acuario de laboratorio en varias salinidades, 30 Mayo- 18 Octubre 1983[a] , y comparación con una población reproductora de mayor edad.

Salinidad en el desove (ppm)	Número de desoves[b]	intérvalo medio entre desoves (días[c])	Número medio de huevos por desove[c]	Longitud del cuerpo media femenina estacional (cm), peso corporal (g)[c]	N° medio de huevos por gramo de peso corporal[c]	Éxito medio de eclosión (%)[d]	Producción total de huevos (por hembra; por gramo de peso corporal)	Producción total de pececillos (por hembra; por gramo de peso corporal)
32	7	31.0 ± 8.5 (16 – 49)	260.1 ± 38.2 (136 – 400)	11.9 ± 0.4 34.3 ± 4.1	9.16 ± 1.4 (6.0 – 12.8)	0.7 ± 0.7 (7) (0 – 5)	1,821 (607; 17.7)	13 (abnormal) (0; 0)
15	20	22.9 ± 2.4 (7 – 40)	180.8 ± 21.8 (11 – 367)	10.3 ± 0.6 18.1 ± 3.3	11.3 ± 1.3 (3.8 – 30.1)	36.9 ± 9.5 (14) (0 – 96)	3,616 (1,205; 66.6)	1,334 (444.7; 24.6)
10	15	17.6 ± 2.2 (10 – 26)	295.9 ± 22.5 (189 – 446)	11.4 ± 0.7 25.4 ± 3.7	11.8 ± 0.5 (9.1 – 13.3)	32.7 ± 10.2 (11) (0 – 99)	4,439 (1,479.7; 58.3)	1,452 (484.0; 19.1)
5	15	18.3 ± 1.9 (11 – 30)	226.9 ± 22.9 (90 – 365)	11.5 ± 0.2 26.7 ± 1.4	8.3 ± 0.9 (4.7 – 14.2)	51.6 ± 8.6 (12) (0 – 93.1)	3,404 (1,134.7; 42.5)	1,757 (585.7; 21.9)
0 Un año de edad	3	–	273.3 ± 70.4 (160 – 394)	11.4 ± 0.8 24.3 ± 1.5	9.6 ± 2.9 (6.6 – 15.3)	30.9 ± 30.9 (3) (0 – 92.8)	820 (273.3; 11.2)	253 (84.3; 3.5)
0 (2-3 yr)	60	19.7 ± 1.3 (13 – 37)	961.3 ± 61.8 (72 – 1490)	21.5 ± 1.3 203.9 ± 19.7	5.2 ± 0.3 (0.6 – 9.2)	64.2 ± 7.3 (35) (0 – 99.9)	57,678 (3,604.9; 17.7)	31,281 (1,953.8; 9.8)

[a]Para la población reproductora de un año de edad, un grupo de 3 hembras y 3 machos se mantuvo en cada salinidad. Para la población reproductora de 2-3 años de edad, un grupo de 18 hembras se mantuvo en un acuario de agua dulce en un radio de 1-3 hembras:1 macho.

[b]El total de desoves observado por grupo, no necesariamente del mismo individuo.

[c] ±E.E.M. medio. Los valores en los paréntesis denotan el rango.

[d]Los datos representan el éxito de eclosión (incluyendo desoves no-fértiles) durante la incubación artificial y se expresan como valores medios ± E.E.M. El rango se da más abajo y el n° de determinaciones se da en paréntesis a la derecha.

Durante la incubación artificial de los huevos de tilapia, desoves no fértiles, caracterizados por la falta de formación de embrión, se observaron en forma ocasional. Para los huevos desovados en condiciones salinas, fue difícil diferenciar entre desoves no fértiles resultantes por la inactividad del macho y aquellos causados por efectos de la salinidad en huevos o calidad del esperma. Por lo tanto, cuando se determinó el éxito de la eclosión medio durante la incubación artificial de huevos desovados en varias salinidades, los desoves no fértiles fueron incluidos (como un 0% de eclosión) en todas las calculaciones. El éxito de incubación extremadamente pobre resultó con huevos desovados en agua de mar (32 ppm). En un ensayo de incubación, unas pocas larvas anormales fueron eclosionadas, todas las cuales murieron poco después de eclosionar. Los éxitos de eclosión media fueron similares para huevos desovados por hembras de un año de edad en agua dulce (30.9%), en 10 ppm (32.7%) y en 15 ppm (36.9%). El éxito de eclosión medio fue considerablemente más alto para huevos desovados en 5 ppm (51.6%) y comparado con el obtenido en huevos desovados por el grupo reproductivo de mayor edad en agua dulce (54.2%). Como el éxito de la eclosión varió desde 0% a más de 90% en cualquier salinidad de eclosión dada hasta los 15 ppm, las diferencias en los éxitos de desove medio entre estas salinidades no fueron estadísticamente significativos ($P>0.05$, prueba-t).

Aunque la producción total de huevos fue más grande en 10 ppm, la producción total de pececillos fue más grande en 5 ppm, debido a la mejora en el éxito de eclosión en 5 ppm. La producción de huevos estacional por hembra fue mucho mayor para individuos reproductores más grandes, mayores en edad y en agua dulce que para individuos reproductores de un año de edad en cualquier salinidad. Sin embargo, la producción estacional de huevos por gramos de peso corporal fue mayor para individuos reproductores de un año de edad en salinidades salobres que para reproductores de mayor edad en agua dulce. La producción estacional de pececillos por gramo de peso corporal también fue mayor para las hembras de un año de edad en salinidades salobres que para hembras de mayor edad en agua dulce. Estos resultados sugieren que el peso total de un pez (más pequeño) hembra de un año de edad en salinidades salobres de hasta 15 ppm producirá un mayor número de huevos y pececillos que hembras más grandes en agua dulce.

Tolerancia a la salinidad de pececillos eclosionados en varias salinidades (pececillos eclosionados en agua salada)

Los pesos, longitudes y factores de condición medios de pececillos de seis a nueve días de nacidos, desovados en varias salinidades están presentes en la tabla 4. Dado que solo una eclosión exitosa fue registrada para las hembras de un año de edad en agua dulce, fue necesario emplear pececillos producidos en agua dulce por hembras de mayor edad como controles en la tabla 4. Tal como lo muestran estos resultados, el peso corporal y la longitud media de las poblaciones desovadas en agua dulce fueron generalmente más altos que los de las poblaciones desovadas en salinidades salobres. El peso y longitud media de las poblaciones de crías desovadas en agua dulce fue significantemente ($P < 0.05$, prueba-t) más grande que los de las poblaciones de crías desovadas en 5 y 10 ppm. En las tilapias, el peso del huevo incrementa con el peso corporal del desovador (Peters 1983). Las diferencias en el peso del huevo se deben principalmente a las diferencias en el contenido de la yema, la cual debería tener un efecto correspondiente en el tamaño de los pececillos que se desarrollan en estos huevos. El tamaño relativamente grande de las poblaciones de crías desovadas en agua dulce, por lo tanto, puede estar relacionado con los tamaños mucho más grandes de los desovadores de donde se originaron. Las diferencias de tamaño entre poblaciones de crías desovadas por hembras de un año de edad en salinidades salobres son difíciles de interpretar, ya que las edades de estas crías varían de seis a nueve días luego de la eclosión. Los factores de condición de poblaciones de crías desovadas en salinidades salobres no difirieron significativamente ($P>0.05$, prueba-t) de los de las poblaciones de crías desovadas en agua dulce.

Los valores correspondientes de TS_{50}, TSP y SLM-96 para estos pececillos de seis a nueve días de edad desovados en varias salinidades también se presentan en la tabla 4. Los valores de TS_{50} y SLM-96 fueron derivados de patrones generalizados de supervivencia, tal como se describió anteriormente. La figura 5 ilustra los patrones de supervivencia generalizada para los pececillos de seis a nueve días de edad desovados en agua salina 96 horas después de la transferencia directa de la salinidad de desove a varias salinidades. El SLM-96 incrementó para poblaciones de crías desovadas en agua dulce, de 19.2 ppm a más de 32 ppm para poblaciones de crías desovadas en 15 ppm. Los patrones de estos cambios son muy similares a los descritos anteriormente en relación con los desoves en agua dulce, y los pececillos eclosionados en agua salina (Figura 3). Tal como lo muestra la figura 5, el SLM-96 creciente con la salinidad de desove creciente también están relacionados con la elevación en la salinidad de la mortalidad incipiente y un incremento en el intérvalo de salinidad entre la mortalidad incipiente y la final. En general, un incremento en la salinidad de desove de 5 ppm elevó la salinidad de la mortalidad incipiente por un 2.5 a 7.5 ppm.

Los patrones de supervivencia generalizados para poblaciones de crías desovadas o eclosionadas en salinidades idénticas se comparan en las figuras 6a, 6b y 6c para las salinidades de 5, 10 y 15 ppm, respectivamente.

Tabla 4. El tiempo medio de supervivencia (TS_{50}), el tiempo de supervivencia promedio (TSP), y la salinidad letal mediana (SLM-55) de los pececillos O. niloticus de 8-9 días de edad desovados en varias salinidades

Salinidad de desove (ppm)	Peso corporal (mg)[a]	Longitud del cuerpo (mm)[a]	Factor de condición[a]	TS_{50} (min)[b]	TSP (min)[a]	SLM-55 (ppm)[b]	Rango de temperatura de ensayo (°C)
0	7.8 ± 0.4 (8)	5.8 ± 0.2 (8)	1.13 ± 0.05 (8)	51.0 (8) 29.0 – 72.0	51.1 ± 5.3 (8) 29.9 – 73.4	19.2 (6) 16.5 – 22.0	25.5 – 2
5	5.2 ± 0.3 (8)	6.1 ± 0.1 (8)	0.99 ± 0.05 (8)	600.0 (6) 131 – 780	930.2 ± 270.4 (8) 143.6 – 1,765.4	28.1 (4) 27 – 30.4	27.4 – 3
10	5.6 ± 0.3 (7)	6.1 ± 0.1 (7)	1.27 ± 0.03 (7)	360.0 (7) 53.0 – >5,760	2,215.2 ± 639.4 (7) 55.0 – 5,045.5	≥32 (4)	27.0 – 2
15	5.9 ± 1.3 (8)	6.3 ± 0.3 (8)	0.92 ± 0.26 (8)	>5,760 (6)	5,326.4 ± 199.6 (8) 4,702.6 – 5,760	>32 (1)	27.0 – 3

[a] ± E.E.M medio (nº de determinaciones). Los rangos de valores se presentan para el TSM.

[b] Derivado de las curvas generalizadas de supervivencia como se describieron en el texto. El rango de valores está debajo de los valores medios; nº de determinaciones en paréntesis.

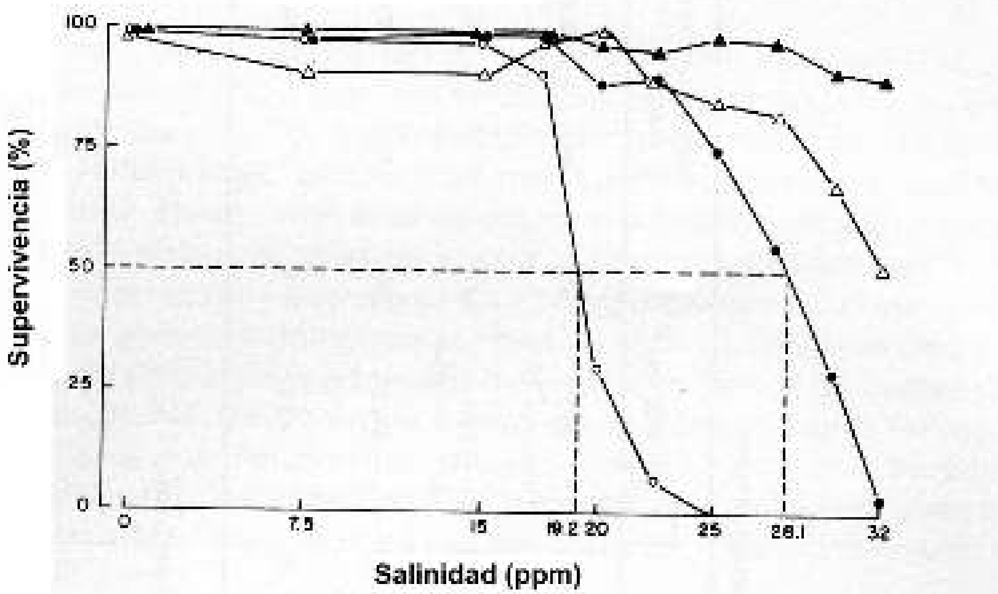


Fig. 5 Supervivencia de pececillos O. niloticus de 6-9 días de edad desovados en agua salina, 96 horas luego de la transferencia directa de la salinidad de desove a varias salinidades. Las salinidades de desove fueron: agua dulce (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲). Cada punto trazado representa el valor medio de supervivencia para determinaciones repetidas. El número de determinaciones para cada salinidad de desove se muestra en la tabla 4. Los valores de SLM-96 de la tabla 4 fueron derivados de estos patrones generalizados.

Así como lo muestran estos resultados, en una salinidad idéntica de desove o eclosión, los pececillos desovados en agua salina mostraron valores SLM-96 más altos que los pececillos desovados en agua dulce y eclosionados en agua salina.

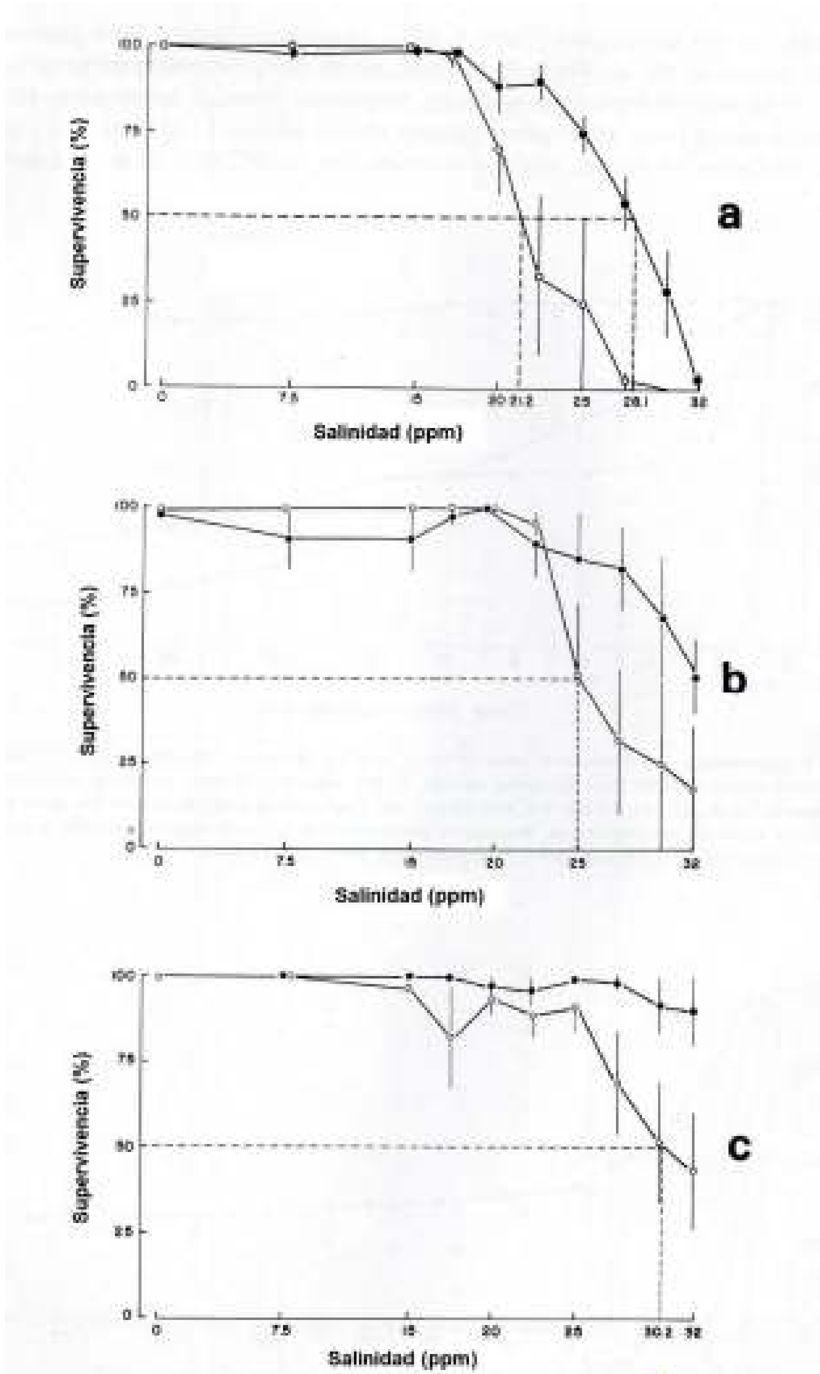
Estos patrones también sugieren que el intervalo entre mortalidad incipiente y mortalidad final pueden ser expandidos a un grado relativamente mayor, incrementando la salinidad de desove y no incrementando la salinidad de eclosión. Desde la variabilidad estadística de los datos ilustrados en las figuras 6a, 6b y 6c, es evidente que los descendientes desovados en agua salina generalmente mostraban valores de supervivencia más consistentes entre poblaciones de crías que los descendientes eclosionados en agua salina y desovados en agua dulce.

La figura 7 ilustra los patrones de supervivencia generalizados como función del tiempo para seis a nueve días de edad de pececillos desovados en agua salina, luego de la transferencia directa desde la salinidad de desove a agua de mar (32 ppm). Tal como lo muestra la figura 7, la TS_{50} aumentó de un 50.9 min, para poblaciones de crías desovadas en agua dulce, a más de 5,760 min para poblaciones de crías desovadas en 15 ppm. Inesperadamente, las poblaciones de crías desovadas en 5 ppm tuvieron un TS_{50} más alto que las desovadas en 10 ppm. Sin embargo, la supervivencia media a las 96 horas fue más alta en poblaciones de crías desovadas en 10 ppm.

Tolerancia a la salinidad de pececillos desovados y eclosionados en agua dulce, aclimatados en varias salinidades (pececillos desovados en agua dulce, eclosionados en agua dulce y aclimatados en agua salina)

Los pesos corporales, longitudes y factores de condición medios de los pececillos *O. niloticus* de 11 a 18 días de edad desovados y eclosionados en agua dulce, pero aclimatados por siete a ocho días en varias salinidades se presentan en la tabla 5. Todas las poblaciones de crías mantenidas en agua dulce tenían 15 días de edad, mientras que las aclimatadas en salinidades de 5 a 15 ppm oscilaban entre los 11 y 18 días de vida. Dado que estos pececillos eran mayores en edad, eran más grandes que los desovados en agua dulce, los pececillos eclosionados en agua salina (de siete días de edad) o los pececillos desovados en agua salina (de seis a nueve días de edad), cuyas tolerancias a la salinidad fueron descritas anteriormente. Los valores de TS_{50} y TSP para estos pececillos de 11 a 18 días de edad, desovados y eclosionados en agua dulce, pero aclimatados a varias salinidades,

Fig. 6



Comparación de la supervivencia entre pececillos O. niloticus desovados en agua dulce, eclosionados en agua salina (○) y desovados en agua salina (•), 96 horas luego de la transferencia directa desde una salinidad idéntica de desove o eclosión, respectivamente, a varias salinidades. Los patrones de supervivencia se comparan para salinidades de eclosión y desove de 5 ppm en la figura 6ª, 10 ppm en la figura 6b y 15 ppm en la figura 6c. Cada punto trazado representa el valor medio de supervivencia para tres a cuatro determinaciones. Las barras verticales representan el ± E.E.M. La ausencia de barras verticales indica que el E.E.M se encuentra dentro del área de los puntos trazados.

también son presentados en la tabla 5. Los valores de TS_{50} fueron derivados de los patrones de supervivencia generalizados, tal como se describió anteriormente. La figura 8 ilustra los patrones de supervivencia generalizados en función del tiempo para los pececillos desovados en agua dulce de 11 a 18 días de edad, eclosionados en agua dulce, aclimatados en agua salina luego de la transferencia directa de la salinidad de aclimatación a agua de mar (32 ppm). El TS_{50} incrementó progresivamente de 29.0 min para crías conservadas en agua dulce, a 270 min para poblaciones de crías aclimatadas en 15 ppm.

Los patrones de supervivencia generalizados para crías desovadas, eclosionadas o aclimatadas en salinidades idénticas se comparan en las figuras 9a, 9b, y 9c, para salinidades de 5, 10 y 15 ppm, respectivamente. Tal como lo muestra la figura 9a, la supervivencia fue similar para las crías aclimatadas o eclosionadas en 5 ppm. En ambos grupos, la transferencia directa al agua de mar resultó en la mortalidad completa en cuatro horas. La supervivencia de poblaciones de crías desovadas en 5 ppm fue claramente diferente con una mayor mortalidad gradual y una supervivencia media de 12.3% en las 96 horas después de la transferencia. En una salinidad de 10 ppm, las diferencias en la supervivencia entre los grupos se hicieron más visibles (Figura 9b). Mientras que la transferencia directa de crías aclimatadas en agua salina a agua de mar resultó en la mortalidad completa dentro de ocho horas, una supervivencia media de aproximadamente 28% fue registrada en ambas (en las crías eclosionadas en agua salina y en las desovadas en agua salina 96 horas luego de la transferencia). En una salinidad de 15 ppm, la supervivencia fue considerablemente mejorada en todos los grupos (Figura 9c). Los valores de supervivencia medios de 30.5, 51.3 y 89.9% se registraron para las crías aclimatadas, eclosionadas y desovadas en agua salina, respectivamente, 96 horas luego de la transferencia directa a agua de mar.

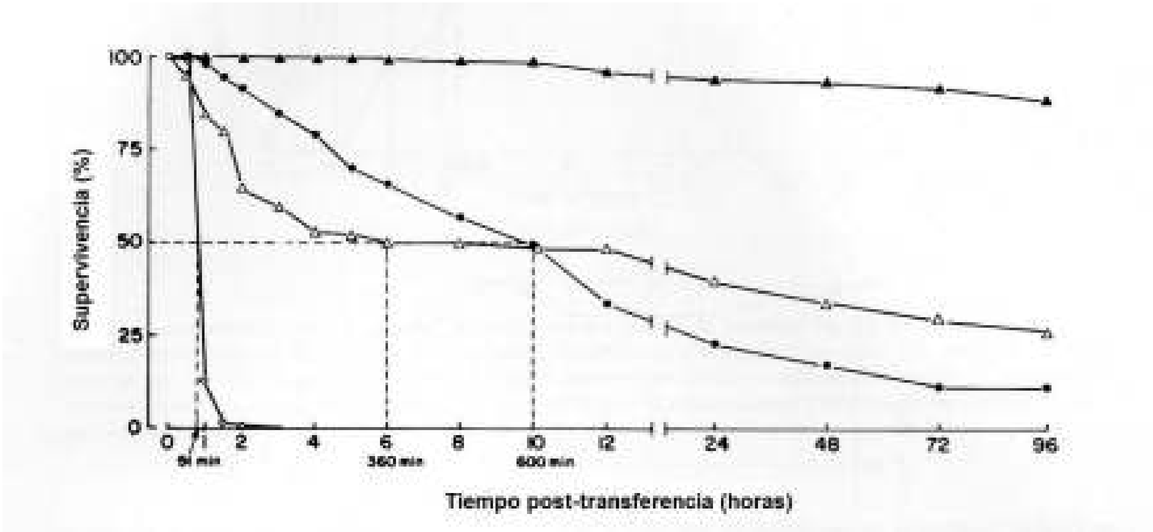


Fig. 7 Supervivencia en función del tiempo para pececillos O. niloticus de 6-9 días de edad desovados en agua salina, luego de la transferencia directa de la salinidad de desove a agua de mar (32 ppm). Las salinidades de desove fueron: agua dulce (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲). Cada punto trazado representa el valor de supervivencia medio para determinaciones repetidas. El número de determinaciones para cada salinidad de desove se muestra en la tabla 4. Los valores de TS_{50} *de la tabla 4 se derivaron de estos patrones generalizados.*

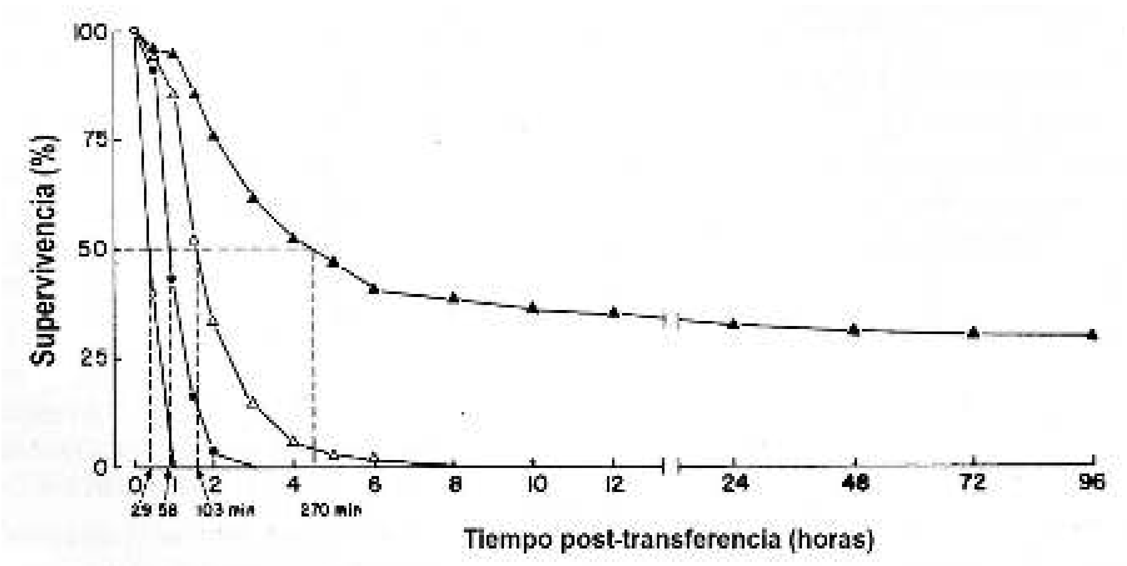


Fig. 8 Supervivencia en función del tiempo para pececillos O. niloticus de 11-18 días de edad desovados en agua dulce, eclosionados en agua dulce, aclimatados en agua salina, luego de la transferencia directa de la salinidad de aclimatación a agua de mar (32 ppm). Las salinidades de aclimatación fueron: (○), 5 ppm (•), 10 ppm (Δ), 15 ppm (▲). Cada punto trazado representa el valor medio de supervivencia para determinaciones repetidas. El número de determinaciones para cada salinidad de aclimatación se muestra en la tabla 5. Los valores de TS_{50} *de la tabla 5 se derivaron de estos patrones generalizados.*

Tabla 5. Tiempo medio de supervivencia (TS_{50}) y tiempo de supervivencia promedio (TSP) de pececillos O. niloticus de 11-13 días de edad desovados en agua dulce y eclosionados en agua dulce, luego de la aclimatación a varias salinidades

Salinidad de aclimatación (ppm)	Peso corporal (mg)[a]	Longitud del cuerpo (mm)[a]	Factores de condición[a]	TS_{50} (min)[b]	TSP (min)[a]	Rangos de temperatura de ensayo (°C)
0	12.2 ± 1.2 (4)	10.6 ± 0.2 (4)	1.08 ± 0.04 (4)	29.0 (4) 24.0 – 32.0	29.3 ± 1.9 (4) 26.2 – 34.0	25.8 – 30.2
5	11.5 ± 1.3 (6)	9.1 ± 0.2 (6)	1.51 ± 0.06 (6)	58.0 (6) 41.0 – 81.0	62.1 ± 15.3 (6) 41.6 – 83.6	27.0 – 28.0
10	11.4 ± 0.8 (6)	9.3 ± 0.1 (6)	1.42 ± 0.05 (6)	103.0 (6) 84.0 – 165.0	116.0 ± 47.6 (6) 72.2 – 165.4	27.5 – 28.0
15	12.3 ± 0.7 (6)	9.7 ± 0.2 (6)	1.32 ± 0.02 (6)	270.0 (6) 155.0 – >5,760	1,966.4 ± 1,608.0 (6) 430.2 – 4,319.3	27.2 – 28.0

[a] ± E.E.M. medio (nº de determinaciones). Los rangos de valores de TSP son presentados.

[b] Derivado de los patrones de supervivencia generalizados. El rango de valores se da debajo de los valores medios; nº de determinaciones en paréntesis.

La figura 10 compara la relación entre la tolerancia a la salinidad (TSP) y la salinidad de desove, salinidad de eclosión y salinidad de aclimatación para los pececillos desovados en agua salina, los pececillos desovados en agua dulce, los pececillos eclosionados en agua salina y los desovados en agua dulce, pececillos eclosionados en agua dulce y aclimatados en agua salina, respectivamente. El TSP no aumentó linealmente con el incremento de desove, eclosión o salinidad de aclimatación. La relación entre el TSP y la salinidad de desove es muy similar a la relación entre el TSP y la salinidad de eclosión. La tasa de aumento en el TSP con la salinidad de aclimatación fue comparativamente más baja. En estas relaciones es evidente que a una salinidad equivalente, la exposición temprana (desove) produjo descendientes con una tolerancia a la salinidad comparativamente más alta que aquellos desovados en agua dulce y eclosionados en salinidades elevadas. Similarmente, en una salinidad equivalente, los descendientes desovados en agua dulce pero eclosionados en una salinidad elevada, mostraron una tolerancia mayor a la salinidad que los desovados y eclosionados en agua dulce y luego aclimatados a una salinidad elevada. Los descendientes desovados en agua salina generalmente mostraron valores de TSP más consistentes entre las crías que los descendientes eclosionados en agua salina. Los valores de TSP para crías eclosionadas en agua salina fueron significativamente ($P < 0.05$, prueba-t) más altos que los de las crías eclosionadas en agua salina de 5 ppm y las crías aclimatadas en agua salina en 5, 10 y 15 ppm. Los valores de TSP medios para crías eclosionadas en agua salina y aclimatadas en agua salina no fueron significativamente diferentes en ninguna salinidad.

Discusión General y Conclusiones

La ontogenia de la tolerancia a la salinidad en *O. niloticus* desovados y criados en agua dulce de 7 a 396 días luego de la eclosión se describió en un reporte anterior (Watanabe et al.

1984). La tolerancia a la salinidad de esta especie durante el primer periodo embrionario de desarrollo se determinó en el presente estudio. El valor de SLM-96 de 18.9 ppm se derivó del patrón de supervivencia generalizado de los huevos desovados en agua dulce e incubados artificialmente en varias salinidades, el valor equivalente al encontrado anteriormente para caracterizar crías de 7 a 120 días después de la eclosión. Por consiguiente, la tolerancia a la sal característica en los *O. niloticus* es evidente durante las etapas iniciales de su ontogenia.

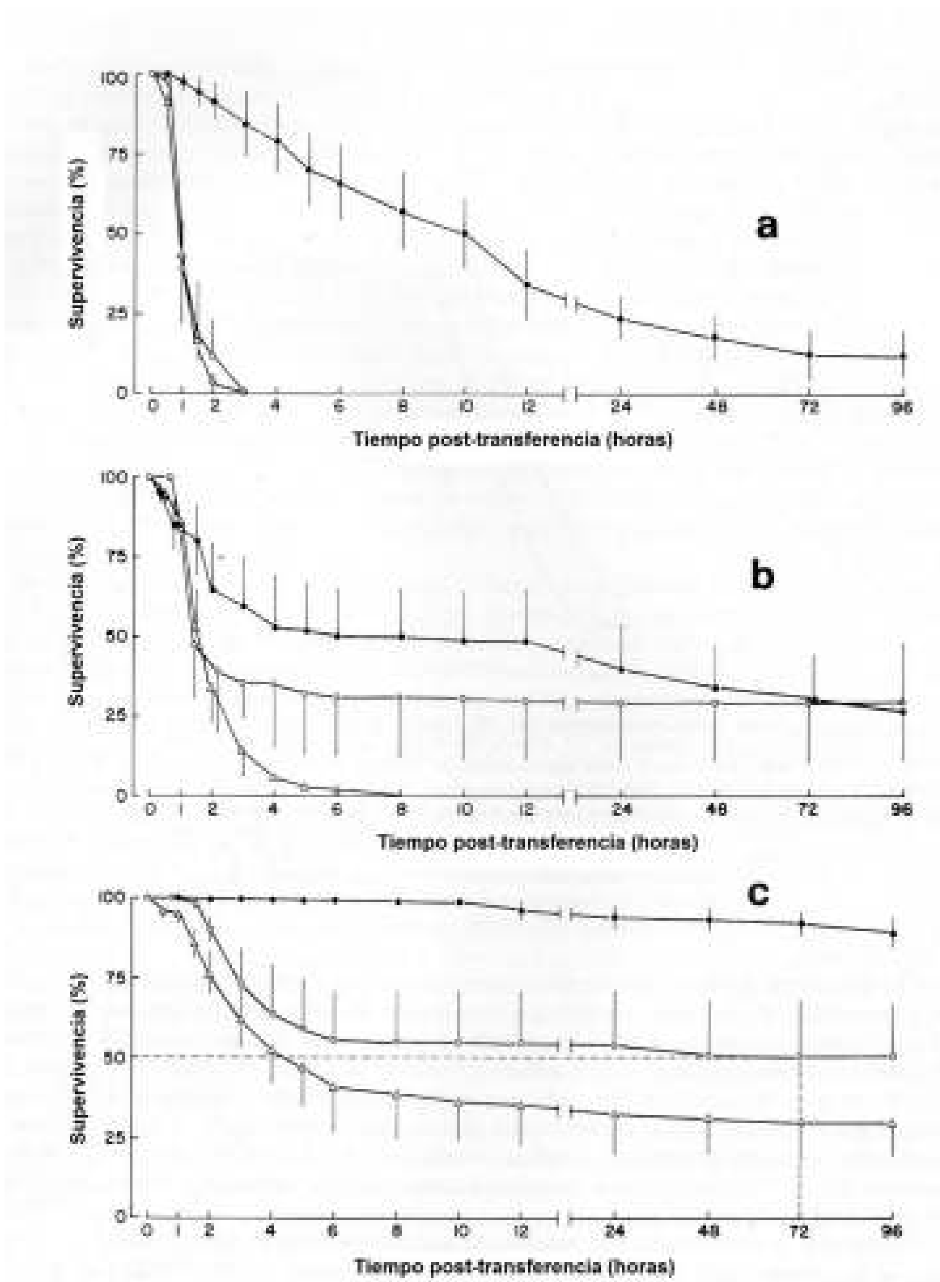
La habilidad de los huevos fertilizados de ciertos teleósteos para desarrollarse en una amplia gama de salinidades ha sido descrita previamente. En la solla, *Pleuronectes platessa,* esta habilidad fue atribuida a la actividad osmorreguladora de la membrana vitelina, la cual es capaz de regular la concentración osmótica de la yema desde el momento de la fertilización (Holliday y Jones, 1967). En el arenque, *Clupea harengus,* esta habilidad estuvo presente solo luego de la finalización de la gastrulación y se le atribuye a la actividad osmorreguladora de las células embrionarias ectodérmicas, en vez de a la membrana vitelina (Holliday y Jones, 1965).

A partir del patrón de supervivencia generalizado como función del tiempo de los huevos de *O. niloticus* desovados en agua dulce transferidos directamente a agua de mar (32 ppm), se derivó un tiempo de supervivencia medio (TS_{50}) de 978 min, el cual es un valor mucho mayor que los encontrados para caracterizar los pececillos y los alevines *O. niloticus* de 7 a 395 días de edad, los cuales oscilan de 28.8 a 179 min. El valor relativamente alto de TS_{50} mostrado por los embriones refleja su habilidad para sobrevivir a la transferencia directa a agua de mar por periodos más largos que los pececillos o los alevines, a pesar de que se observó una mortalidad completa a las 96 horas después de la transferencia para ambos, los embriones y los pececillos o alevines. Weisbart (1968) encontró que la presencia del corión impartido incrementó la resistencia a la salinidad en embriones de salmón del pacifico (*Oncorhynchus spp.*). Él no pudo atribuir este incremento en la resistencia a la impermeabilidad del corion, ya que el fluido perivitelino de los huevos inmersos por cuatro horas o más en agua de mar de 31.8 ppm fue ligeramente hiperosmótico al medio externo. Sin embargo, los embriones disecados mostraron una disminución en los tiempos de supervivencia en agua de mar. Los valores altos de TS_{50} mostrados por los embriones *O. niloticus* en el estudio presente pueden estar relacionados similarmente a la presencia del corion.

La membrana vitelina también puede funcionar para proteger el embrión contra cambios osmóticos a través de la impermeabilidad o la actividad osmorreguladora (Hempel, 1979). Sin embargo, la mortalidad diferencial durante la incubación en varias salinidades antes de la eclosión descarta la posibilidad de la impermeabilidad de la membrana vitelina. Los resultados son más consistentes con la posibilidad de que la membrana vitelina le proporciona protección al embrión a través de la actividad osmorreguladora, la cual se vuelve ineficaz en salinidades altas. Esos valores de TS_{50} se reducen sustancialmente luego de la eclosión, además, sugieren que la alta tolerancia a la salinidad mostrada por los embriones se relaciona con la presencia de membranas en los huevos, en vez de a la actividad osmorreguladora de las células embrionarias ectodérmicas como fue postulado para el arenque (Holliday y Jones, 1965).

No obstante, la gran diferencia en los valores de TS_{50} mostrados por los embriones y los pececillos o los alevines deben ser interpretados con cautela, pues los embriones que sobrevivieron periodos largos en el agua de mar mostraron anormalidades estructurales,

Fig. 9



Comparación de la supervivencia en función del tiempo entre pececillos O. niloticus desovados en agua salina (•), desovados en agua dulce (○), y pececillos desovados en agua dulce, eclosionados en agua dulce y aclimatados en agua salina (Δ), luego de la transferencia directa de salinidades idénticas, salinidad de eclosión o aclimatación, respectivamente, a agua de mar (32 ppm). Los patrones de supervivencia se comparan para la eclosión, el desove, o salinidades de aclimatación de 5 ppm en la fig. 9[a]*, 10 ppm en la fig. 9b, y 15 ppm en la fig. 9c. Cada punto trazado representa el valor medio para cinto a siete determinaciones. Las barras verticales representan el ± E.E.M. La ausencia de barras verticales indica que el E.E.M. se encuentra dentro de área del punto trazado.*

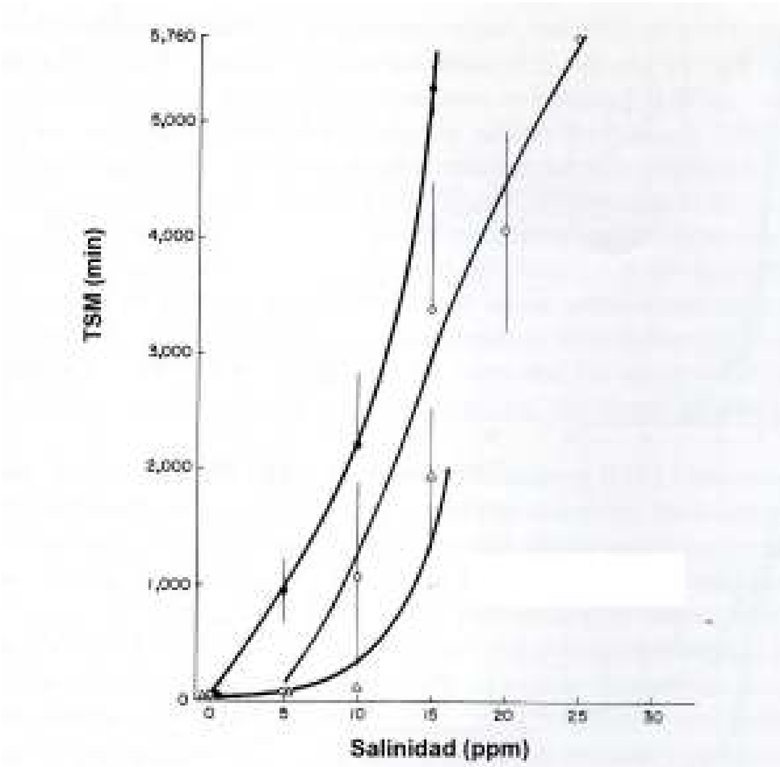


Fig. 10 Tolerancia a la salinidad (TSP) de los pececillos O. niloticus en función a la salinidad de desove (pececillos desovados en agua salina) (•), salinidad de eclosión (pececillo desovados en agua dulce, eclosionados en agua salina) (○), o la salinidad de aclimatación (pececillos desovados en agua dulce, eclosionados en agua dulce, aclimatados en agua salina) (Δ). Los puntos trazados representan los valores medios de la tabla 4, 2 y 5, respectivamente. Las barras verticales representan el ± E.E.M. La ausencia de barras verticales indica que el E.E.M. se encuentra dentro de área del punto trazado. El análisis de regresión produjo las siguientes relaciones: pececillos desovados en agua salina, $Y = 51.10 + 253.02X + 2.04X^3$; $R^2 = 1.00$; pececillos desovados en agua dulce, eclosionados en agua salina; $Y = 3.90 – 98.90X + 29.15X^2 – 0.65X^3$; $R^2 = 0.98$; pececillos desovados en agua dulce, eclosionados en agua dulce, aclimatados en agua salina, $InY = 2.68 + 0.31X$; $R^2 = 0.86$.

generalmente caracterizadas por un subdesarrollo de los órganos. Holiday (1969) resumió las descripciones del desarrollo de las anormalidades resultantes de los efectos de la salinidad durante la incubación del huevo. Sin embargo, es notable que los huevos desovados en agua dulce pueden ser incubados y exitosamente eclosionados en salinidades tan altas como 25 ppm; mientras que los pececillos o los alevines de 7 a 395 días de edad no son capaces de sobrevivir la transferencia directa a esta salinidad. Estos resultados pueden reflejar un nivel relativamente mayor de adaptabilidad de los embriones prematuros a la salinidad del ambiente, que el nivel de los pececillos o los alevines. Kinne (1962) propuso que en el "desert pupfish" (*Cyprinodon macularius*) la capacidad e intensidad de las adaptaciones no genéticas a la salinidad ambiental pueden ser máximas durante el desarrollo prematuro ontogénico. En su reseña sobre los efectos de la salinidad en los huevos y larvas de teleósteos, Holliday (1969) similarmente expresó sorpresa en los reportes (Oliphan 1940, 1941) de la eclosión exitosa de varias especies desovadas en agua dulce en salinidades tan altas como 20 ppm.

Ninguna relación consistente fue observada entre la salinidad de incubación y el tiempo de eclosión. Sin embargo, es conocido que los efectos de salinidad en la tasa de desarrollo de los huevos de teleósteos pueden ser profundamente modificados por muchos factores incluyendo la temperatura, el oxígeno disuelto y el genotipo de peces padre (Holliday, 1969). La interacción de estos factores puede haber confundido cualquier efecto relacionado con la salinidad en el tiempo de eclosión en el estudio presente.

Los pesos corporales, longitudes medios y factores de condición de los pececillos de siete días de edad desovados en agua dulce y eclosionados en varias salinidades no fueron significativamente diferentes de los de los pececillos eclosionados en agua dulce. Forrester y Alderice (1966) sugirieron que en el "pacific cod" (*Gadus macrocephalus*), el tamaño máximo de larvas fue asociado con estas condiciones de salinidad y temperatura, produciendo así una supervivencia máxima a la hora de eclosionar. A los 5 a 7º C el tamaño y supervivencia máximo de las larvas se lograron en salinidades asociadas con menor estrés osmótico. Por lo tanto, se dedujo que las condiciones ambientales que permitieron la distribución máxima de energía para el crecimiento, mientras cumplía con requisitos para el mantenimiento y la actividad física, deberían maximizar la supervivencia y el tamaño de las larvas en un periodo mínimo de incubación (Aldderice y Forester, 1968). La falta de diferencias en el tamaño significativo de las larvas eclosionadas en varias salinidades a pesar de la mortalidad diferencial en estas salinidades es difícil de explicar sobre esta base.

En el presente estudio, la tolerancia a la salinidad fue determinada en pececillos sometidos a varios tipos de exposición prematura a la salinidad. Se observó un incremento progresivo en la tolerancia a la salinidad con un incremento en la exposición a la salinidad. Rao (1975) informó que la tolerancia a la salinidad de larvas recién eclosionadas de la sardina chococo (*Fundulus parvipinnis*) fue influida por la salinidad de incubación; las larvas eclosionadas en salinidades de incubación bajas mostraron mayor tolerancia al agua dulce que las eclosionadas en salinidades más altas. Contrariamente, la tolerancia de las larvas recién eclosionadas a 70 ppm incrementó con la salinidad de incubación. Similarmente, Pfeiler (1981) observó en los macabí (*Albula vulpes*) jóvenes que el incremento en la salinidad de adaptación aumentó la salinidad letal incipiente superior (definida como la salinidad en la cual teóricamente 50% de la población puede sobrevivir indefinidamente). Que dicha exposición a salinidades bajas puede no necesariamente resultar en una mayor tolerancia a la salinidad, se sugiere por medio de la observación de los alevines de salmón del pacífico (*Oncorhynchus spp.*), expuestos a 10 ppm por dos días seguidos, luego por 20 ppm por dos días subsiguientes, lo cual produjo tiempos de supervivencia medios después de la transferencia a agua de mar, los cuales fueron iguales que los de los alevines transferidos directamente de agua dulce a agua de mar de 31.8 ppm (Weisbart, 1968).

La exposición a agua de mar diluida puede minimizar las variaciones osmóticas asociadas con la transferencia directa a agua de mar. Por ejemplo, Iwata et al. (1982)

encontraron que la preaclimatación de los pececillos de salmón chum (*oncorhynchus keta*) a una salinidad de 12 ppm por 12 horas resultó en un incremento gradual en el sodio plasmático en los niveles de aclimatación de agua de mar. La exposición subsecuente a agua de mar (36 ppm) no causó un cambio significativo en el nivel de sodio de plasma. Similarmente, Boeuf y Harache (1982) observaron que la preadaptación del salmón coho (*Oncorhynchus kisutch*) a 25 ppm por tres semanas suprimió la larga fluctuación en fluidos corporales internos observados durante la transferencia directa a agua de mar (36 ppm).

De acuerdo con Bashamohideen y Parvatheswararao (1972), la aclimatación previa de *O. mossambicus* a agua de mar de 75% facilitó la aclimatación a agua de mar al 100%, de modo que había menos trabajo osmótico y, por lo tanto, menos energía gastada en agua de mar del 100%. Esto se mostró en una tasa más baja del uso de la glucosa.

La información sobre la reproducción de tilapias en relación con la salinidad ambiental es escasa. Los rangos generales de salinidades sobre los que varias especies son conocidas por reproducirse han sido resumidos por Wohlfarth y Hulata (1983). La tilapia del Nilo (*O. niloticus*) junto con el *T.zillii* y el *S.galilaeus* se reportaron para la reproducción en salinidades de 13.5 a 29 ppm en el Gran Lago Amargo de Egipto (El Saby 1951, in Kirk 1972). Sin embargo, en el lago Qarun, un antiguo lago de agua dulce, el cual se convirtió progresivamente en más salino, solo el *T. zillii* continuó persistiendo a los 29 ppm, luego de que otras especies incluyendo el *O. niloticus* y el *S.galilaeus* hubiesen desaparecido (El Zarka, 1956, in Kirk, 1972).

Chervinski (1961) observó el desove de los *O. niloticus* en agua de mar de 50% (19 ppm) durante experimentos de crecimiento en tanques de concreto. Del corto número de jóvenes nacidos, él dedujo que relativamente menos jóvenes son nacidos en agua salobre que en agua dulce. Resultados similares habían sido reportados anteriormente para los *O. mossambicus,* los cuales produjeron considerablemente menos desoves a los 36.2 ppm que en agua dulce (Zaneveld, 1958, in Chervinski, 1961). Chervinski y Yashouv (1971) notaron que durante los experimentos de crecimiento del *O. aureus* en estanques de agua de mar, no hubo reproducción, ni construcción de nidos, además de una caída en el índice gonadosomático, el cual ellos sugirieron ocurrió debido a una reabsorción de los huevos.

La evidencia experimental sobre el rendimiento reproductivo de las tilapias en varias salinidades es insuficiente. En el presente estudio, el rendimiento reproductivo de *O. niloticus* de un año de edad fue monitoreado bajo condiciones de laboratorio en varias salinidades. También se observó un efecto inhibidor de salinidad alta en la reproducción. En general, hubo una tendencia en los intervalos entre desoves para alargar las salinidades más altas, lo cual resultó en considerablemente menos desoves en agua de mar que en agua salobre. Sin embargo, estos resultados deben ser interpretados con cierta precaución, pues la reabsorción de desoves maduros es un fenómeno común en las tilapias y el número de desoves completados puede no necesariamente indicar el número de desoves realmente elaborados por un pez específico (Peters, 1983). Un resultado aparentemente anómalo fue que el total de desoves llegó a ser el más bajo entre hembras de un año de edad en agua dulce. En las tilapias, se piensa que la madurez precoz en tamaños pequeños es una respuesta común a condiciones ambientales inestables o estresantes (Payne, 1983). Por lo tanto, la mayor actividad de desove en agua salobre y de mar puede haber sido relacionada con el historial de exposición a la salinidad de estos individuos. Alternativamente, el desove poco frecuente en agua dulce puede haber resultado de una mayor reabsorción de desoves maduros por razones que son por ahora inciertas. No se pueden sacar conclusiones firmes con base en los datos disponibles.

Los éxitos en la eclosión fueron comparables para las hembras de un año de edad en 5 ppm y para hembras de mayor edad en agua dulce. Sin embargo, el efecto inhibidor de la salinidad alta en la reproducción fue demostrado por considerablemente menores éxitos en eclosión a los 10 y 15 ppm. No se pudo lograr una eclosión exitosa en agua de mar. Por lo tanto, no se produjeron pececillos en agua de mar a pesar del hecho que los huevos continuaban siendo producidos y desovados en esta salinidad. La crianza en salinidades altas ha sido sugerida como una forma para prevenir las sobrepoblaciones en estanques, sin la necesidad de separación sexual (Chervinski y Yashouv, 1971). Los resultados presentes muestran que a pesar de que los *O. niloticus* fallaron en reproducirse en agua de mar, la energía fue, sin embargo, canalizada en la producción de huevos de hembras de tamaños pequeños. Por consiguiente, la crianza de machos a través de la separación sexual, la inversión de sexo y la hibridación son todavía técnicas apropiadas para maximizar las tasas de crecimiento en salinidades altas.

En un estudio detallado sobre el desarrollo del huevo en tilapias, Peters observó que el número de huevos liberados por desove incrementó con el peso corporal en el reproductor de sustrato *T. tholloni,* así como en las especies incubadoras bucales *O. mossambicus, S. melanotheron* y *S. galilaeus.* Sin embargo, los resultados revelaron, sin embargo, que las curvas relacionadas a un incremento en el número de huevos desovados con el aumento del peso corporal tendían a convertirse en planas cuando los pesos corporales alcanzaban valores altos, lo cual indicaba que las hembras grandes liberaban relativamente menos huevos por unidad de peso en cada desove. Payne y Collinson (1983) similarmente reportaron que en ambos *O. aureus* y *O. niloticus,* las hembras más pequeñas produjeron más huevos por unidad de peso corporal. Dado que las condiciones ambientas adversas estimulan la madurez temprana en tilapias de menor tamaño, la fecundidad relativamente mayor en peces de menor tamaño mejora las oportunidades de supervivencia bajo estas condiciones (Payne y Collison, 1983). Los resultados presentes claramente muestran que las hembras *O. niloticus* pequeñas, de un año de edad liberan menos huevos en cada desove que las hembras de mayor edad y más grandes. Sin embargo, de acuerdo con los resultados de estudios previos, las hembras más grandes liberaban menos huevos por unidad de peso que las hembras de un año de edad independientemente de la salinidad de desove.

Puesto que los individuos más pequeños son más fértiles por unidad de peso que los más grandes, es importante para el piscicultor intentar maximizar la productividad de la población reproductiva para determinar el tamaño máximo por el cual la producción de huevos por unidad de peso comienza a disminuir. Sin embargo, la mayor producción de huevos por unidad de peso tiene poco uso práctico, si los desoves son menos frecuentes o si los éxitos en la eclosión son relativamente pocos. Los resultados del presente estudio indican que la producción de huevos y pececillos estacional por unidad de peso fue mayor entre las hembras de un año de edad que desovaron en salinidades salobres de 5 a 15 ppm que en hembras más grandes que desovaron en agua dulce. Por lo tanto, la producción estacional de pececillos se esperaría que fuera mayor para las hembras de menor tamaño por un peso total en ellas, incluso en condiciones de agua salobre.

Kinne (1962) en sus experimentos con el teleósteo eurihalino, *Cyprinodon macularius,* demostró que la eclosión en los peces eclosionados de huevos restantes en la salinidad de desove mostraron mayor eficiencia de conservación de alimentos que aquellos transferidos entre las tres y seis horas después de la fertilización, a otra salinidad dentro de su rango de tolerancia ecológica. Por ejemplo, en una temperatura de crianza de 30Cº, los peces desovados y criados en agua de mar (35 ppm) mostraron mejor eficiencia de conversión que los de la misma población eclosionados y criados en agua dulce. De igual manera, los peces desovados y criados en agua dulce mostraron mejor eficiencia de conversión que los de la misma población eclosionados y criados en agua de mar. Sin embargo, los resultados sugieren que si la crianza se realizará en una salinidad fuera del rango óptimo de crecimiento para las especies, entonces el crecimiento máximo y la eficiencia de conservación de alimentos pueden lograrse mediante el desove en la misma salinidad. Kinne concluyó que el ambiente osmótico al que los huevos fueron expuestos entre tres a seis horas luego que el desove induce ajustes, los cuales persisten durante las vidas de los peces eclosionados de estos huevos y estos ajustes son adaptaciones no genéticas de los organismos a la salinidad del ambiente, los cuales no son transmitidos a la siguiente generación. Él además propuso que los efectos de la salinidad de desove se basaron en el paso del medio externo a través del corion del huevo en la formación del fluido perivitelino, de este modo modificar el ambiente en el que el embrión se desarrolla.

En el presente estudio se determinó que en una salinidad equivalente, la exposición temprana (desove) produce la descendencia de tilapia del Nilo, de comparativamente mayor tolerancia a la salinidad que los desovados en agua dulce, pero eclosionados en una salinidad elevada. Estos resultados son consistentes con la idea de que ajustes significativos a la salinidad del ambiente se hacen dentro de un periodo breve luego del desove. En los huevos de tilapia, la formación del espacio perivitelino, debido a la absorción de agua, es completado dos a tres horas después de la fertilización (Peters, 1983). Similarmente, se puede hipotetizar que el ambiente osmótico, al cual los huevos son expuestos dentro de dos a tres horas luego del desove, induce a ajustes, los cuales afectan la tolerancia a la salinidad de los pececillos eclosionados de estos huevos.

Los resultados relativamente más consistentes obtenidos con descendencia desovada en agua salina comparada con la descendencia eclosionada en agua salina pueden estar relacionados con el hecho que mientras los pececillos desovados y eclosionados en una salinidad dada fueron expuestos a una constante salinidad de ambiente durante su desarrollo, los pececillos removidos del agua dulce para la incubación a salinidades elevadas fueron removidos en diferentes etapas de desarrollo. Esto resultó del hecho que debido a que el tiempo exacto de desove fue algunas veces desconocido, el de remoción pudo haber sido entre 12 a 36 horas después del desove. Por lo tanto, cada cría fue expuesta al medio de desove de agua dulce en tiempos distintos. Se esperaría que las crías transferidas a salinidades elevadas en una etapa prematura de desarrollo que mostraran mayor tolerancia a la salinidad.

En el presente estudio también se determinó que en una salinidad equivalente, la descendencia de la tilapia del Nilo desovada en agua dulce pero eclosionada en una salinidad alta mostrara comparativamente mayor tolerancia a la salinidad que la desovada y eclosionada en agua dulce, y subsecuentemente aclimatada a una salinidad alta. Estos resultados sugieren que la adaptabilidad a una salinidad ambiental dada durante el desarrollo prematuro disminuye a medida que el desarrollo avanza. Las similitudes en los valores de tolerancia a la salinidad mostrados por los pececillos eclosionados en agua salina y los aclimatados a agua salina comparados con los pececillos desovados en agua salina también sugieren que mayores ajustes profundos a la salinidad del ambiente deben realizarse durante el periodo de desarrollo prematuro luego de la fertilización.

En un estudio previo se determinó (Watanabe et al., 1984) que la descendencia híbrida de los *O. mossambicus* (♀) y los *O. niloticus* (♂) mostró mayor tolerancia a la salinidad que los *O. aureus* o los *O. niloticus.* Dado que se observaron cambios relacionados con el tamaño en estas especies, se sugirió que una combinación de hibridación (para incrementar los niveles de tolerancia a la salinidad) y una maximización del crecimiento prematuro en agua dulce para medir la tolerancia máxima (para minimizar los requerimientos del agua dulce), pueden optimizar las condiciones para una crianza económica de tilapias en agua de mar. Los resultados del presente estudio han demostrado que la exposición prematura a la salinidad, a través del desove y la incubación en salinidades elevadas, puede efectivamente mejorar los niveles de tolerancia a la salinidad en pececillos jóvenes de tilapia. La viabilidad del desove en condiciones salinas se demostró mediante el éxito en la producción de pececillos bajo salinidades tan altas como 15 ppm. Así mismo, la producción estacional de pececillos por unidad de peso de hembras en salinidades salobres de 5 a 15 ppm excedió a la observada en hembras más grandes en agua dulce. Además de mejorar los niveles de tolerancia a la salinidad de los pececillos, la exposición prematura a la salinidad proporciona el beneficio adicional de reducir los requerimientos de agua dulce asociados con la explotación de la población reproductora y la crianza prematura.

La maximización del crecimiento prematuro en agua dulce para medir la tolerancia máxima a la salinidad y la exposición temprana a la salinidad mediante el desove y la eclosión en salinidades elevadas aparentan ser enfoques conflictivos. No obstante, si la tolerancia incrementa con el tamaño se relaciona con la superficie del cuerpo: relaciones de volumen (Parry, 1960), para el desarrollo del sistema hipoosmorregulador (Wedemeyer et al.,1980) o para los cambios ontogénicos en la hemoglobina (Perez y Maclean, 1976), entonces parece razonable asumir que la descendencia desovada y eclosionada en altas salinidades podría similarmente mostrar cambios ontogénicos en la tolerancia de la salinidad. En los salmónidos, la tasa de desarrollo del sistema hipoosmorregulador es influida por la aclimatación previa a salinidades bajas y a la tasa de crecimiento (Wagner et al., 1969). Por lo tanto, se dice que el tiempo óptimo para la transferencia a agua de mar de pececillos desovados y eclosionados en salinidades elevadas se logra. Por lo tanto, la hibridación, la exposición temprana a la salinidad y la maximización del crecimiento prematuro hasta el tamaño máximo de tolerancia a la salinidad son técnicas compatibles para la crianza de tilapias en agua salada. El control de temperatura, la aplicación de promotores de crecimiento o la crianza de solo machos son técnicas potencialmente útiles para alcanzar el tamaño máximo de tolerancia a la salinidad en el menor lapso. Se requieren más experimentos para determinar la ontogenia de la tolerancia a la salinidad en la descendencia desovada y eclosionada en salinidades elevadas.

No es posible equiparar la alta tolerancia a la salinidad con las tasas altas de crecimiento en agua de mar con base en los datos disponibles. Sin embargo, como los resultados hasta la fecha han demostrado que la tolerancia a la salinidad varía considerablemente con la edad, el tamaño, y el historial de exposición a la salinidad de los individuos, es importante que estos factores se definan y estandaricen cuando se diseñen experimentos para evaluar el desempeño de crecimientos de las tilapias en relación con la salinidad del ambiente.

El enfoque genético para el desarrollo de deformidades o híbridos, los cuales muestran un buen crecimiento y supervivencia en agua de mar, permanece como una importante prioridad de investigación para la crianza de tilapias en agua salada. Además, las técnicas no genéticas como las de exposición temprana a la salinidad y la selección de tiempos de transferencia óptimos, pueden ayudar a maximizar el potencial de las especies moderadamente tolerantes a la sal, como el *O. niloticus,* para la supervivencia y el crecimiento durante la crianza en salinidades más altas que la óptima.

Agradecimientos

Los autores desean agradecer a las siguientes entidades y personas por hacer este trabajo posible: El Instituto de Biología Marina, la Universidad Nacional de Sun Yat-Sen, a Kaohsiung por la provisión de las instalaciones experimentales y el apoyo logístico; la Fundación Rockefeller por proveer uno de los autores (W.O.W.) con una asociación de investigación postdoctoral; a Mr. Anne van Dam por la asistencia en la realización de los experimentos y al Dr. Roger S.V. Pullin por sus útiles consejos. Este trabajo se llevó a cabo durante un programa de cooperación de investigación entre el Centro Internacional para el Manejo de Recursos Vivos Acuáticos, Manila y el Consejo para el Planeamiento de la Agricultura y el Desarrollo de Taiwán.

Referencias

Alderice, D.F y C.R. Forrester. 1968. Some effects of salinity and temperatura on early development and surbvival of the English sole (*Parophrys vetulus*). J. Fish. Res. Board Can. 25(3): 495-521.

Bashamohideen, M. y V. Parvatheswararao. 1972. Adaptations to osmotic stress in the freshwater euryhaline teleost *Tilapia mossambica.* IV. Changes in blood glucose, liver glycogen and muscle glycogen levels. Mar. Biol. 16: 68-74.

Boeuf, G. y Y. Harache. 1982. Criteria for adaptation of salmonids to high salinity seawater in France. Aquaculture 28: 163-176.

Chervinski, J. 1961. On the spawning of *T. nilotica* in brackishwater during experiments in concrete tanks. Badgesh 13(1): 30.

Chervinski, J. y A. Yashouv. 1971. Preliminary experiments on the growth of *Tilapia aurea* (Steindachner) (Pisces, Cichlidae) in sea water ponds. Bamidgeh 23(4): 125-129.

Chervinski, J. 1982. Environmental physiology of tilapias, p. 119-128. *In* R.S.V. Pullin y R.H. Lowe-McConnell (eds.) The biology and culture of tilapias. ICLARM Conference Proceedings 7, 432 p. International Center for Living Aquatic Resources Management, manila, Philippines.

Forrester, C.R and D.F. Alderice. 1966. Effects of salinity and temperature on embryonic development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23(3): 319-340.

Hempel, G. 1979. Early life history of marine fish. University of Washington Press, Seattle.

Holliday, F.G.T. 1969. The effects of salinity on the eggs and larvae of teleosts, p. 293-311. *In* W.S. Hoar y D.J. Randall (eds.) Fish physiology. Vol. 1, Academic Press, New York.

Holliday, F.G.T. y M.P. Jones. 1965. Osmotic regulation in the embryo of the herring (*Clupea harengus*). J. Mar. Biol. Ass. U.K. 45: 305-311

Holliday, F.G.T. y M.P. Jones. 1967. Some effects of salinity on the developing eggs and larvae of the plaice (*Pleuronectes platessa*). J.Mar. Biol. Ass. U.K. 47: 39-48.

Iwata, M., T. Hirano y S. Hasegawa. 1982. Behavior and plasma sodium regulation of chum salmon fry during transition into seawater. Aquaculture 28: 133-142.

Kinne, O. 1962. Irreversible non-genetic adaptation. Comp. Biochem. Physiol. 5: 265-282.

Kirk, R.G. 1972. A review of recent developments in Tilapia culture, with special reference to fish farming in the heated effluents of power stations. Aquaculture 1: 45-60.

Landless, P.J. y A.J. Jackson. 1976. Acclimatising young salmon to sea water. Fish Farming Int. 3(2): 15-17.

Lee, J.C. 1979. Reproduction and hybridization of three cichlid fishes, *Tilapia aurea* (Steindachner), *T. hornorum* (Trewavas) and *T. nilotica* (Linnaeus) in aquaria and in plastic pools. Auburn University, Auburn, Alabama. 84 p. Ph.D. dissertation.

Oliphan, V.I. 1940. Contributions to the physiological ecology of the eggs and larvae of fishes. I. The effect of salinity on early development stages pf *Abramis brama* L., *Lucioperca lucioperca* L. and *Caspialosa volgensis Berg. Zool. Zh. 19: 73-98.*

Oliphan, V.I. 1941. Effect of salinity on the eggs and larvae of carp, vobla and bream. Vses. Nauchn.-Issled. Inst. Morsk, Nybnogo. Khoz. I Okeanogr. Tr. 16: 159-172.

Parry, G. 1960. The development of salinity tolerance in the salmon, *Salmo salar* (L.) and some related species. J. Exp. Biol. 37: 425-434.

Payne, A.I. 1983. Estuarine and salt tolerant tilapias, p. 534-543. *In* L. Fishelson and Z. Yaron (compilers). International Symposium on Tilapia in Aquaculture, Nazareth, Israel, 8-13 May 1983. Tel Aviv University, Israel.

Payne, A.I. y R.I. Collison. 1983. A comparison of the biological characteristics of *Sarotherodon niloticus* (L.) with those of *S. aureus* (Steindachner) and other tilapia of the delta and lower Nile. Aquaculture 30: 335-351.

Perez, J.E. y N. Maclean. 1976. The haemoglobins of the fish *Sarotherodon mossambicus* (Peters): functional significance and ontogenic changes. J. Fish Biol. 9(5): 447-455.

Peters, H.M. 1983. Fecundity, egg weight and oocyte development in tilapias (Cichlidae, Teleostei). ICLARM Translations 2, 28 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Pfeiler, E. 1981. Salinity tolerance of leptocephalus larvae and juveniles of the bonefish (Albulidae : Albula) from the Gulf of California. J. Exp. Mar. Biol. Ecol. 52:37-45.

Rao, T.R. 1975. Salinity tolerance of laboratory- reared larvae of the California killifish, *Fundulus parvipinnis* Girard. J. Fish Viol. 7(6): 783-790.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis* and *Danakilia.* British Museum (Natural History), London.

Wagner, H.H., F.P. Conte y J.L. Fessler. 1969. Development of osmotic and ionic regulation in two races of chinook salmon *Oncorhynchus tshawytscha.* Comp. Biochem. Physiol. 29: 325-341.

Watanabe, W.O., C-M. Kuo y M-C. Huang. 1984. Salinity tolerance of the tilapias *Oreochromis aureus (*Steindachner*), O. niloticus* (L.), and *O. mossambicus* (Peters) x *O. niloticus hybrid.* ICLARM Technical Reports 16. (In press)

Wedemeyer, G.A., R.L. Saunders y W.C. Clarke. 1980. Environmental factors affecting smoltification and early marine survival of anafromous salmonids. Mar. Fish. Rev. 42(6): 1-14.

Weisbart, M. 1968. Osmotic and ionic regulation in embryos, alevins, and fry of five species of Pacific salmon. Can. J. Zool. 46: 385-397.

Wohlfarth, G.W. and G. Hulata. 1983. Applied genetics of tilapias. ICLARM Studies and Reviews 6, 26 p. Second edition. International Center for Living Aquatic Resources Management, Manila, Philippines.

Spanish to English Translation

The Pruning of the Cork Oak (Quercus Suber L.). Quantification of its Products

GREGORIO MONTERO GONZALES

CIT – INIA Forest Systems Department,

Coruña highway, Km 7. 28040 Madrid

RAFAEL CURRAS CAYON

Regional Inspection of I.C.O.N.A. Valencia

Ministerio de Agricultura Pesca y Alimentación

Secretaria General de Estructuras Agrarias

Pruning of Cork Oak (Quercus Suber L.) Quantification of its Products

In the first part of this publication, it is presented a series of general considerations about the pruning of the cork oak and its effects based on bibliography and the opinion of the authors. In the second part, it is presented the data about weight of the firewood, primary cork, and twigs obtained in three experimental pieces of land located in: San Pedro mountain range (15 ha), Sevilla mountain range (7.5 ha) and cork oaks of Cádiz (7.5 ha), in which it was determined the weight of the firewood, primary cork, and slash in a sample of 371 trees. The results show that the percentages of primary cork, in regards to the total weight of wood, increase when the number of years elapsed since the last pruning. The yields, from moderate pruning, vary between 1500 and 9900 kg/ha of firewood and between 600 and 4300 kg/ha of primary cork, per hectare.

Introduction

Pruning of cork oak remains as a subject of permanent controversy, both in theory and its practical application. The research in Spain has not contributed with enough information, not even to be able to judge objectively and rationally this important forestry and the economic fact that is totally integrated to the regular use of the cork oaks of Extremadura, north Huelva, and Sevilla. In the cork oak woodlands Cádiz, Málaga and Cataluña pruning is not usual. In Portugal, some experiments were made in the Cork Oak Experimental Station between the years of 1930 and 1940, in order to quantify its effects on the growth of the tree and the production of cork and its acorn. The results are published in the works of Vieira (1932, 1937, 1938 and 1950), Brito Dos Santos, and Rodrigues (1975).

In Spain, the only known attempt is the one carried out by the I.F.I.E – I.N.I.A (Forestry Institute of Research and Experiences - National Institute of Agricultural and Food Research and Technology), that intended to quantify the products of moderate pruning in cork oaks located in the mountain range of San Pedro, Sevilla, and Cádiz, whose results are presented in this work.

This study was planned secondarily within a much broader study led to know the production and mechanisms of regeneration of the cork oak woodland. Its publication seems interesting, since it can help to quantify the production of the prunings that are carried out prudently, and always taking into account the difficulty involved in making the correct quantitative and qualitative estimate of the wood and primary cork obtained, since it depends on variables such as pruning intensity, years elapsed since the last pruning and intensity, size of the cut branches, etc., which are difficult to measure. Either way, in a field where it practically does not exist any quantified information, with certain exactitude and homogeneity of procedure, it is considered important to make known the results that were obtained in a total of 30 pruned hectares, in which the wood was weighed with and without the virgin primary cork and the twigs (sheaf) of 371 trees proportionally distributed in all the diametric classes, trying to keep the same intensity and type of pruning and following the same procedure to estimate the amount of products of these three zones.

Shape Pruning

Shape pruning, rarely practiced cork oaks acorns, has a long-term high economic interest; however, its lack of immediate profitability does not make it very attractive for the owners. In many acorns it is observed a high percentage of trees with defective, bent, with really low limps, poor disposition of first order limps that do not allow to climb to the height of the uncork tree area, etc. This poor surface shape, potentially uncorkable, reduces the production, raises the cost of cork extraction, makes impossible the extraction of flat and straight edged cork planks, that allow a better utilization of cork bottle stoppers, and increases the percentage of defects, due to the small size and to the geometrical irregularity of the planks.

Figure 1.- 6-year-old plantation in forest. At this age, and with normal development conditions, the shape pruning becomes essential, along with the elimination of malformed individuals and creeping sprouts, leaving only one specimen per point. Picture: G. Montero.

The shape pruning becomes essential if in the future it is tried to make possible the mechanization of the uncork process. This idea would be seen as beneficial if the trees had straight and flat shafts. The conditions in which the uncork surfaces are nowadays in the majority of trees (bent shafts, abundance of bumps produced by injuries in the pruning and/or uncork, etc.) makes impossible to think on a mechanized extraction.

Pruning must be initiated in very young trees to avoid irreparable malformations, but this way of proceeding can be harmful if restriction of the cattle does not exist, since the small pruned trees are frequently bent by goats and cows to eat the branches of its small crown, causing further damages than in the apostatized and pruned masses. When the tree is about 3 to 4 years old, it is convenient to remove low-positioned branches in the resettlements and in delimited places with pruning scissors. If the main guide has been lost, a lateral branch is chosen as the new guide. The young and very twisted plants end up entangled with time if they are not well pruned and guided, and the small scars will heal easily.

If shape pruning is made later on in trees with very defective shafts and very thick branches that are necessary to eliminate, we should be cautious and do not force too much the objective of getting straight and flat shafts in 2.5-3 meters of height, as it would be ideal.

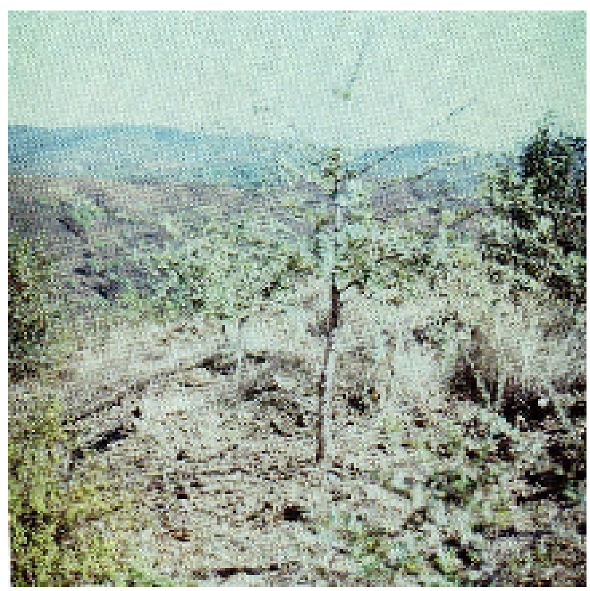


Figura 2 Shape pruning in a 4 years old plantation in hills. The height of the pruning ranges from 50 to 80 cm, depending on the size of the plant. Picture: G. Montero.

Pruning of Adult Trees

If you look for the origins of cork oak pruning, we can realize that it is an emulation of the holm oak pruning, searching for a production of regular and sustainable acorn, which it is not always achieved in reality, the decrease of the cover to stimulate the cultivation of other types of cereals and pruning (only cutting the tip of the branches).

It is confirmed that the production of the acorn is favored by the presence of new and vigorous sprouts on the peripheral zone of the crown (not sucker or thief sprouts). The main effect of the pruning is precisely to stimulate the growth of new and more vigorous sprouts, by centering all the production capability of the tree to just a few selected branches. The imbalance is reestablished in a few years, because the biomass of the crown increases and it seems that the radical system decreases in proportion to the reduction that the pruning provoked on the crown (Vieira, 1937). When the balance is achieved again, the growth of the sprout is slowed down and the production of acorn per unity of the surface of the crown is established again in the existing original amount before the pruning. In this period of time, it becomes necessary to perform a second pruning, which must be repeated periodically.

Vigorous regrowth is produced; partly, by the concentration of nutrients in a smaller number of branches, by the elimination of shadowy and weakened branches (which energetic balance can be negative), by spending more energy in the process of breathing than what is contributed through the assimilation; and, fundamentally, at the expense of the accumulated reserves in the rest of the tree. Therefore, if the pruning is too intense, it becomes a process that weakens the tree, as after the initial imbalance it concentrates almost its full potential in reestablishing the leaf balance with the emission of new sprouts, and only when this is reached it begins the process of accumulation on the reserve tissues. If in this moment, it is proceeded to carry out the next pruning and to create again the new sought unbalance to favor the emission of vigorous sprouts, extracting once again almost all the leaf biomass accumulated, since the last pruning. The tree is being forced to live in a permanent state of biologic imbalance. The regrow will be less intense every time, due to the fact that the tree has less accumulated reserves and these are the ones which are most involved in the process; the final result is that the effects of the pruning are less apparent or viewable everytime.

On the other hand, the process of willfully forced fructification through the pruning consumes large amounts of reserves, carbohydrates, fats, starch, etc., that is manifested externally the following year in an abundant bush, through the loss of the greenery intensity and even the yellowing of the leaves, as well as the emission of less and smaller young sprouts. The necessary reserves to a new emission of fruit are accumulating slowly; for this reason, to one year of good acorn grass, it usually comes another of scarce or no fructification. Only the proper fertilization could effectively mitigate the scarcity of fruit, such as the one that occurs in fruit trees (Vieira, 1937).

The effects of a moderate pruning over fructification last few years (4 to 5). It would be convenient to prune moderately every 5 years, but this is expensive and it generally does not pay the cost of the operation. Therefore, the owner only has two options left; perform a more intense pruning, but at longer time intervals, so that the extracted products in the pruning could subsidize the operation and the effects of this one, and last longer, or to perform rather frequent and intense prunings, at the cost of "decapitalizing" the mass, provoking the weakening and premature ageing, with negative consequences in the production of cork.

This type of vicious circle was discovered masterfully by Vieira (1937) with the following words;

"It was initially pruned to regularize the fruit production; the pruning was continued with higher intensity, so the products of the pruning (wood and primary cork) could compensate the costs of the operation. It was later pruned with a higher intensity, even to obtain a supplementary income from the cork oak, and in that way, little by little, the excessive and abusive pruning became generalized, perfected, and intensified."

This process of "forward escape," through which it was found a way to obtain new and unexpected productions of cork oak, received a warm welcome among the owners. There is no other known silviculture technique that has been so quickly disclosed and so scrupulously followed by interested people. However, excessive pruning was not invented by selvicultorists nor the swineherd or the cork producer; it was invented by the coalmen, who were, as Vieira says, the inventors, publishers, and executers.

Due to the lack of importance of the acorn production within the economy of the cork oak, moderate and frequent pruning, only one capable to, partly, ease up the yielding in which some trees in only one year produce a lot of fruit, but others lack of it and to increment the annual production of acorn, it is not justified economically and even less in the current socioeconomic conditions of our cork oaks.

From the point of view of the fruit production, excessive pruning is also not an advisable operation and it can never be justified as a rational and economic system to regulate the fruit production, because it is an accepted fact that only in a small part accomplishes the fructification objectives that some people make as an excuse for its realization. They are well known and widely disclosed by some Portuguese authors, many of its inconveniences, such as it diminishes considerably the fruit production surface, with the visible effect of a higher abundance of acorn in the few branches that are left, it is not demonstrated that are correspondent to a higher total production. No work is known to compare the production of acorn in intensely pruned trees and in moderately pruned trees, and even trees without being pruned. The result is probably surprising to the, to the sometimes interested, popular believe.

Another contrasting fact is that after an intense pruning, there are periods of scarce or no fruit production, because the nutritive substances that should be dedicated to the fructification become to be used, after excessive pruning, in the formation of poacher sprouts especially, and to the reconstruction of the crown in general. If pruning had not been excessive, part of those substances would have been dedicated to the development of more useful peripheral branches for fructification.

If pruning is frequent, the majority of the sprouts (suckers or poachers) are cut in the next pruning, before it has produced acorn in abundance and when many of them still have a small portion of primary cork. From the sprouts that are cut in the next pruning and that were formed primarily at the expense of the substances that the tree has stored throughout the years, it is taken off a scarce real production (acorn and primary cork), thus everything seems to indicate that a process of authentic waste of the

Figure 3.- Stand obtained by natural regeneration through limited shepherding. The high density in which the trees have developed, stimulates the rectitude and height of the shafts and allows to select the best ones. A subsequent intervention of clearing and pruning will allow a new selection. Picture: G. Montero.

accumulated capital is been followed. If, on the contrary, in the next pruning the thick branches left from the last pruning are cut and the young sprouts are left to bear fruit and to produce; although it is performed a system similar to the utilization of crown sprouts; pruning is produced at two or three meters of height. This system starts off from the fact that it would have to be regulated and studied based on the technique of exploitation of cuts or scrub, in the forest sense of the word, we do not believe that anybody can defend it as a cork oak exploitation method.

The Cork Oak has a relatively slow growth, so its masses that are very lighten, have little capacity to produce biomass, and its rational exploitation does not support intensive periodical extractions of woody material; if it is not at the expense of consuming the forest capital that the mass has accumulated throughout the years. It cannot be carried out frequent (9 to 10 years) and intense prunings that provide between 4000 and 5000 kg of wood, 100-1300 kg of primary cork, and 2500-3000 kg of twigs, for the owner to get a net income. This would mean that one cork oak field with 40-50 trees per hectare would need to produce between 7.5 and 9.3 mt (metric ton) in 9-10 years terms.

If intensive prunings are done to produce wood and virgin primary cork, separating them from any other objective, which is normally not obtained, there would have to be determined the capability of the cork oak to produce wood in its branches; and the minimum age to cut these branches for their production of wood and primary cork to be optimal (turn); and, depending on these variables and costs of pruning, the most advisable rotation or pruning turn. Besides, this option would have to take into account its repercussions on the production of cork.

To end this topic about the devitalizing influence of excessive pruning on the cork oak fields, Vieira (1937) concludes his comments with this paragraph, which is a textual quote;

"The practice of excessive pruning, as a normal pruning system, has a profound devitalizing action over the trees, which is translated into a minor resistance to plague attacks and diseases, in the precarious conditions of vegetation, and in the least longevity of the tree. From this point of view, excessive pruning seriously affects the economy of the cork oak fields."

From the point of view of the cork production, Vieira (1937, 1938) demonstrated that an excessively pruned cork oak field produces 20% less than others identical in characteristics and in age conditions –forest related and ecological- that had suffered a moderate pruning. In these same tasks, and to the same plots compared for the cork production, it is stated that the growth in diameter decreased 20% in the plot excessively pruned. The average annual growth of the cork gauge decreased in the proportion that figures 1 and 2 show. The data were obtained from an experience that lasted 12 years (1929-1937). Another effect of excessive pruning is that the cork is not obtained

Figure 4- 27-year plantation on mountain. The form of the shaft exposes the disadvantages of delaying excessively the shape pruning: the pruning wounds are enormous; the division of the main branches has occurred at a low altitude and the forms of the shafts and branches are very irregular. This shape pruning can improve the physiognomy of the trees, but it does not accomplish its goal of achieving straight and 2-3m height shafts. Picture: G. Montero.

in the years following such pruning. For this reason, pruning has to be done three years after the uncork process; when this is not possible, it should precede a minimum of three years. This temporal synchronization of uncork-pruning is also justified because in the immediate subsequent years to the uncork process, the tree is physiologically weak (uncork crisis) and the healing of the pruning wounds is slow.

In the opinion of numerous authors, excessive pruning, seen from diverse points of view, has no other serious justification than the immediate income. This fact would fully justify it, just as the uncork process is justified, if it was not because its practice has negative consequences to the whole economy of the cork oak fields. This is finished with the same words that Vieira began his work of 1937, for having the conviction that his arguments remain valid in our country in 1989.

"If those who consider excessive pruning as a defensible cultural operation, consecrated by the practice and experience of many years; if those who see this tremendous devastation benevolently, as dictated by the study and observation of the pruner, by the accumulated wisdom over time, and as an interpretation of the necessity of the trees; anyway, if excessive pruning followers go back to the origins of such a disastrous practice and analyze its evolution, they will see; sadly, that it is about the simple use transformed into abuse. Where they were looking for the old knowledge of experience and the facts, they will only find vicious recklessness"

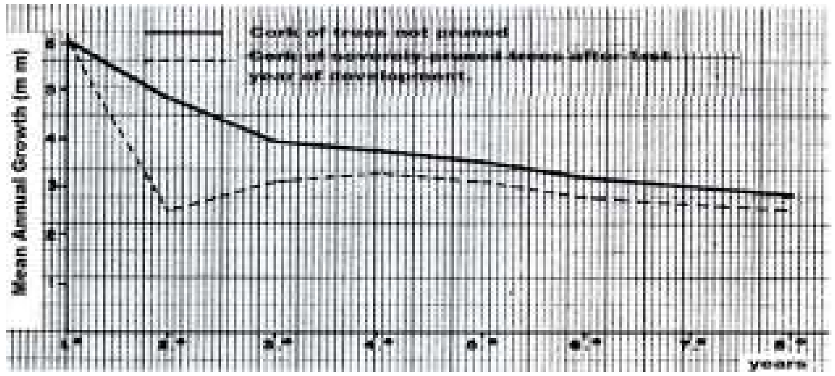


Figure 5 – Growth curves of the cork obtained from trees not pruned and intensively pruned (according to Vieira, 1938)

When talking about excessive pruning, we talk about prunings systematically performed and those which affect more than 30% of the total tree branches, without taking into account neither the age nor the vegetative conditions of this. That is to say, same intensity prunings in young trees and in adults, and in the old and decrepit ones, carried out periodically as an usual system. This way of proceeding has nothing to do with rejuvenation pruning, that in spite of being really intense, only affect aged trees, and are usually applied once at the end of the tree's life.

The decision of when and where to prune supposes an option of economic nature that has to be taken by the owner, according to the forest guidelines established by the Forestry Administration. In any case, it should be considered the scientific-technical arguments necessary to enable the incorporation of a greater objectivity and rationality in making decisions.

Quantification of Pruning Products

Plot selection

The sample data proceed from an I.F.I.E-I.N.I.A. Investigation Project, started and directed in its first phase by González Aldama and Curras, and was finalized by Montoya and Montero. This project was aimed to meet the most suitable forestry guidelines to obtain an increase of the production and natural regeneration of the cork oak fields, as well as an improvement of the quality of the corks. After thoroughly covering each of the zones (San Pedro, Norte de Sevilla mountain ranges, and the mounts of Cádiz and Málaga), it was installed an experience plot in each one of them; that is in the areas that were thought to be more representative for the whole. This way of selection that might look unorthodox from the statistical point of view, is a practice frequently used in forestry studies, and it is endorsed by the efficiency of its results in numerous works.

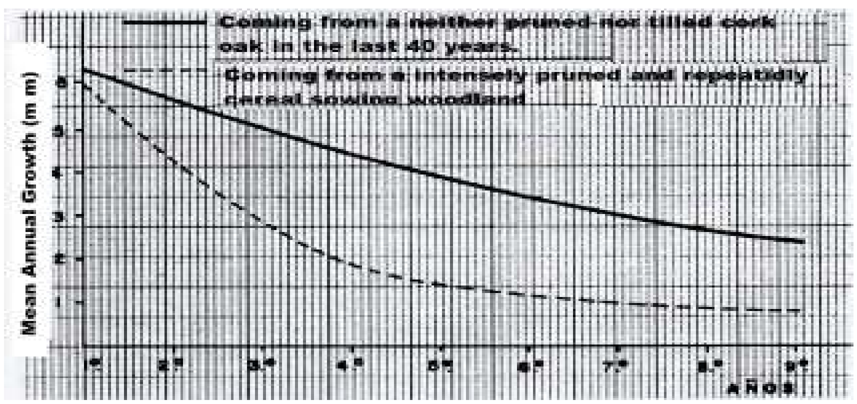


Figure 6 – Cork growth curves (according to Vieira, 1951).

Objectives

The implementation of prunings and measurement of products in these plots, was made within a set of works or foliage forestry operations, cultivation of the land, fertilization, etc., which objective was to meet and increase the production of the cork oak forest and its regeneration. That is to say, the pruning experience was not an experience with its own objectives, but it was part of another with a broader scope. It was considered that pruning should be moderate and inspired in the guidelines given by the Portuguese authors.

This kind of pruning offers small immediate incomes and it may not cover the costs. This is the most serious aspect of the problem, because as long as the owner can perform prunings of enough intensity so the income of its products generate some net benefits, it would be idle that nobody might try to convince them that the inconveniences or advantages that the performance of less intense or moderate prunings might bring in the future should guide their immediate intervention. For the solution of the problem there would have to be a long-term agreement on the forestry interests with the immediate economic, searching for a system that allows the owner to obtain a benefit causing the minimum damage to the woodland. These criteria, and not exclusively forestry reasons, have been used as a base to perform prunings whose results are exposed as follows.

SAN PEDRO'S MOUNTAINS SAMPLE

Localization

- Municipal term: Cáceres
- Mountain range: San Pedro range
- Mount: Moro Alto del Mayoralgo
- Place: between "El Moro" and "El Marqués" ports, on the North hillside of the range
- Average Height: 470m
- Average gradient: 30%

Forestry Characteristics

Description of sample place

- Mean density:

- Trees in plant: 136/ha.
- Cork oak plant: 188/ha.

- Fraction of place covered (Fpc):
  - Maximum: 0.64.
  - Minimum: 0.16.
  - Median: 0.43.
- Mean uncork surface/ha: 274 m^2
- Uncork coefficient:
  - Maximum: 5.6.
  - Minimum: 1.9.
  - Median: 2.3.
- Pruned surface: 15 ha.
- Number of pruned trees: 2047.

Years elapsed since the last pruning: 24

Figure 7-. Pruning in an adult cork oak field with excellent vegetative state. This kind of strong pruning, that affect really thick branches, create rotting that shorten the life of the tree and produce abundant sucker sprouts. If it is repeated in short periods (9-10 years) they end up by eliminating practically all the adult branches and transform the tree into a pollard. Picture: G. Montero.

General Forestry Characteristics of the Area which Expects to Represent the Sample

Within this area, the Cork Oak fields are clearly differential that are found in bounded shape and take up the areas with a softer relief, and the ones from the mountain range, that are located in the most steep and pending areas.

The action of men has been really intense in the first ones; as for centuries the mankind has been cultivating the ground periodically for the production of cereals and pastures, subduing it afterwards to an intense shepherding, until the scrubland invaded it again. The alternation of the cycle creates serious difficulties to the natural regeneration, which is basically non-existent on this type of mass, that become lighter gradually until they transform into fossil masses, as the few feet that are left on them are generally old, and they will end up disappearing if natural regeneration is not helped.

Furthermore, right now, the production of pasture is scarce and periodic, since the pasture only appears when the ground is cleaned from the scrub and it is always formed from thin, seasonal, grazing grasses; except by the small areas of talweg, in which thin elements of the ground have accumulated, by high points washed, and that usually count with certain degree of edaphic humidity.

Figura 8- Intense and repeated prunings transform the tree into a pollard, decreasing the production of cork and acorn. The beneficial effect of the tree over the pasture can be significantly reduced. Picture: G. Montero.

In the cork oak fields, which can be called of mountain range, the man's action has been much less intense, so this creates pure or almost pure masses in the high and medium parts of the hillside. As they come closer to the hillside, they get more and more mixed with the holm oak and some Portuguese oak, until they end up being controlled or totally substituted by the holm oak on the plains and valley bottoms. This probably happens because the areas of accumulation of thin elements have originated grounds with poor aeration, which are more suitable for the holm oak than for the cork oak.

In general, the cork oak reaches good development in the lower and medium parts of the hillsides, and less as it rises toward the top. In nearby areas and mountain peak zones, it is really frequent that the ground possesses scarce depth and this circumstance, along with the wind lashing, causes the masses to be lighter and trees of poor posture and small dimensions, sometimes showing up drowned by the scrubland.

Natural regeneration is satisfactory on the masses located in the medium and low parts of the hillsides, in which the cultivation of cereals and pasture is not often practiced; as long as they are not subdued to a really intense shepherding and the nibble of hunting animals is not excessive.

On the highest zones and peaks of mountains, the natural regeneration is scarce, possibly due to the lack of soil and to the abundance of scrubland, which make the freshly sprouted plants of one or two years to die almost totally during summer due to the lack of water.

Prunings are usually excessive, and follow defective techniques, which tend to enlarge and shrink crowns leaving really low branches and forming an almost ring around the trunk (Curras, 1972). This pruning method is more marked in the cork oak fields, called of meadow.

Pruning Production

Pruning Type

The applied pruning type consisted, in general, on eliminating the low branches (angled branches), whenever this was possible, reducing the diameter of the crown to leave, some branches directed to the center of the crown with the objective of achieving placing shadow on the first order branches and a rounded posture of the tree's crown. To avoid rotting, it was left the branches whose cut was horizontal (towards the sky) or showed danger of rain water accumulation. It was specially ensured, to achieve a balance in the crown's constitution, by leaving in each first order branch a quantity of foliage that was proportional to its maximum diameter that the branches to be cut should have, following the general criteria of not cutting the branches which are 20 cm long from the base, nor those that were inserted in uncork branches. The remaining branches were cleaned from dry, weakened, etc. rambling. (Curras, 1972).

Pruning Intensity

The intensity of pruning in this species is difficult to quantify, and it depends on the quantity of the branches that the tree has before the pruning and the percentage of branches that are cut at the time of performing the pruning. In terms of percentage, it was attempted not to surpass the 20-25 percent, only approaching the 30 percent in some trees, that because of its crown shape or deformation, it was believed to be advisable for its future development. The fraction of covered space (measured tree by tree, before and after the pruning) was reduced by 30 percent. This strong reduction was due more to the type of pruning than to its intensity. A rule internationally admitted by the specialists, is that the ideal intensity of a pruning is the one in which the tree responds by not sprouting any or just a few “suckers.” In this case, only 8-10 percent of the trees sprouted relatively intense, which indicates that pruning was excessive in those trees; in the rest, therefore either no sucker sprouts or there were some very weak, so it can be deduced that in them the intensity of the pruning was the correct one.

Data Collection

The 15 ha experience plot was divided in 15 subplots of 1 ha each. When the diametric distribution of each plot was known, a random sample of the 10 percent of the trees of each circumference class was chosen. A minimum of one tree was taken in the types with less than 10 trees. The total resultant sample for the entire plot was of 232 trees, and in each one of them the following variables were measured:

- Standard circumference
- Surface of projection of the crown, before and after the pruning
- Kilograms of thick firewood with primary cork produced by the pruning. It was considered as thick wood, all the branches with a measurable quantity of primary cork, which tends to coincide with branches of 4-5 or more centimeters of diameter. The rest, thin twigs (sheaves), were estimated as indicated in the next item

Determination of Percentages of Primary Cork, Wood without Primary Cork and Sheaf

Five (5) plots of 100 kg of wood with primary cork were made to determine these percentages, making sure of grabbing branches of all diameters and different trees. Thin twigs (sheaf) coming from the 100 kg of wood were weighed separately to determine how many kilograms of sheaf are produced per 100 kg of wood with primary cork, and this percentage was applied to each tree of the sample to determine the weight of sheaf produced per tree. Later, it was taken off the primary cork from the 100 kg of wood and then weighed, in one side the wood without primary cork and in the other the primary cork alone, and in this how we determined the percentage of primary cork in the wood. The average results obtained were the following:

- Per each 100 kg of wood with primary cork, it was obtained 68.25 of sheaf
- Per each 100 kg of wood with primary cork, it was obtained 69.5 kg of wood without primary cork, and 26.75 kg of primary cork. The loss per chopping and peeling was 3.75 kg.

These percentages were applied to the wood with primary cork weight that each tree of the sample had produced, to calculate the modular values per types of circumference (Table CC-1)

Since each subplot had different number of trees and trees of different sizes, the obtained productions in each one of them were included, as we consider that from them, we can complete information about the pruning production (Table CC-2). Once the pruning of all the plot is finished, the wood without primary cork and the primary cork were weighted separately, to be then fertilized by the buyer. The difference between the total real weight and the one estimated by the sample did not reach the 2 percent.

Table CC-1 Wood, natural cork and sheaf per tree and circunference classes (CAP)

CAP class (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural Cork (kg)	Sheaf (kg)
25-34	2,6	1,8	0,7	1,8
35-44	3,0	2,1	0,8	2,0
45-54	5,8	4,0	1,6	3,9
55-64	13,2	9,2	3,5	9,0
65-74	29,4	20,5	7,9	20,1
75-84	41,2	28,6	11,0	28,1
85-94	68,7	47,7	18,4	46,9
95-104	74,8	52,0	20,0	51,1
105-114	95,6	66,4	25,6	65,2
115-124	102,7	70,9	27,5	70,1
125-134	115,5	79,7	30,9	78,8
135-144	125,5	86,6	33,6	85,6
145-154	134,6	92,9	36,0	91,9
155-164	164,7	113,6	44,1	112,4
165-174	195,3	134,7	52,2	133,3
175-184	198,7	137,1	53,2	135,6
185-194	209,0	144,2	55,9	142,6
195-204	214,1	147,7	57,3	146,1

Table CC-2. Weight in green (kg) of wood, naturall cork and sheaf per hectare and tree.

	Values per hectare						Mean values per tree		
Sub plot	Number of trees (ha)	Mean CAP (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)
1	58	95	3.069	2.132	820	2.094	37	14	36
2	89	89	3.624	2.518	969	2.473	28	11	28
3	93	81	3.327	2.312	890	2.270	25	10	24
4	109	89	4.784	3.325	1.280	3.265	31	12	30
5	114	91	4.908	3.411	1.313	3.349	30	12	29
6	122	94	7.602	5.283	2.033	5.188	43	17	42
7	126	83	4.262	2.962	1.140	2.909	24	9	23
8	126	103	7.680	5.337	2.054	5.241	42	16	41
9	139	101	8.187	5.690	2.190	5.588	41	16	40
10	154	90	6.917	4.808	1.850	4.721	31	12	30
11	157	97	8.593	5.972	2.299	5.865	38	15	37
12	169	94	7.830	5.442	2.094	5.344	32	12	31
13	173	98	9.272	6.444	2.480	6.328	37	14	36
14	182	92	8.495	5.904	2.272	5.797	32	12	31
15	236	88	9.911	6.888	2.651	6.765	29	11	28

Sample of the Sevilla Mountain Range

Localization

- Municipal term: Constantine
- Mountain system: Morena mountain range
- Mount: El Robledo public area
- Spot: XIII section
- Average height: 700 m
- Average slope: 20%

Forestry Characteristics

Description of the Location of the Sample

- Average density
  - Trees in plant: 59/ha
  - Cork oaks: 97 ha
- Fraction of average area covered (Fsp)
  - Maximum: 0.46
  - Minimum: 0.22
  - Average: 0.32.
- Average uncork surface/ha: 340 m^2
- Uncork coefficient:
  - Maximum: 3.7
  - Minimum: 2.1
  - Average: 3.3

- Pruned surface: 7.5 ha
- Number of pruned trees: 442
- Years elapsed since the last pruning: 15

General Forestry Characteristics of the Area that Expects to Represent the Sample

In this cork oak fields, the scrub practically covers the ground. Therefore, the practice of scrub clearance is frequent, as a defense against fire and to facilitate the exploitation of the acorn and the few pastures that it produces.

Despite the exploitation of the scrub clearance, its natural regeneration is acceptable, mostly because of the protection that the scrubland gives to the fallen acorns.

Generally, this cork oak fields are located in moderately rugged terrains and its slopes have slim shaft and the crown well developed, being its thickness clearly incomplete in the majority of the masses.

Figure 9.- The excessive pruning does not establish a general line of action in our cork oak fields, but it can be neither qualified as an isolated fact. The examples of this type are abounding and, sometimes, it is even justified. Picture: F. Carrascosa.

Traditionally, the prunings are made by eliminating the young branches directed upwards, originated by "sucker" sprouts that emerged as a consequence of the previous prunings, leaving those which were outward of the crown; it could be said that the tree was left completely branchless in the center and spilled in the exterior circle. The reasons of this technique have always been of immediate economic type and deprived of forestry basis and a narrow vision of the future. Practically, only the branches that are more comfortable to cut, and those that because of its thickness provide visible quantities of wood and primary cork are cut.

Pruning Production

Type of Pruning

The type of pruning was performed following the same guidelines and pursuing the same objectives that we have described for the sample of the San Pedro - Cáceres mountain range.

Pruning Intensity

It was followed the same criteria described for the area of the San Pedro mountain range, and the response of the mass was similar in terms of sprout. Some trees with very horizontal first order branches took a shape similar to a “chandelier” when trying to move the crown.

Data Collection

Similar to everything described for the San Pedro mountain range area, without any other difference than the size of the plot that in this case was 7.5 ha and was divided in 15 subplots of 0.5 ha. The number of trees in which it was weighted the wood with primary cork from the pruning was of 67, and the total pruned was of 442.

Table SE-1. Weight in green (kg) of wood, natural cork and sheaf per tree and circumference classes (CAP)

CAP class (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)
45-54	16,7	11,8	4,2	10,3
55-64	35,0	24,7	8,8	21,7
65-74	49,9	32,2	12,5	30,9
75-84	64,6	45,5	16,3	40,1
85-94	97,7	68,9	24,7	60,6
95-104	103,1	72,7	26,0	63,9
105-114	115,6	81,5	29,2	71,7
115-124	130,4	91,9	32,9	80,8
125-134	164,7	116,1	41,6	102,1
135-144	205,0	144,5	51,8	127,1
145-154	216,0	152,3	54,5	133,9
155-164	237,5	167,4	60,0	147,2
165-174	243,5	171,7	61,5	151,0
175-184	281,7	198,6	71,1	174,6
185-194	298,5	210,4	75,4	185,1
195-204	308,7	217,6	77,9	191,4

Table SE-2. Weight in green (kg) of wood, natural cork and sheaf per hectare and tree.

	Values per hectare						Mean values per tree		
Sub plot	Number of trees (ha)	Mean CAP (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)
1	32	154	3.243	2.286	819	2.010	71	26	63
2	36	131	2.999	2.114	757	1.859	59	21	52
3	42	154	5.313	3.745	1.354	3.294	89	32	78
4	48	101	1.934	1.363	488	1.199	28	10	25
5	50	107	2.527	1.781	630	1.567	36	13	31
6	54	88	2.347	1.655	593	1.455	31	11	27
7	60	123	3.725	2.626	941	2.310	44	16	38
8	62	141	5.793	4.084	1.463	3.592	66	24	58
9	64	109	3.212	2.264	811	1.991	35	13	31
10	66	130	4.651	3.279	1.174	2.884	50	18	44
11	68	102	2.947	2.078	744	1.827	31	11	27
12	68	101	2.602	1.834	657	1.613	27	10	24
13	70	113	3.273	2.307	826	2.029	33	12	29
14	74	94	2.384	1.681	602	1.478	23	8	20
15	90	101	3.473	2.448	877	2.153	27	10	24

Determination of Primary Cork, Wood without Primary Cork and Sheaf Percentages

By following the same procedure that the one in the San Pedro mountain range area, the following percentages were obtained:

- 100 kg of wood without primary cork produced 62 kg of sheaf
- 100 kg of wood with primary cork produced 70.5 kg of wood without primary cork and 25.25 kg of primary cork. The loss per chopping and peeling was of 4.25 kg

As in the previous case, these percentages were applied to the wood with primary cork weight that each tree of the sample had produced, and thus the modular values per type of circumference were calculated (Table SE-1). In the table SE-2, the values per hectare are given according to each one of the 15 subplots.

Sample of the Cadiz Cork Oak Fields

Localization

- Municipal term: Los Barrios
- Mountain system: Penibético. Montecoche mountain range
- Mount: Las Presillas
- Spot: La Polvorilla
- Average height: 125 m
- Average slope: 25%

Forestry Characteristics

Description of the location of the sample

- Density

  - Trees in plant: 73/ha
  - Cork oak plant: 16/ha
- Fraction of average covered space (Fcs):
  - Maximum: 0.64
  - Minimum: 0.31
  - Average: 0.50
- Average uncork surface: 305 m^2/ha
- Number of pruned trees: 544
- Years elapsed since the last pruning: 43

General Forestry Characteristics of the Area that Expects to Represent the Sample

The fact that the most of the cork oak fields of this type are located in very rugged and of abundant rocky outcrops slopes, is the reason why the shrub layer and bush are found less altered than those from other masses; grazing with goats, fires, and clearances have undoubtedly influenced its composition and development, thus creating great devoid clears of cork oak that have been invaded by the scrubland.

The scrubland reaches great development and density, totally covering the soil, which it invades again in a few years after the clearing, tillage, or fire.

The herbaceous vegetation is almost non-existent in the areas covered by the described scrubland, limited to occupy the clears that it leaves, and it appears vigorously in the vicinity of water courses, valley bottoms, and other places with abundant edaphic humidity.

The cork oak is located in the abrupt slopes of the mountain ranges mentioned before, spreading from the sea level to 1300m of altitude. It reaches good posture and development, with thin shafts and well gathered up crowns. The thicket is very variable from some cork oaks to others due to the irregularities of the relief and the grounds that make the “buoy” and “stony” cork oaks perfectly distinguishable with the smaller, clearer, with lots of scrub, and without the presence of *Quercus canariensis* Willd trees and the “Canute” ones with thin trees and abundant feet of *Quercus canariensis* Willd. The pruning is less frequent in this area and there are never performed tending prunings to open the crown to benefit fuctification.

Figura 10.- The response to the excessive pruning is always an apparent tree rejuvenation. However, it is a response to the traumatic unbalance between the radical and aerial system, from which both end up hurt. Picture: F. Carrascosa

Pruning Production

The type and intensity of the pruning, the data collection, and the determination of the percentages of wood, primary cork and sheaf, were carried out by following the previously mentioned procedure.

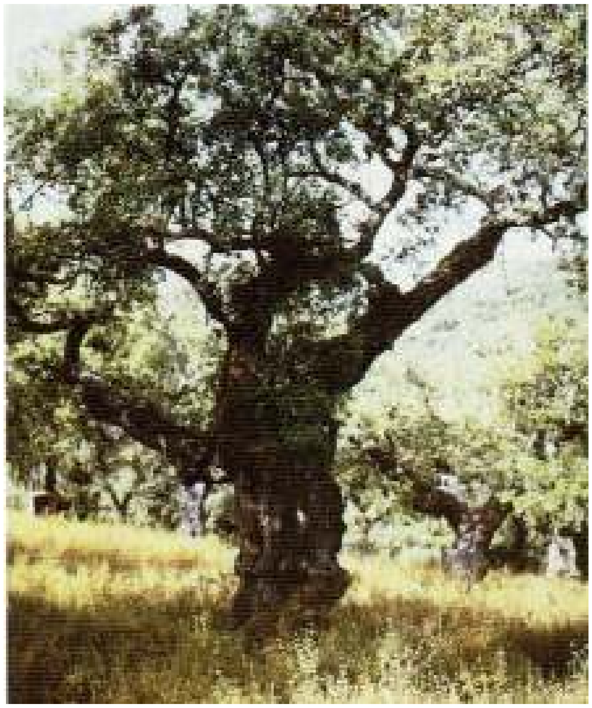


Figure 11.- The so called rejuvenation prunings make only sense in very old trees, and its effects are more apparent than real. Picture: G. Montero.

The number of measured trees in the sample was of 73 and the percentages of wood, primary cork, and sheaf were the following:

- 100 kg of wood with primary cork gave 65 kg of sheaf
- 100 kg of wood with primary cork gave 68 kg of wood without primary cork and 30 kg of primary cork. The loss per chopping and peeling was of 2.0 kg

Figure 12.- The worth of the pruning products (wood and primary cork), the ease of the tilling with tractor, and the seasonal production of grass and cereal, are facts that help to comprehend the excessive pruning performance better than the forestry objectives that are usually argued to justify it. Picture: G. Montero.

Table CA-1. Weight in green (kg) of wood, natural cork and sheaf per tree and diametric classes

Diametric class (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)
15-24	53,0	36,0	15,9	34,4
25-34	65,3	44,4	19,6	42,4
35-44	173,8	118,2	52,1	113,0
45-54	246,8	167,8	74,0	160,4
55-64	374,0	254,3	112,2	243,1
65-74	567,5	385,9	170,2	368,8
75-84	635,0	413,8	190,5	412,7

Table CA-2. Weight in green (kg) of wood, natural cork and sheaf per hectare and tree.

	Valores Medios por Hectárea						Valores Medios por árbol		
Sub plot	Number of trees (ha)	Mean diameter (cm)	Wood with natural cork (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)	Wood without natural cork (kg)	Natural cork (kg)	Sheaf (kg)
1	54	52,1	10.570	7.187	3.171	6.870	133	59	127
2	56	49,2	8.882	6.040	2.665	5.773	108	48	103
3	58	39,9	5.176	3.520	1.553	3.364	61	27	58
4	58	43,6	6.095	4.145	1.828	3.962	71	31	68
5	58	50,0	9.916	6.743	2.975	6.445	116	51	111
6	60	45,1	7.929	5.392	2.379	5.154	90	40	86
7	64	51,0	10.683	7.264	3.205	6.944	113	50	108
8	66	45,5	9.769	6.643	2.931	6.350	101	44	96
9	70	47,4	12.431	8.453	3.729	8.080	121	53	115
10	72	47,1	10.918	7.424	3.275	7.096	103	45	99
11	82	47,1	11.977	8.144	3.593	7.785	99	44	95
12	88	50,4	14.572	9.909	4.372	9.472	113	50	108
13	92	41,5	10.292	6.998	3.088	6.690	76	34	73
14	96	40,8	10.325	7.021	3.097	6.711	73	32	70
15	114	40,6	12.063	8.203	3.619	7.841	72	32	69

These percentages were applied to the weight of the wood with primary cork that each tree of the sample had produced, in order to calculate the modular values per diametric class, no circumference (table CA-1), and to obtain the production per hectare of each one of the 15 plots of about 5000 m^2, in which the experience plot was divided (Table CA-2).

Comments Regarding the Tables

Although the tables are simple and clear enough to interpret the results with its simple observation, here are some comments that can provide more information to the reader:

- The percentages of primary cork with respect to the wood with primary cork weight, rise when the number of elapsed years since the last pruning increased. This can mean that at equal branch thickness, the older ones have a higher percentage of primary cork. The thickness of the cut branches can also influence it, since it is known that the percentage of cork lowers when their diameter increases; but we do not believe that this variable had much influence, since generally every branch had less than 20 cm of diameter on the base.
- The percentage of thin twigs with respect to the wood remains relatively close in the three areas.
- The modular values depend on the density of the mass; Cáceres, with higher density has the lowest values, because the trees that grow denser have smaller crowns.

Figura 13.- In this 9-100 year mass, it has only been performed one shape pruning. It is a mistake to think that a pruning is the only way to keep the vigor and sanity of the cork oak. Masses as this one have an excellent vegetative and sanitary state, even when they are too dense. Picture G. Montero.

- The average values per tree are minor on the mountains of Cáceres than on the Sevilla ones, and in the latter than in the mountains of Cádiz. This variation depends of the size of the tree (the ones of the San Pedro mountain range are thinner), and also on the number of elapsed years since the last pruning. 43 years have passed since the last pruning in the mountain of Los Barrios-Cádiz, and it also seems like the last pruning was extremely moderate; for this reason, it is not unusual that its trees have given a greater number of products than the other two areas.
- The values per hectare are very variable and depend logically on the number of trees/ha, their thickness, and the number of elapsed years since the last pruning. The more frequent the prunings are, the less amount of wood and primary cork obtained from them will be.

Cover photo given by the Promotion of Cork Institute (IPROCOR).

Chapter V

Data Analysis

This chapter is of great value to the conclusions the researcher is going to draw, without it the investigator will not be able to analyze all the relevant information taken from the investigation itself to finally come to end. Johnson (2011) states the importance of data analysis in his website, where he says “Data analysis is a process used to transform, remodel and revise certain information (data) with a view to reach to a certain conclusion for a given situation or problem” (pp. 1). In this case, the researcher does have a problem, or as it was called in this project a research question, which states the main problem. He adds, “Data analysis, in a research supports the researcher to reach to a conclusion. Therefore, simply stating that data analysis is important for a research will be an understatement rather no research can survive without data analysis” (pp. 1). Thus, this project does have three instruments, which are going to be essential for the investigator.

5.1 Analysis and Interpretation of the Results

This section contains the three instruments, which are used by the investigator in order to analyze every bit of data that was gathered throughout this whole project.

5.1.1 Text Analysis.

Before beginning the translation process, it is necessary as well as helpful for the translator to make an analysis of the text or texts that will be translated, this benefits the process by predicting certain aspects that the documents will contain, for example; if it is a descriptive text it will probably contain many adjectives. Other elements that this may predict are the difficulty of its vocabulary and even the formality of this vocabulary. In this case a table is used to have a better look and compare the two original documents.

Elements to analyze	Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Salt Water Culture	La Poda del Alcornocal (Quercus Suber L.). Cuantificación de sus Productos
Text Style	Descriptive	Informative
Text function or intention	Inform	Inform
Intention of the translator	Inform	Inform
Stylistic scale		
Formality	Formal	Neutral
Generality or difficulty	Technical	Educated
Emotional Tone	Factual	Factual
Translation Method	Communicative	Communicative

Table 5 shows the text analysis of both documents

5.1.2 Color-coding.

When the translator has already finished making a text analysis, the translation process begins with this previously gathered information from the investigator. After having finished the translation, it is time for the color coding process. This step is of great importance for the translation process due to the fact that it helps the translator to have a visualization of what was done in the translation, how many techniques were used and why others were not used, so that the translator can make any arrangement or decide whether the way it was done is the right one. For this project a table containing all six techniques is used, these techniques are transposition, modulation, omission, amplification, explicitation and finally literaly translation, with their respective color, yellow, green, turquoise, grey, purple and red. These colors where chosen in this way to make the distinction of the procedures easier to observe for the readers.

Transposition
Modulation
Omission
Amplification
Explicitation
Literal Translation

Table 6 shows the color for each translation techniques

5.1.2.1 Translation from English to Spanish

Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Salt Water Culture

Paragraph 1

Fertilized eggs of the Nile tilapia (Oreochromis niloticus L.) spawned in freshwater were removed from mouthbrooding females one day post-spawning and artificially incubated at elevated salinities. Mortality during artificial incubation occurred primarily during early development and generally increased with increasing incubation salinity. At six days post-hatching, mean survivals of 85.5, 84.4, 82.5, 56.3, 37.9, 20.0 and 0% were recorded for broods incubated at salinities of 0, 5, 10, 15, 20, 25 and 32 ppt, respectively. Fertilized eggs exhibited a 96-hour median lethal salinity (MLS-

96) of 18.9 ppt, identical to that of 7 to 120-day old fry and fingerlings. Fertilized eggs, however, exhibited a much higher median survival time (ST_{50} = 978 min) than 7 to 395-day old fry and fingerlings (ST_{50} = 28.8 - 179.0 min), reflecting the ability of eggs to survive direct seawater transfer for longer periods of time than fry or fingerlings.

Los huevos fertilizados de la tilapia del Nilo (Oreochromis niloticus L.) desovados en agua dulce fueron removidos de las hembras con incubación bucal un día después del desove y artificialmente incubados en salinidades elevadas. La mortalidad durante la incubación artificial ocurrió principalmente en el desarrollo prematuro y generalmente incrementaba con el aumento en la salinidad de la incubación. A los seis días luego de la eclosión, los promedios de supervivencia del 85.5, 84.4, 82.5, 56.3, 37.9, 20.0, y 0% fueron registrados para crías incubadas en salinidades del 0, 5, 10, 15, 20, 25 y 32 ppm, respectivamente. Los huevos fertilizados mostraron un promedio letal de salinidad a las 96 horas (SLM-96) de 18.9 ppm, idéntico al de pececillos y alevines de 7 a 120 días de edad. Sin embargo, los huevos fertilizados mostraron un tiempo de supervivencia media mucho más alto (TS_{50}= 978 min) que los pececillos y alevines de 7 a 395 días de edad (TS_{50} = 28.8 – 179.0 min), lo cual refleja la habilidad de los huevos para sobrevivir a la transferencia directa al agua salada por periodos más largos que los pececillos o alevines.

Paragraph 2

The reproductive performance of yearling O. niloticus broodstock was monitored under laboratory conditions at various salinities and results compared with the performance of an older (two to three-year) broodstock in freshwater. Spawning was observed in salinities ranging from freshwater to full seawater (32 ppt). Mean hatching successes were similar for eggs spawned by yearling females in freshwater (30.9%), 10 ppt (32.7%) and 15 ppt (36.9%). Extremely poor hatching success was obtained with eggs spawned in full seawater. Mean hatching success was considerably higher for eggs spawned at 5 ppt (51.6%) and compared with that obtained with eggs spawned by older females in freshwater (54.2%). Seasonal egg and fry production per female was much greater in the older broodstock in freshwater than in yearling females in any salinity.

El rendimiento de la población reproductora de *O. niloticus* de un año de edad fue monitoreado bajo condiciones de laboratorio en varias salinidades y fue comparado con los resultados del rendimiento de la población reproductora de mayor edad (de dos a tres años) en agua dulce. El desove fue observado en salinidades que oscilan desde agua dulce hasta agua de mar (32 ppm.). El promedio de éxitos en la eclosión fue similar al de los huevos desovados por hembras de un año de edad en agua dulce (30.9%), en 10 ppm (32.7%) y en 15 ppm. (36.9%). Un éxito extremadamente bajo en la eclosión fue obtenido con huevos desovados en agua de mar. El promedio de éxito en la eclosión fue considerablemente más alto para huevos desovados en 5 ppm (51.6%) y fue comparado con el obtenido en huevos desovados por hembras de mayor edad en agua dulce (54.2%). La producción estacional de pececillos y huevos por hembra fue mucho más alta en la población reproductora de mayor edad en agua dulce que la de hembras de un año de edad bajo cualquier salinidad.

Paragraph 3

The salinity tolerance of fry spawned at various salinities and fry spawned in freshwater but hatched at various salinities, was determined using the median survival time (ST60), mean survival time (MST) and 96-hour median lethal salinity (MLS-96) indices. For comparative purposes, fry spawned and hatched in freshwater were acclimatized to various salinities and their salinity tolerances likewise determined. Fry salinity tolerance progressively increased with increasing salinity of spawning, hatching, or acclimatization. However, at equivalent salinity, early exposure (spawning) produced progeny of comparatively higher salinity tolerance than those spawned in freshwater and hatched at elevated salinity. Similarly, at equivalent salinity, progeny spawned in freshwater but hatched at elevated salinity exhibited higher salinity tolerance than those spawned and hatched in freshwater, then acclimatized to an elevated salinity.

La tolerancia a la salinidad de pececillos desovados en varias salinidades y pececillos desovados en agua dulce, pero eclosionados en varias salinidades, fue determinada usando los índices de: el tiempo medio de supervivencia (TS_{50}), el tiempo de supervivencia promedio (TSP) y la salinidad letal mediana de 96 horas (SLM-96). Para fines comparativos, los pececillos desovados y eclosionados en agua dulce fueron aclimatados a varias salinidades y su tolerancia a la salinidad, también fue determinada. La tolerancia a la salinidad de los pececillos incrementó progresivamente con la creciente salinidad de desove, eclosión o aclimatación. Sin embargo, en una salinidad equivalente, la exposición temprana (el desove) produjo una descendencia de comparativamente mayor tolerancia a la salinidad que la de los desovados en agua dulce y eclosionados en una salinidad elevada. En forma similar, en una salinidad equivalente, la descendencia desovada en agua dulce, pero eclosionada en una salinidad elevada mostró una mayor tolerancia a la salinidad que la descendencia desovada y eclosionada en agua dulce y luego aclimatada en una salinidad alta.

Paragraph 4

The general approach to saltwater tilapia culture has been to produce seed and juveniles in freshwater, followed by growout in brackishwater or seawater. In an earlier study (Watanabe et al.,1984), ontogenic changes in salinity tolerance were observed in several tilapia species. In Oreochromis niloticus and O. aureus, salinity tolerance increased from relatively low values over the initial 45 to 60 days post-hatching, to maximal values from 150 to 180 days post-hatching. Hybrid progeny of O. mossambicus (♀) and O. niloticus (♂) exhibited a comparatively faster rate of increase in tolerance with age. These ontogenic changes in salinity tolerance were determined to be more closely related to body size than to chronological age.

El enfoque general hacia la crianza de tilapia en agua salada tiene como propósito el producir descendencia y alevines en agua dulce, seguido de criaderos en agua salobre o agua de mar. En un estudio previo (Watanabe et al., 1984) se observaron cambios ontogénicos en la tolerancia a la salinidad en varias especies de tilapia. En Oreochromis niloticus y O. aureus, la tolerancia a la salinidad incrementó desde valores relativamente bajos sobre la posteclosión inicial de 45 a 60 días, a valores máximos desde 150 a 180 días posteclosión. La descendencia híbrida del O. mossambicus (♀) y el *O. niloticus* (♂) mostraron una velocidad creciente de tolerancia, comparativamente más rápida con la edad. Estos cambios ontogénicos en la tolerancia a la salinidad fueron determinados al estar más estrechamente relacionados con el tamaño del cuerpo que con la edad cronológica.

Paragraph 5

An alternative approach to the problem of saltwater tilapia culture is to expose the fish to low concentrations of seawater at very early stages of their life cycle in order to pre-adapt them to subsequent rearing at higher salinities. This approach may involve, for example, the exposure of freshwater-spawned and hatched progeny to elevated salinities soon after hatching. Exposure may be performed at an even earlier stage of development by removing fertilized eggs from the mouth of the parent female for artificial incubation and hatching at elevated salinities. Alternatively, if successful spawning is achieved at elevated salinities, the eggs are exposed to a saline environment immediately after oviposition when they leave the ovarian fluid.

Un enfoque alternativo para el problema de la crianza de tilapia en agua de mar es exponer a los peces a bajas concentraciones de agua de mar en etapas muy tempranas de sus ciclos de vida, para así preadaptarlos a la posterior crianza en salinidades altas. Este enfoque puede involucrar, por ejemplo, la exposición de la descendencia desovada y eclosionada a salinidades elevadas poco después de la eclosión. La exposición puede ser ejecutada en una etapa de desarrollo, incluso más temprana, removiendo los huevos fertilizados de la boca de la madre para su incubación artificial y eclosión en salinidades elevadas. Opcionalmente, si el desove es logrado con éxito en salinidades elevadas, los huevos son expuestos a un ambiente salino inmediatamente después de la oviposición, cuando dejan el fluido ovárico.

Paragraph 6

At 40 days following initiation of acclimatization (272 days post-hatching), one female in the seawater-acclimatized group (length, weight: 9.6 cm, 12.6 g) was observed to be mouthbrooding eggs. The eggs were removed from the mouth of the female and artificially incubated in seawater (32 ppt.) although no embryonic development was observed. At 118 days, following initiation of acclimatization (350 days post-hatching), another female in the seawater-acclimatized group (length, weight: 10.0 cm, 16.0 g) was observed mouthbrooding. No embryonic development was observed during artificial incubation. One female in the freshwater control group (length, weight: 11.0 cm, 18.8 g) was observed to be mouthbrooding eggs at 312 days post-hatching, although eggs were not removed for artificial incubation.

A los 40 días posteriores a la iniciación de la aclimatación (272 días luego de la eclosión), se observó a una hembra en el grupo de aclimatados en agua de mar (longitud, peso: 9.6cm, 12.6g) incubando huevos bucalmente. Los huevos fueron removidos de la boca de la hembra y se incubaron artificialmente en agua de mar (32 ppm), a pesar de que ningún desarrollo embrionario se observó. A los 118 días luego de la iniciación de la aclimatación (350 días luego de la eclosión), otra hembra en el grupo de aclimatados en agua de mar (longitud, peso: 10.0cm, 16.0g) fue observada incubando bucalmente. Ningún desarrollo embrionario fue observado durante la incubación artificial. Una hembra en el grupo de control de agua dulce (longitud, peso: 11.0cm, 18.8g) fue vista incubando huevos bucalmente a los 312 días luego de la eclosión, aunque los huevos no fueron removidos para su incubación artificial.

Paragraph 7

Seawater-acclimatized individuals (mean initial length, weight: 9.9 cm, 16.6 g) were subsequently distributed to salinities of 32, 15, 10, and 5 ppt. and their reproductive performance monitored parallel to that of the freshwater controls. Spawnings were conducted in indoor 120-l glass aquaria at 27.0-30.2°C, under natural photoperiod conditions. Semi-closed system conditions were employed as described earlier. Approximately one-third of the tank volume was replaced with conditioned water of equivalent salinity each week. Three individually-tagged females and three males were maintained in each aquarium. Each tank was observed daily for spawning activity. Whenever a female was observed to be mouthbrooding, spawner and spawn date were recorded.

Los individuos aclimatados en agua de mar (longitud media inicial, peso: 9.9cm, 16.6g) fueron distribuidos posteriormente a salinidades de 32, 15,10 y 5 ppm y su desempeño reproductivo fue monitoreado paralelo al de los grupos de control de agua dulce. Los desoves fueron llevados a cabo en acuarios de vidrio de 120l bajo techo a 27.0-30.2Cº, bajo condiciones de fotoperiodo natural. Se emplearon los sistemas semicerrados descritos anteriormente. Aproximadamente, un tercio del volumen del tanque fue reemplazado cada semana con agua condicionada de la misma salinidad. Tres hembras y tres machos etiquetados individualmente fueron mantenidos en cada acuario. Cada tanque se observó diariamente, en caso de cualquier actividad de desove. Cuando una hembra fuese observada incubando bucalmente, se registró el desovador y la fecha de desove.

Paragraph 8

Median Lethal Salinity-96 hours (MLS-96) defined as the salinity at which survival falls to 50% 96 hours following direct transfer from the salinity to which the brood had been pre-exposed (during spawning, hatching, or acclimatization) to varying test salinities (0, 7.5, 15, 17.5, 20, 22.5, 25, 27.5, 30 and 32 ppt). A sample of 25-30 individuals was weighed and measured in order to establish mean body length, weight and condition factor of the experimental brood. Individual fish were blotted with tissue before weighing. Total length was determined to the nearest 0.01 cm. Condition factor (K) was calculated from the formula ($K = W/L^3 \times 100$), where W denotes weight in grams and L denotes total length in centimeters.

Salinidad Letal Mediana-96 horas (SLM-96), definida como la salinidad a la que la supervivencia cae a un 50% a las 96 horas luego de la transferencia directa a la salinidad a la que la población de crías había sido previamente expuesta (durante el desove, eclosión o aclimatación) a varias pruebas de salinidad (0, 7.5, 15, 17.5, 20, 22.5, 25, 27.5, 30 y 32 ppm). Una muestra de 25-30 individuos fue pesada y medida a fin de establecer la longitud media del cuerpo, el peso y el factor de condición de la población de crías experimental. Cada pez se secó con pañuelos de papel antes de pesarse. La longitud total fue determinada al 0.01cm más cercano. El factor de condición (K) fue calculado con la fórmula ($K=P/L^3$ X 100), donde P denota el peso en gramos y L la longitud total en centímetros.

Paragraph 9

Although total egg production was greater at 10 ppt, total fry production was greatest at 5 ppt, due to the improved hatching success at 5 ppt. Seasonal egg production per female was much greater for larger, older breeders in freshwater than for yearling breeders in any salinity. However, seasonal egg production per g body weight was greater for yearling breeders in brackish salinities than for older breeders in freshwater. Seasonal fry production per g body weight was also greater for yearling females in brackish salinities than for older females in freshwater. These results suggest that for a given total weight of fish, smaller, yearling females in brackish salinities of up to 15 ppt will produce a greater number of eggs and fry than larger females in freshwater.

Aunque la producción total de huevos fue más grande en 10 ppm, la producción total de pececillos fue más grande en 5 ppm, debido a la mejora en el éxito de eclosión en 5 ppm. La producción de huevos estacional por hembra fue mucho mayor para individuos reproductores más grandes, mayores en edad y en agua dulce que para individuos reproductores de un año de edad en cualquier salinidad. Sin embargo, la producción estacional de huevos por gramos de peso corporal fue mayor para individuos reproductores de un año de edad en salinidades salobres que para reproductores de mayor edad en agua dulce. La producción estacional de pececillos por gramo de peso corporal también fue mayor para las hembras de un año de edad en salinidades salobres que para hembras de mayor edad en agua dulce. Estos resultados sugieren que el peso total de un pez (más pequeño) hembra de un año de edad en salinidades salobres de hasta 15 ppm producirá un mayor número de huevos y pececillos que hembras más grandes en agua dulce.

Paragraph 10

Corresponding ST_{50}, MST and MLS-96 values for these six to nine-day old fry spawned at various salinities are also presented in Table 4. ST_{50} and MLS-96 values were derived from generalized survivorship patterns as described earlier. Fig. 5 illustrates generalized survivorship patterns for six to nine-day old saline water-spawned fry 96 hours following direct transfer from the spawning salinity to various salinities. MLS-96 increased from 19.2 ppt for broods spawned in freshwater to greater than 32 ppt for broods spawned in 15 ppt. The patterns of these changes are very similar to those described earlier for freshwater-spawned, saline water-hatched fry (Fig. 3). As Fig. 5 shows, increasing MLS-96 with increasing spawning salinity is also related to an elevation of the salinity of incipient mortality and an increase in the salinity range between incipient and final mortality.

Los valores correspondientes de TS_{50}, TSP y SLM-96 para estos pececillos de seis a nueve días de edad desovados en varias salinidades también se presentan en la tabla 4. Los valores de TS_{50} y SLM-96 fueron derivados de patrones generalizados de supervivencia, tal como se describió anteriormente. La figura 5 ilustra los patrones de supervivencia generalizada para los pececillos de seis a nueve días de edad desovados en agua salina 96 horas después de la transferencia directa de la salinidad de desove a varias salinidades. El SLM-96 incrementó para poblaciones de crías desovadas en agua dulce, de 19.2 ppm a más de 32 ppm para poblaciones de crías desovadas en 15 ppm. Los patrones de estos cambios son muy similares a los descritos anteriormente en relación con los desoves en agua dulce, y los pececillos eclosionados en agua salina (Figura 3). Tal como lo muestra la figura 5, el SLM-96 creciente con la salinidad de desove creciente también están relacionados con la elevación en la salinidad de la mortalidad incipiente y un incremento en el intervalo de salinidad entre la mortalidad incipiente y la final.

Paragraph 11

Generalized survivorship patterns for broods spawned, hatched or acclimatized at identical salinities are compared in Figs. 9a, 9b and 9c, for salinities of 5, 10 and 15 ppt, respectively. As Fig. 9a shows, survivorship was similar for broods acclimatized or hatched at 5 ppt. In both groups, direct seawater transfer resulted in complete mortality within four hours. The survivorship for broods spawned at 5 ppt was distinctly different with more gradual mortality and a mean survival of 12.3% at 96 hours following transfer. At a salinity of 10 ppt, differences in survivorship between groups became more distinct (Fig. 9b). Whereas direct transfer of saline water-acclimatized broods to full seawater resulted in complete mortality within eight hours, a mean survival of approximately 28% was recorded in both the saline water-hatched and saline water-spawned broods 96 hours following transfer.

Los patrones de supervivencia generalizados para crías desovadas, eclosionadas o aclimatadas en salinidades idénticas se comparan en las figuras 9a, 9b, y 9c, para salinidades de 5, 10 y 15 ppm, respectivamente. Tal como lo muestra la figura 9a, la supervivencia fue similar para las crías aclimatadas o eclosionadas en 5 ppm. En ambos grupos, la transferencia directa al agua de mar resultó en la mortalidad completa en cuatro horas. La supervivencia de poblaciones de crías desovadas en 5 ppm fue claramente diferente con una mayor mortalidad gradual y una supervivencia media de 12.3% en las 96 horas después de la transferencia. En una salinidad de 10 ppm, las diferencias en la supervivencia entre los grupos se hicieron más visibles (Figura 9b). Mientras que la transferencia directa de crías aclimatadas en agua salina a agua de mar resultó en la mortalidad completa dentro de ocho horas, una supervivencia media de aproximadamente 28% fue registrada en ambas (en las crías eclosionadas en agua salina y en las desovadas en agua salina 96 horas luego de la transferencia).

Paragraph 12

Fig. 10 compares the relationships between salinity tolerance (MST) and spawning salinity, hatching salinity and acclimatization salinity for saline water-spawned, freshwater spawned, saline water-hatched, and freshwater-spawned, freshwater-hatched, saline water acclimatized fry, respectively. MST rose non-linearly with increasing spawning, hatching or acclimatization salinity. The relationship between MST and spawning salinity is very similar to that between MST and hatching salinity. Rate of increase in MST with acclimatization salinity was comparatively lower. It is evident from these relationships that at equivalent salinity, early exposure (spawning) produced progeny of comparatively higher salinity tolerance than those spawned in freshwater and hatched at elevated salinity.

La figura 10 compara la relación entre la tolerancia a la salinidad (TSP) y la salinidad de desove, salinidad de eclosión y salinidad de aclimatación para los pececillos desovados en agua salina, los pececillos desovados en agua dulce, los pececillos eclosionados en agua salina y los desovados en agua dulce, pececillos eclosionados en agua dulce y aclimatados en agua salina, respectivamente. El TSP no aumentó linealmente con el incremento de desove, eclosión o salinidad de aclimatación. La relación entre el TSP y la salinidad de desove es muy similar a la relación entre el TSP y la salinidad de eclosión. La tasa de aumento en el TSP con la salinidad de aclimatación fue comparativamente más baja. En estas relaciones es evidente que a una salinidad equivalente, la exposición temprana (desove) produjo descendientes con una tolerancia a la salinidad comparativamente más alta que aquellos desovados en agua dulce y eclosionados en salinidades elevadas.

Paragraph 13

The large difference in ST_{50} values exhibited by embryos and fry or fingerlings should be interpreted with some reservation, however, as embryos surviving extended periods in full seawater exhibited structural abnormalities, generally characterized by an under-development of organs.

Descriptions of developmental abnormalities resulting from the effects of salinity during egg incubation have been summarized by Holliday (1969). Nevertheless, it is remarkable that eggs spawned in freshwater may be incubated and successfully hatched at salinities as high as 25 ppt, whereas 7 to 395-day old fry and fingerlings are unable to survive direct transfer to this salinity. These results may reflect a relatively greater degree of adaptability of early embryos to high environmental salinity than fry or fingerlings.

No obstante, la gran diferencia en los valores de TS_{50} mostrados por los embriones y los pececillos o los alevines deben ser interpretados con cautela, pues los embriones que sobrevivieron periodos largos en el agua de mar mostraron anormalidades estructurales, generalmente caracterizadas por un subdesarrollo de los órganos. Holiday (1969) resumió las descripciones del desarrollo de las anormalidades resultantes de los efectos de la salinidad durante la incubación del huevo. Sin embargo, es notable que los huevos desovados en agua dulce pueden ser incubados y exitosamente eclosionados en salinidades tan altas como 25 ppm; mientras que los pececillos o los alevines de 7 a 395 días de edad no son capaces de sobrevivir la transferencia directa a esta salinidad. Estos resultados pueden reflejar un nivel relativamente mayor de adaptabilidad de los embriones prematuros a la salinidad del ambiente, que el nivel de los pececillos o los alevines.

Paragraph 14

Mean body weights, lengths and condition factors of seven-day old freshwater-spawned fry hatched at various salinities were not significantly different from those of fry hatched in freshwater. Forrester and Alderice (1966) suggested that in Pacific cod (Gadus macrocephalus), maximum larval size was associated with those salinity and temperature conditions producing maximum survival to hatching. At 5 to 7°C, maximum survival and larval size were achieved at salinities associated with least osmotic stress. It was inferred that environmental conditions allowing maximum distribution of energy to growth, while satisfying requirements for maintenance and physical activity, should maximize survival and size of larvae in a minimum period of incubation (Alderice and Forrester 1968).

Los pesos corporales, longitudes medios y factores de condición de los pececillos de siete días de edad desovados en agua dulce y eclosionados en varias salinidades no fueron significativamente diferentes de los de los pececillos eclosionados en agua dulce. Forrester y Alderice (1966) sugirieron que en el "pacific cod" (*Gadus macrocephalus*), el tamaño máximo de larvas fue asociado con estas condiciones de salinidad y temperatura, produciendo así una supervivencia máxima a la hora de eclosionar. A los 5 a 7º C el tamaño y supervivencia máximo de las larvas se lograron en salinidades asociadas con menor estrés osmótico. Por lo tanto, se dedujo que las condiciones ambientales que permitieron la distribución máxima de energía para el crecimiento, mientras cumplía con requisitos para el mantenimiento y la actividad física, deberían maximizar la supervivencia y el tamaño de las larvas en un periodo mínimo de incubación (Aldderice y Forester, 1968).

Paragraph 15

Since smaller individuals are more productive per unit weight than larger individuals, it is important for the culturist attempting to maximize broodstock productivity to determine maximum size above which egg production per unit weight begins to decline. Higher egg productivity per unit weight has little practical value, however, if spawnings are less frequent or hatching successes relatively poorer. Results of the present study indicate that seasonal egg and fry production per unit weight was greater among yearling females spawning in brackish salinities of 5 to 15 ppt than in larger females spawning in freshwater. Therefore, seasonal fry production would be expected to be greater for smaller females for a given total weight of fish, even under brackishwater conditions.

Puesto que los individuos más pequeños son más fértiles por unidad de peso que los más grandes, es importante para el piscicultor intentar maximizar la productividad de la población reproductiva para determinar el tamaño máximo por el cual la producción de huevos por unidad de peso comienza a disminuir. Sin embargo, la mayor producción de huevos por unidad de peso tiene poco uso práctico, si los desoves son menos frecuentes o si los éxitos en la eclosión son relativamente pocos. Los resultados del presente estudio indican que la producción de huevos y pececillos estacional por unidad de peso fue mayor entre las hembras de un año de edad que desovaron en salinidades salobres de 5 a 15 ppm que en hembras más grandes que desovaron en agua dulce. Por lo tanto, la producción estacional de pececillos se esperaría que fuera mayor para las hembras de menor tamaño por un peso total en ellas, incluso en condiciones de agua salobre.

5.1.2.2 Translation from Spanish into English

La poda del Alcornocal (Quercus Suber L.). Cuantificación de sus Productos

Paragraph 1

La poda del alcornocal sigue siendo un tema de permanente controversia, tanto en el plano de las ideas como en el de las aplicaciones prácticas. La investigación en España no ha aportado información suficiente, ni siquiera para poder opinar de forma objetiva y racional sobre este importante hecho selvícola y económico que está totalmente integrado en el aprovechamiento habitual de los alcornocales de Extremadura y norte de Huelva y Sevilla. En los alcornocales de Cádiz, Málaga y Cataluña no es habitual la práctica de la poda. En Portugal se hicieron algunas experiencias en la Estación de Experimentación de Alcornoque, entre los años 1930 y 1940, para intentar cuantificar sus efectos sobre el crecimiento del árbol y sobre la producción de corcho y bellota. Los resultados están publicados en los trabajos de Vieira (1932, 1937, 1938 y 1950) y Brito Dos Santos y Rodríguez (1975).

Pruning of cork oak remains as a subject of permanent controversy, in both theory and its practical application. The research in Spain has not contributed with enough information, not even to be able to judge objectively and rationally this important forestry and the economic fact that is totally integrated to the regular use of the cork oaks of Extremadura, north Huelva, and Sevilla. In the cork oak woodlands Cádiz, Málaga and Cataluña pruning is not usual. In Portugal, some experiments were made in the Cork Oak Experimental Station between the years of 1930 and 1940, in order to quantify its effects on the growth of the tree and the production of cork and its acorn. The results are published in the works of Vieira (1932, 1937, 1938 and 1950), Brito Dos Santos, and Rodrigues (1975).

Paragraph 2

Este estudio se planteó de forma marginal dentro de un estudio más amplio encaminado a conocer la producción y los mecanismos de regeneración del monte alcornocal. Su publicación parece interesante por cuanto puede ayudar a cuantificar la producción de las podas, que sean realizadas con cierta prudencia, y siempre teniendo en cuenta la dificultad que supone efectuar una correcta estimación cuantitativa y cualitativa de las leñas y bornizo obtenido, ya que depende de variables tales como intensidad de la poda, años transcurridos desde la última e intensidad de la misma, tamaño de las ramas cortadas, etc., que son de difícil medición.

This study was planned secondarily within a much broader study led to know the production and mechanisms of regeneration of the cork oak woodland. Its publication seems interesting, since it can help to quantify the production of the prunings that are carried out prudently, and always taking into account the difficulty involved in making the correct quantitative and qualitative estimate of the wood and primary cork obtained, since it depends on variables such as pruning intensity, years elapsed since the last pruning and intensity, size of the cut branches, etc., which are difficult to measure.

Paragraph 3

La poda de formación, poco practicada en alcornocales, tiene un alto interés económico a largo plazo, pero su falta de rentabilidad inmediata la hace poco atractiva para los propietarios. En muchos alcornocales se observa un alto porcentaje de árboles con fustes defectuosos, torcidos, con ramas muy bajas, mala disposición de las ramas de primer orden que no permiten subir la altura de descorche, etc. Esta mala configuración de la superficie potencialmente descorchable reduce la producción, eleva los costos de extracción del corcho, hace imposible la extracción de panas planas y de bordes rectos, que permitan un mejor aprovechamiento del corcho taponable, y aumenta el porcentaje de refugo, debido al pequeño tamaño y a la irregularidad geométrica de las panas.

Shape pruning, rarely practiced in cork oak acorns, has a long-term high economic interest; however, its lack of immediate profitability does not make it very attractive for the owners. In many acorns it is observed a high percentage of trees with defective, bent, really low limps, and poor disposition of first order limps that do not allow to reach the height of the uncork tree area, etc. This poor surface shape, potentially uncorkable, reduces the production, raises the cost of cork extraction, makes impossible the extraction of flat and straight edged cork planks, that allow a better utilization of cork bottle stoppers, and increases the percentage of defects, due to the small size and to the geometrical irregularity of the planks.

Paragraph 4

La poda debe iniciarse en árboles muy jóvenes para evitar malformaciones incorregibles, pero esta forma de proceder puede ser perjudicial si no existe acotamiento al ganado, pues los pequeños árboles podados son doblados con frecuencia por cabras y vacas para comer el ramón de su pequeña copa, causando mayores daños que en las masas no apostonadas y podadas. En las repoblaciones y lugares acotados conviene quitar las ramas bajas, a partir de 3-4 años de edad, con unas tijeras de podar. Si la guía principal se ha perdido, se elige una rama lateral como nueva guía. Las plantas jóvenes muy torcidas se acaban enderezando con el tiempo si son bien podadas y guiadas, y las pequeñas heridas cicatrizan con facilidad.

Pruning must be initiated in very young trees to avoid irreparable malformations, but this way of proceeding can be harmful if restriction of the cattle does not exist, since the small pruned trees are frequently bent by goats and cows to eat the branches of its small crown, causing further damages than in the apostatized and pruned masses. When the tree is about 3 to 4 years old, it is convenient to remove low-positioned branches in the resettlements and in delimited places with pruning scissors. If the main guide has been lost, a lateral branch is chosen as the new guide. The young and very twisted plants end up entangled with time if they are not well pruned and guided, and the small scars will heal easily.

Paragraph 5

Está demostrado que la producción de bellota se ve favorecida por la presencia de nuevos y vigorosos brotes en la zona periférica de la copa (no de brotes chupones o ladrones). El principal efecto que produce la poda consiste, justamente, en estimular la emisión de nuevos y más vigorosos brotes, al concentrar toda la capacidad productora del árbol en unas cuantas ramas seleccionadas. El desequilibrio se restablece en pocos años, pues la biomasa de la copa va aumentando y parece que el sistema radical se reduce en proporción a la reducción que la poda provocó en la copa (Vieira 1937). Cuando el equilibrio se alcanza de nuevo se ralentiza el crecimiento de los brotes y la producción de bellota por unidad de superficie de copa vuelve a estabilizarse en la cuantía original existente antes de la poda; en este estado se hace necesario realizar una segunda poda, que habrá de ser repetida periódicamente.

It is confirmed that the production of the acorn is favored by the presence of new and vigorous sprouts on the peripheral zone of the crown (not sucker or thief sprouts). The main effect of the pruning is precisely to stimulate the growth of new and more vigorous sprouts, by centering all the production capability of the tree to just a few selected branches. The imbalance is reestablished in a few years, because the biomass of the crown increases and it seems that the radical system decreases in proportion to the reduction that the pruning provoked on the crown (Vieira, 1937). When the balance is achieved again, the growth of the sprout is slowed down and the production of acorn per unity of the surface of the crown is established again in the existing original amount before the pruning. In this period of time, it becomes necessary to perform a second pruning, which must be repeated periodically.

Paragraph 6

El rebrote vigoroso se produce, en parte, por la concentración de nutrientes en un menor número de ramas; por la eliminación de ramos asombrados y debilitados, cuyo balance energético puede ser negativo, al gastar más en el proceso de respiración que lo que aportan por asimilación; y, fundamentalmente, a costa de las reservas acumuladas en el resto del árbol. Por consiguiente, si la poda es muy intensa se convierte en un proceso de debilitación del árbol, ya que tras el desequilibrio inicial concentra casi todo su potencial en restablecer el equilibrio foliar con la emisión de nuevos brotes, y solo cuando este es alcanzado comienza el proceso de acumulación en los tejidos de reserva.

Vigorous regrowth is produced; partly, by the concentration of nutrients in a smaller number of branches, by the elimination of shadowy and weakened branches (which energetic balance can be negative), by spending more energy in the process of breathing than what is contributed through the assimilation; and, fundamentally, at the expense of the accumulated reserves in the rest of the tree. Therefore, if the pruning is too intense, it becomes a process that weakens the tree, as after the initial imbalance it concentrates almost its full potential in reestablishing the leaf balance with the emission of new sprouts, and only when this is reached it begins the process of accumulation on the reserve tissues.

Paragraph 7

Desde el punto de vista de la producción de fruto, la poda excesiva no es tampoco una operación aconsejable, y nunca puede justificarse como un sistema racional y económico de regularizar la producción de fruto, pues es un hecho aceptado que solo en muy pequeña medida logra los objetivos de fructificación que algunos ponen como pretexto para su realización. Son bien conocidos, y ampliamente divulgados por algunos autores portugueses, muchos de sus inconvenientes, tales como que disminuye considerablemente la superficie de producción de fruto, con lo cual el efecto visible de una mayor abundancia de bellota en las pocas ramas que quedan no está demostrado que se corresponda con una mayor producción total. No se conoce ningún trabajo que compare la producción de bellota en árboles intensamente podados y en árboles podados moderadamente e incluso sin podar. El resultado es probable que deparase sorpresa a la, algunas veces interesada, creencia popular.

From the point of view of the fruit production, excessive pruning is also not an advisable operation and it can never be justified as a rational and economic system to regulate the fruit production, because it is an accepted fact that only in a small part accomplishes the fructification objectives that some people make as an excuse for its realization. They are well known and widely disclosed by some Portuguese authors, many of its inconveniences, such as it diminishes considerably the fruit production surface, with the visible effect of a higher abundance of acorn in the few branches that are left, it is not demonstrated that are correspondent to a higher total production. No work is known to compare the production of acorn in intensely pruned trees and in moderately pruned trees, and even trees without being pruned. The result is probably surprising, to the sometimes interested, popular believe.

Paragraph 8

Si las podas son frecuentes, la mayoría de los brotes «chupones o ladrones» son cortados en la próxima poda, antes de haber producido bellota en abundancia y cuando muchos de ellos aún tienen una pequeña proporción de bornizo. A estos brotes que se cortan en la siguiente poda y que se han formado principalmente a expensas de las sustancias que el árbol ha ido almacenando durante años se les saca una escasa producción real (bellota y bornizo), con lo cual todo parece indicar que se está siguiendo un proceso de auténtico despilfarro del capital acumulado. Si, por el contrario, en la siguiente poda se cortan las ramas gruesas que quedaron después de la poda anterior y se dejan los brotes jóvenes para que fructifiquen y produzcan bornizo, se está realizando un sistema parecido al de aprovechamiento de brotes de cepa, aunque el recepe se produzca a dos o tres metros de altura (trasmocho). Este sistema, parte de que tendría que ser regulado y estudiado su turno con base en la técnica de aprovechamiento de los tallares o monte bajo, en el sentido forestal de la palabra, no creemos que nadie pueda defenderle como método de aprovechamiento de nuestros alcornocales.

If pruning is frequent, the majority of the sprouts (suckers or poachers) are cut in the next pruning, before it has produced acorn in abundance and when many of them still have a small portion of primary cork. From the sprouts that are cut in the next pruning and that were formed primarily at the expense of the substances that the tree has stored throughout the years, it is taken off a scarce real production (acorn and primary cork), thus everything seems to indicate that a process of authentic waste of the accumulated capital is been followed. If, on the contrary, in the next pruning the thick branches left from the last pruning are cut and the young sprouts are left to bear fruit and to produce; although it is performed a system similar to the utilization of crown sprouts; pruning is produced at two or three meters of height. This system starts off from the fact that it would have to be regulated and studied based on the technique of exploitation of cuts or scrub, in the forest sense of the word, we do not believe that anybody can defend it as a cork oak exploitation method.

Paragraph 9

Si los que suponen la poda excesiva como una operación cultural defendible, consagrada por la práctica y por la experiencia de muchos años; si los que ven benévolamente esta devastación tremenda, como dictada por el estudio y observación del podador, por la sabiduría acumulada en el correr de los tiempos, y como traducción de una necesidad de los arboles; en fin, si los partidarios de la poda excesiva descienden a los orígenes de tan nefasta práctica y analizan su evolución, verificaran, tristemente, que se trata del simple uso transformado en abuso. Donde buscaban el viejo saber de la experiencia y los hechos solo encontraran maliciosa imprudencia.

If those who consider excessive pruning as a defensible cultural operation, consecrated by the practice and experience of many years; if those who see this tremendous devastation benevolently, as dictated by the study and observation of the pruner, by the accumulated wisdom over time, and as an interpretation of the necessity of the trees; anyway, if excessive pruning followers go back to the origins of such a disastrous practice and analyze its evolution, they will see; sadly, that it is about the simple use transformed into abuse. Where they were looking for the old knowledge of experience and the facts, they will only find vicious recklessness.

Paragraph 10

Los datos de la muestra proceden de un proyeto de Investigación del I.F.I.E.-I.N.I.A., iniciado y dirigido en su primera fase por Gonzalez Aldama y Curras y finalizado por Montoya y Montero. Este proyecto estaba encaminado a conocer las normas selvicolas más idóneas para conseguir un incremento de la producción y de la regeneración natural de los montes alcornocales, así corno una mejora de la calidad de los corchos. Después de recorrer detenidamente cada una de las zonas (sierra de San Pedro, sierra Norte de Sevilla y los montes de Cádiz y Málaga), se instaló una parcela de experiencias en cada una de ellas, en aquellos montes que se creyó que eran más representativos del conjunto. Esta forma de elección que puede parecer poco ortodoxa desde el punto de vista estadístico es una práctica frecuentemente usada en los estudios forestales, y está avalada por la eficiencia de sus resultados en numerosos trabajos.

The sample data proceed from an I.F.I.E-I.N.I.A. Investigation Project, started and directed in its first phase by González Aldama and Curras, and it was finalized by Montoya and Montero. This project was aimed to meet the most suitable forestry guidelines to obtain an increase of the production and natural regeneration of the cork oak fields, as well as an improvement of the quality of the corks. After thoroughly covering each of the zones (San Pedro, Norte de Sevilla mountain ranges, and the mounts of Cádiz and Málaga), it was installed an experience plot in each one of them; that is in the areas that were thought to be more representative for the whole. This way of selection that might look unorthodox from the statistical point of view, is a practice frequently used in forestry studies, and it is endorsed by the efficiency of its results in numerous works.

Paragraph 11

Este tipo de podas ofrecen rentas inmediatas pequeñas y pueden llegar a no cubrir costos, y este es el aspecto más grave del problema, porque mientras que el propietario pueda realizar podas de suficiente intensidad para que la renta de sus productos le reporte unos beneficios netos, será ocioso que nadie intente convencerles de que los inconvenientes o ventajas que en el futuro pueda reportarle la realización de podas menos intensas o moderadas deben guiar su actuación inmediata. Para la solución del problema habrá que poner de acuerdo los intereses selvícolas a largo plazo con los inmediatos económicos, buscando un sistema que permita al propietario obtener algún beneficio causando el mínimo perjuicio al arbolado. Estos criterios, y no razones exclusivamente selvícolas, han servido de base para realizar las podas cuyos resultados exponemos a continuación.

This kind of pruning offers small immediate incomes and it may not cover the costs. This is the most serious aspect of the problem, because as long as the owner can perform prunings of enough intensity so the income of its products generate some net benefits, it would be idle that nobody might try to convince them that the inconveniences or advantages that the performance of less intense or moderate prunings might bring in the future should guide their immediate intervention. For the solution of the problem there would have to be a long-term agreement on the forestry interests with the immediate economic ones, searching for a system that allows the owner to obtain a benefit causing the minimum damage to the woodland. These criteria, and not exclusively forestry reasons, have been used as a base to perform prunings whose results are exposed as follows.

Paragraph 12

El tipo de poda aplicada consistió, en general, en eliminar las ramas bajas (sobaqueras o cabriteras), siempre que ello fue posible, reducir el diámetro de la copa, dejar algunas ramas dirigidas hacia el centro de la copa con objeto de conseguir el asombramiento de las ramas de primer orden y un porte redondeado de la copa del árbol. Para evitar pudriciones se respetaron las ramas cuyo corte quedase horizontal (al cielo) o presentasen peligro de acumulación de aguas de lluvia. Se procuró, especialmente, conseguir un equilibrio en la constitución de la copa, dejando en cada rama de primer orden una cantidad de follaje «proporcional» a su diámetro máximo que debían tener las ramas a cortar, siguiendo el criterio general de no cortar ramas con más de 20 centímetros en la base, ni aquellas que estuviesen insertadas en ramas descorchadas. A las ramas que quedaron se les hizo una limpieza de ramallos secos, debilitados, etc. (Curras, 1972).

The applied pruning type consisted, in general, on eliminating the low branches (angled branches), whenever this was possible, reducing the diameter of the crown to leave some branches directed to the center of the crown with the objective of achieving placing shadow on the first order branches and a rounded posture of the tree's crown. To avoid rotting, it was left the branches whose cut was horizontal (towards the sky) or showed danger of rain water accumulation. It was specially ensured, to achieve a balance in the crown's constitution, by leaving in each first order branch a quantity of foliage that was proportional to its maximum diameter that the branches to be cut should have, following the general criteria of not cutting the branches which are 20 cm long from the base, nor those that were inserted in uncork branches. The remaining branches were cleaned from dry, weakened, etc. rambling. (Curras, 1972).

Paragraph 13

La intensidad de la poda en esta especie es difícil de cuantificar, y depende de la cantidad de ramas que tenga el árbol antes de la poda y del porcentaje de ramas que se cortan al efectuarla. En términos de porcentaje de ramas se intentó no sobrepasar el 20-25 por ciento, acercándose al 30 por ciento solamente en algún árbol que por la configuración o deformación de su copa se creyese aconsejable para su desarrollo futuro. La fracción de cabida cubierta (medida árbol a árbol, antes y después de la poda) se redujo en un 30 por ciento. Esta fuerte reducción se debió más al tipo de poda que a la intensidad de la misma. Una regla internacionalmente admitida por los especialistas es que la intensidad ideal de una poda es aquella a la que el árbol responde no echando ninguno o muy pocos brotes «chupones». En este caso solo un 8-10 por ciento de los árboles brotaron con relativa intensidad, lo cual indica que en ellos la poda fue excesiva; en el resto, o no salieron brotes chupones o salió alguno muy débilmente, por lo que puede deducirse que en ellos la intensidad de la poda fue la correcta.

The intensity of pruning in this species is difficult to quantify, and it depends on the quantity of the branches that the tree has before the pruning and the percentage of branches that are cut at time of performing the pruning. In terms of percentage, it was attempted not to surpass the 20-25 percent, only approaching the 30 percent in some trees, because of its crown shape or deformation, it was believed to be advisable for its future development. The fraction of covered space (measured tree by tree, before and after the pruning) was reduced by 30 percent. This strong reduction was due more to the type of pruning than to its intensity. A rule internationally admitted by the specialists, is that the ideal intensity of a pruning is the one in which the tree responds by not sprouting any or just a few "suckers." In this case, only 8-10 percent of the trees sprouted relatively intense, which indicates that pruning was excessive in those trees; in the rest, therefore either no sucker sprouts or there were some very weak, so it can be deduced that in them the intensity of the pruning was the correct one.

Paragraph 14

Para la determinación de estos porcentajes se hicieron cinco (5) lotes de 100 kg de leña con bornizo, procurando coger ramas de todos los diámetros y de distintos árboles. Las ramillas delgadas (gavilla) procedentes de los 100 kg de leña se pesaron aparte para determinar cuantos kilos de gavilla se producen por cada 100 kg de leña con bornizo, y este porcentaje se aplicó a cada uno de los árboles de la muestra para determinar el peso de gavilla producido por cada árbol. Posteriormente se desbornizaron los 100 kg de leña y se pesó, por un lado, la leña sin bornizo, y por otro el bornizo, así determinamos el porcentaje de bornizo en leña.

Five (5) plots of 100 kg of wood with primary cork were made to determine these percentages, making sure of grabbing branches of all diameters and of different trees. Thin twigs (sheaf) coming from the 100 kg of wood were weighed separately to determine how many kilograms of sheaf are produced per 100 kg of wood with primary cork, and this percentage was applied to each tree of the sample to determine the weight of sheaf produced per tree. Later, it was taken off the primary cork from the 100 kg of wood and then weighed, in one side the wood without primary cork and in the other the primary cork alone, in this way is how we determined the percentage of primary cork in the wood.

Paragraph 15

El alcornoque puebla las abruptas laderas de las serranías antes citadas, extendiéndose en ellas desde el nivel del mar a los 1.300 m de altitud. Alcanza buen porte y desarrollo, con fustes esbeltos y copas más bien recogidas. La espesura es muy variable de unos alcornocales a otros a causa de las irregularidades del relieve y los suelos, que hacen que se distingan perfectamente los alcornocales de «bujeo»; los de «pedriza», con árboles más pequeños, más claros, con mucho matorral y sin la presencia de Quercus canariensis Willd; y los de «canuto», con árboles esbeltos, y abundantes pies de

Quercus canariensis Willd. La poda es poco frecuente en esta zona y nunca se hacen podas tendentes a abrir la copa para favorecer la frutificación.

The cork oak is located in the abrupt slopes of the mountain ranges mentioned before, spreading from the sea level to 1300m of altitude. It reaches good posture and development, with thin shafts and well gathered up crowns. The thicket is very variable from some cork oaks to others due to the irregularities of the relief and the grounds that make the "buoy" and "stony" cork oaks perfectly distinguishable with the smaller, clearer, with lots of scrub, and without the presence of *Quercus canariensis* Willd trees and the "Canute" ones with thin trees and abundant feet of *Quercus canariensis* Willd. The pruning is less frequent in this area and there are never performed tending prunings to open the crown to benefit fructification.

5.1.3 Glossary

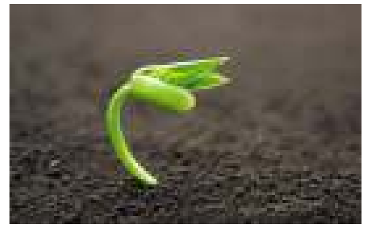
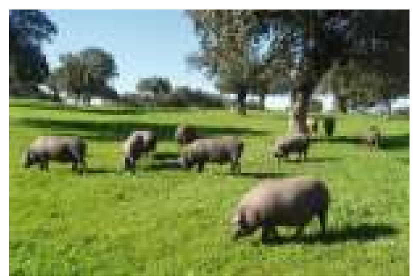
Glossaries are not only important to the translator but also to the future readers of these translated documents. They serve as a quick and small dictionary to look up difficult or confusing vocabulary. These glossaries are a smart instrument that translators use to help readers to accelerate their understanding on the topic of discussion in both documents.

5.1.3.1 Spanish to English Glossary

La poda del Alcornocal (Quercus Suber L.). Cuantificación de sus Productos

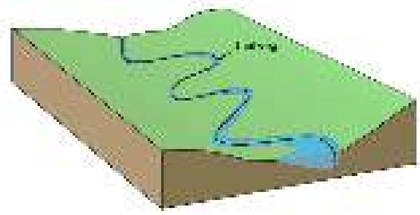
Spanish Term	English Term	Grammatical Category	Definition
Acotamiento	Limitation	Noun	Reservar, prohibir o limitar.
Alcornocal	Cork oak field	Noun	Sitio poblado de alcornoques.

Alcornoque	Cork oak	Noun	Árbol siempre verde, de la familia de las fagáceas, de ocho a diez metros de altura, copa muy extensa, madera durísima, corteza formada por una gruesa capa de corcho, hojas aovadas, enteras o dentadas, flores poco visibles y bellotas por frutos. 
Bellota	Acorn	Noun	Fruto de la encina, del roble y de otros árboles del mismo género. Es un aquenio ovalado, algo puntiagudo, de dos o más centímetros de largo. 
Biomasa	Biomass	Noun	Materia total de los seres que viven en un lugar determinado, expresada en peso por unidad de área o de volumen.
Bornizo	Primary cork	Noun	Corcho natural virgen. 
Brote	Sprout	Noun	Pimpollo o renuevo que empieza a desarrollarse.

			
Cabida	Place/Area	Noun	Extensión superficial de una finca o terreno.
Cicatrización	Healing	Noun	Acción y efecto de cicatrizar.
Corcho	Cork	Noun	Tejido vegetal constituido por células en las que la celulosa de su membrana ha sufrido una transformación química y ha quedado convertida en suberina.
Cualitativo	Qualitative	Adjective	Perteneciente o relativo a la cualidad.
Cuantitativo	Quantitative	Adjective	Perteneciente o relativo a la cantidad.
Dehesa	Pasture	Noun	Tierra generalmente acotada y por lo común destinada a pastos. 
Edáfico	Edaphic	Adjective	Perteneciente o relativo al suelo, especialmente en lo que respecta a las plantas.
Emulación	Imitation	Noun	Acción y efecto de emular (imitar).
Encina	Holm oak	Noun	Árbol de la familia de las fagáceas, de diez a doce metros de altura, con tronco grueso, ramificado en varios brazos, de los que parten las ramas, formando una copa grande y

			redonda, hojas elípticas y flores de color verde amarillento. 
Fructificación	Fructify	Noun	Acción y efecto de fructificar. 
Fuste	Shaft	Noun	Parte sólida de los árboles.
Gavilla	Sheaf	Noun	Conjunto agrupado de sarmientos, cañas, mieses, ramas, hierba, etc., mayor que el manojo y menor que el haz. 
Hectárea	Hectare	Noun	Medida de superficie equivalente a 100 áreas.
Homogeneidad	Homogeneity	Noun	Cualidad de homogéneo.
Laboreo	Tilling	Noun	Cultivo de la tierra o del campo.

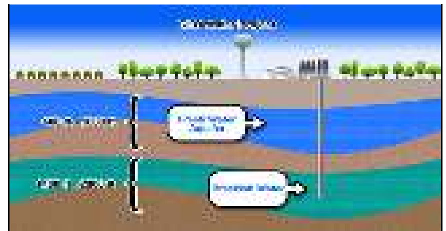
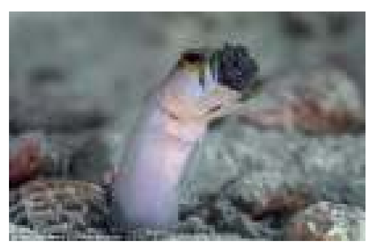
			
Ladera	Hillside	Noun	Declive de un monte o de una altura.
Leña	Firewood	Noun	Parte de los árboles y matas que, cortada y hecha trozos, se emplea como combustible. 
Paraje	Place	Noun	Lugar, sitio.
Parcela	Plot	Noun	Porción pequeña de terreno, de ordinario sobrante de otra mayor que se ha comprado, expropiado o adjudicado.
Poda	Pruning	Noun	Acción y efecto de podar. 
Ramilla	Twig	Noun	Rama de tercer orden o que sale inmediatamente del ramo.
Selvícola/Silvícola	Forestry	Adjective	Que habita en la selva. Relativo a la selva.
Sierra	Mountain range	Noun	Parte de una cordillera.

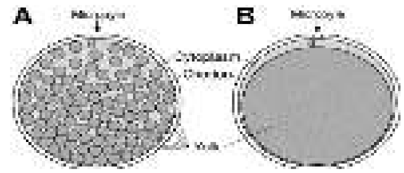
			
Vaguada	Talweg	Noun	Línea que marca la parte más honda de un valle, y es el camino por donde van las aguas de las corrientes naturales. 
Vigoroso	Vigorous	Adjective	Que tiene vigor.

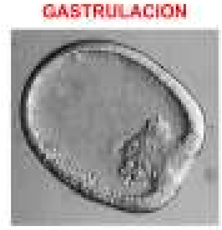
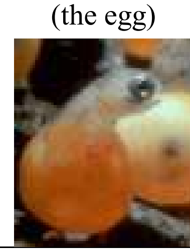
5.1.3.2 English to Spanish Glossary

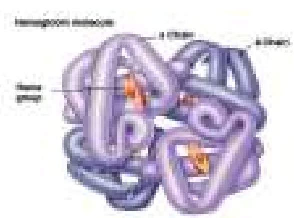
Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Salt Water Culture

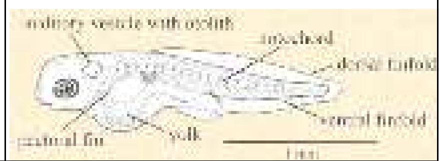
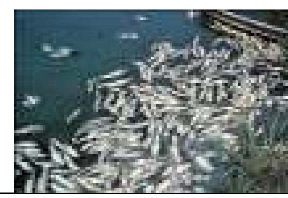
English Term	Spanish Term	Grammatical Category	Definition
Acclimatized	Aclimatado	Adjective	Adapted to a new temperature, altitude, climate, environment, or situation.
Brackish	Salobre	Adjective	Somewhat salty.

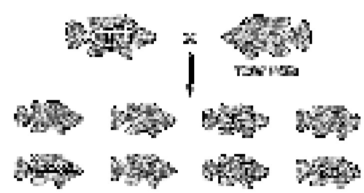
			
Breeder	Criador	Noun	An animal or plant kept for propagation. 
Brood	Crías	Noun	The young of an animal or a family of young; especially: the young (as of a bird or insect) hatched or cared for at one time. 
Broodstock	Reproductores (Población reproductiva)	Noun	A small population of any animal maintained as a source of population replacement or for the establishment of new populations in suitable habitats.

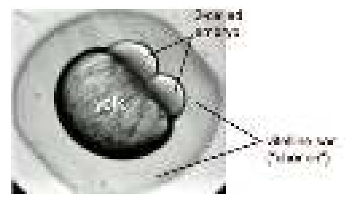
Chorion	Corion	Noun	The highly vascular outer embryonic membrane of reptiles, birds, and mammals that in placental mammals is associated with the allantois in the formation of the placenta. 
Culture	Cultivo/ Crianza	Verb	The act or process of cultivating living material (such as bacteria or viruses) in prepared nutrient media.
Ectodermal	Ectodérmico	Noun	The outermost of the three primary germ layers of an embryo that is the source of various tissues and structures.
Embryo	Embrion	Noun	An animal in the early stages of growth and differentiation that are characterized by cleavage, the laying down of fundamental tissues, and the formation of primitive organs and organ systems. 
Euryhaline	Eurihalino	Noun	These are organisms that are able to adapt to a wide range of salinities.
Fingerlings	Alevines	Noun	A small fish especially up to one year of age.

			
Freshwater	Agua dulce	Noun	Water that is not salty especially when considered as a natural resource.
Fry	Pececillos	Noun	Recently hatched or juvenile fishes. 
Gastrulation	Gastrulación	Noun	The process of becoming or of forming a gastrula. An early metazoan embryo in which the ectoderm, mesoderm, and endoderm are established either by invagination of the blastula. GASTRULACION 
Hatching	Eclosión	Noun	To cause young to emerge from (the egg) 

Herring	Arenque	Noun	One that in the adult state is preserved by smoking or salting and in the young state is extensively canned and sold as sardines. 
Hemoglobin	Hemoglobina	Noun	A protein appearing in red blood cells, which contains iron and carries oxygen from the lungs to the tissues of the body. 
Hybrid	Híbrido	Noun	An offspring of two animals or plants of different races, breeds, varieties, species, or genera.
Incubating	Incubar	Verb	To maintain (something, such as an embryo or a chemically active system) under conditions favorable for hatching, development, or reaction. 

Isothermal	Isotérmico	Noun	Of, relating to, or marked by equality of temperature.
Larvae	larvas	Noun	The early form of an animal (such as a frog or sea urchin) that at birth or hatching is fundamentally unlike its parent and must metamorphose before assuming the adult characters. 
Mean	Promedio	Noun	An average, esp. the arithmetic mean.
Median	Media	Noun	A value in an ordered set of values below and above which there is an equal number of values or which is the arithmetic mean of the two middle values if there is no one middle number.
Mortality	Mortalidad	Noun	The number of deaths in a given time or place. 
Mouthbrooder	Incubación Bucal	Noun	Any of several fishes that carry their eggs and young in the mouth.
Ontogeny	Ontogenia	Noun	The development or course of development especially of an individual organism. 

Opercular	Opercular	Noun	The covering of the gills of a fish. 
Osmoregulatory	Osmorregulación	Adjective	Regulation of osmotic pressure especially in the body of a living organism.
Oviposition	Oviposición	Noun	To lay eggs.
Pelletized	Granulado	Adjective	To form or compact into pellets. 
Photoperiod	Fotoperiodo	Noun	A recurring cycle of light and dark periods of constant length.
Progeny	Descendientes	Noun	Offspring of animals or plants. 
Range	Oscilar	Noun	The set of values a function may take on.
Rearing	Crianza	Verb	To breed and raise (an animal), to bring to maturity or self-sufficiency usually through nurturing care.
Salinity	Salinidad	Noun	Consisting of or containing salt. 

Seasonal	Estacional	Noun	Of, relating to, or varying in occurrence according to the season.
Spawn	Hueva (huevos de rana o pez)	Noun	The mass of eggs deposited in the water by fishes and other creatures that live in the water.
Spawning	Desove	Verb	To produce or deposit (eggs) used of an aquatic animal.
Vitelline	Vitelino	Noun	Resembling the yolk of an egg especially in yellow color. 
Yearling	De un año de edad	Noun	A one year old animal.

After analyzing the final data that these instruments show, it is important to restate the influence that these have for the investigator to be able to come to good and strong conclusions and also to realize the difficulty that all these steps of the translation process have. Every bit of information that can be taken out of these instruments must be taken into account either for future projects or simply to the present study.

Chapter VI

Conclusions and Recommendations

6.1 Purpose of the Conclusion

When looking at the conclusion, it should be the right amount of information for the readers to, even if they read briefly, have a general idea of the aspects discussed in the entire investigation. Furthermore, it is important to analyze certain pieces of information when writing long and developed investigations or projects. The investigator should ensure at all means that this information is supported by other experts, as well as the investigator's own experience while developing the research, and also to ensure that everything is related to the main topic of discussion or research question. That means conclusions should naturally follow the same direction as the gathered information in the entire investigation to finally create a smooth line between introduction, theoretical and methodological frameworks, and the used instruments of data collection. At this point, is important to mention that the researcher should not draw conclusions based on irrelevant information to the topic or to write about personal opinions related to collected data.

One of the important purposes of the conclusion is to remind the reader which were the previously chosen objectives of the present project; additionally, that every one of them needs to be discussed and analyzed to have a better idea of what was accomplished. Furthermore, reminding the reader why certain steps, decisions or selected instruments were chosen to achieve one or many of these objectives. Besides that, the research question should be restated by the investigator in order to finally deeply analyze the effects.

6.2 Conclusions

6.2.1 To translate the documents *La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture* from English to Spanish for UNA.

Before confronting the upcoming documents, it is important to mention the text analysis instrument. This instrument is a step that should be done previous to the translation, and it is of great benefit to this process, for it helps to visualize and be prepared for what is going to be found in these texts, and define whether they are going to be challenging and will have obstacles like linguistical barriers among other possible situations. In fact, the applied text analysis did help the translator to accelerate the investigation and translation process.

The document "La poda del alcornocal (Querus Suber L.) cuantificación de sus productos" translated from Spanish into English for UNA, contained several words difficult to translate due to their technical nature, out of ten different terms, three had no exact translation into English, which was a challenge for the translator to come up with a way to perfectly explain the terms without having to write a long sentence. The other seven terms had their respective translation, however; the vocabulary was genuinely technical, that means not every reader will be able to understand the idea of the sentence, this is where the glossaries and their importance take place. Regardless of the difficulties the translator might have had with this document, the result was satisfactory, no term was left untranslated and the troublesome ones were adequately translated into the target language.

Furthermore, regarding the second document "Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture", although it was quite a technical text as the one mentioned before, all of the terms this text contained were easily translated to their respective term in the target language. It did have a large amount of these kind of terms, which were in fact included in the glossaries for readers to look for them; however, they were not a challenge for the translator, and additionally, these terms were repeated many times throughout the document, which was beneficial for the translation process.

Although this document was long, which means the translator took more time to translate it compared to the one from Spanish into English, and that it contained many graphics, which had to be translated as well, the result was successful, with no major complications.

6.2.2 To apply various translation techniques to the documents in order to achieve communicative texts.

As described before, the techniques of transposition, modulation, omission, amplification, explicitation, and literal translation were the ones chosen to be applied to a sample of thirty paragraphs within both documents, and in that way, it was possible to analyze their effects on the translation process once the procedures were applied. The application of these procedures was successful for the translator, for it was found a considerable number of transpositions and literal translation in both samples of fifteen paragraphs, as well as modulations, explicitations and omissions although in a smaller quantity.

It is valuable to mention that these procedures were significant for the final result of the translations, since applying these techniques helped the translator to analyze what was done in the document and why it was done that way. This means that, when these procedures are applied and the data can be analyzed and changes are made to improve the final results, this process helps the translation to be more natural and accurate.

6.2.3 To evaluate the effect of the translation techniques applied on the documents.

The fact that these techniques were easy to apply to both documents, and analyzing the similitudes in both texts, for example; the fact that both had a relatively similar amount of transpositions and literal translations, reveals that these two languages are not much different from one another, and that both have their own characteristics, which in fact make them be alike. Although, Lavadeira (2015) states that there exist many linguistic differences among these two languages, and thus she believes that they should be translated into two completely different ways to be able to accomplish the communicative accuracy, the investigator has found that it is not necessary for this statement to be taken completely literal because other possibilities can happen while researching and developing the translations.

Despite what the Lavadeira (2015) stated about the differences, and that her work is irrefutably accurate about the linguistic differences among the two languages, when the color coding took place in this project and the results showed how all 30 paragraphs, from the samples, used a large amount of the literal translation technique, it reinforces the fact that both languages present resemblances in their semantic characteristics. When this is further analyzed, it makes sense that being able to translate from one language to another and not having much changes in the order of words and tenses of the sentences, and it clearly means that there are significant similarities among both languages.

Besides that, transposition, which was another technique present in large amount, is another supporting detail to the findings of the investigator, which reveal the small variations that these two languages have between each other, because many of those transpositions were of word order type, which concludes what was stated before. Additionally, another technique like modulation represents the real changes that have to be made in the translation process, like changing tenses in sentences or explaining certain terms, as well as explicitation, which in very few cases was found.

Finally, other techniques like omission and amplification were present in these translations, not in a large amount, but they are still important as part of the instrument to delimitate other relevant differences. For example, the fact that in the translation from English to Spanish there are more amplifications than omissions, contrary to the one from Spanish to English were there are not many amplifications.

6.2.4 To create a glossary with the most relevant terminology found in both texts

As it was mentioned before in Chapter I and III, these glossaries were crucial for the translation process to help both, the translator to better understand all the troublesome vocabulary at the time of engaging these terms, and the readers, which will be students, to have a quick way to look up these terms in the last pages of the document.

The glossaries used in this investigation were simple and easy to understand and find by the future readers of the translated texts. They consisted on only four elements, which were Spanish terms, English term (or vice versa), the grammatical category and, finally, the definition in the source language, in addition; many of the chosen terms contained a picture representing the meaning to have a clearer idea of its definition.

The translator found these glossaries to be truly valuable along the translation process due to the fact that a previous investigation had to take place before developing these glossaries, and besides that, the search for pictures perfectly representing the chosen terms was an extra help to come to a final result or objective, which is delivering at all means a communicatively accurate translation.

6.3 Restatement of the Research Question

The research question of this project is, what is the effect of procedure and methods used to translate the documents *La poda del alcornocal (Quercus Suber L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia fry (Oreochromis niloticus) for salt water culture* from English into Spanish for UNA? First of all, and as an important fact, was this questioned answered or was the main objective accomplished in this investigation? A direct answer to the latter question is yes, it was accomplished.

As it was mentioned before, the procedures and methods used in this project were chosen carefully and applied to both, the original and the translated documents, so that the translator could render a communicatively accurate final result, which is created with naturalness to the target language, so that it is a comfortable reading for those whose studies depend on these documents.

This could be accomplished with the three instruments applied to these texts, the text analysis is the first instrument, which helped to accomplish this goal or in other words, answer this stated question, then the color coding marking all the translation techniques necessary to analyze the documents and their hidden data, and finally, the realization of the glossaries. All three instruments are of great value to this investigator for they were the ones that assisted the research to accomplish these conclusions, which cover all of the significant data collected in the entire process of development of the project.

6.4 Unexpected Results

One of the most relevant unexpected results is the final recollection of terms for the creation of the glossary of the document from Spanish into English. This document at first sight seemed to have a large amount of troublesome terms, which were going to be the challenge for the translator, however; when having finished the creation of this vocabulary the true final number of difficult vocabulary was of eighteen words, without taking into account other terms, which were not that challenging for the translation process. This final result is in fact an advantage for this process because no further investigation took place. Besides this specific case, no other unexpected results were found while developing the translations or investigating terms etc.

6.5 Recommendations

It is important to take into consideration, as a first step, to be organized at the time of first encountering what is going to be done. This organization state includes preparing a previous list of tasks and dates of when certain steps have to be finished and revised by the people in charge. Managing the time is crucial and goes hand by hand with organization, without these two characteristics the developing process is going to be messy and ideas will probably be more difficult to get.

In other terms, as in this case for this project, two translations had to be done, it is a good decision to read thoroughly the text so that any difficulties can be spotted before having to deal with the translation itself, and in that way accelerating the term research process and consequently the future glossaries that will be developed.

Furthermore, in later steps, like the color coding instrument, it is recommendable, if not necessary, to have a notebook or booklet in hand with all the translation techniques that exist, because there are many of them, so that while encountering this step there is no need for the translator to think or guess which technique goes where, but having a trustworthy support that reminds the translator which technique is better in each case and why it is that way.

Finally, following the advice of third parties, that is experts in the translation topic or experienced people in this area, is one of the most important advice that the investigator or translator should follow, because it is a truth recognized by experienced people that translation is a process which should be done by two or more people, for the opinion of other experts should be taken into consideration due to the valuable information they can provide and that way improve both, the translators knowledge and the content of those translations. Elaborating a translation alone can lead it to be biased or even, in other cases, to have numerous grammatical or vocabulary errors. Consulting with experienced translators and having them revise the work done helps improve every element of the final result.

References

Andrews, R. (2003). Research Question. New York. Continuum.

Bassnett, S. (2014). Translation Studies (4th ed.). New York: Methuen & Co. Ltd.

Di, J, & Nida A. E. (2006). On Translation: An expanded edition. Hong Kong. City University of Hong Kong Press.

Essays, UK. (November 2013). Three Scales of Emotional Tone English Language Essay. Retrieved from https://www.uniassignment.com/essay-samples/english-language/three-scales-of-emotional-tone-english-language-essay.php?cref=1

Ferraro, E. F. (2006). Investigations in the Workplace. Florida. Auerbach Publications.

House, J. (2015). Translation Quality Assessment: past and present. New York. Routledge.

Johnson, S. (2011) Dissertation Writing Assignment Help UK. Importance of SPSS in Data Presentation for Dissertation. Retrieved from: dissertation-help-uk.blogspot.com/2011/11/importance-of-spss-in-data-presentation.html.

Lavadeira, S. (2015) A Comparative Linguistic Analysis of English and Spanish Advertising Discourse. Spain. Universidade da Coruña

Lionbridge. (2016). How to Create Translation Style Guide and Terminology Glossary. Retrieved from: http://content.lionbridge.com/how-to-create-a-translation-style-guide-and-terminology-glossary/

Lionbrisge. (2013). What is a Translation Glossary? Retrieved from http://info.lionbridge.com/rs/lionbridge/images/Lionbridge%20FAQ_Glossary_2013.pdf

Newmark, P. (1988). *A textbook of Translation*. Hertfordshire. Prentice Hall International vUIO Ltd.

Osimo, B. (2002). The "Translation Book:" Method Applied for Primary Sources. Milano.

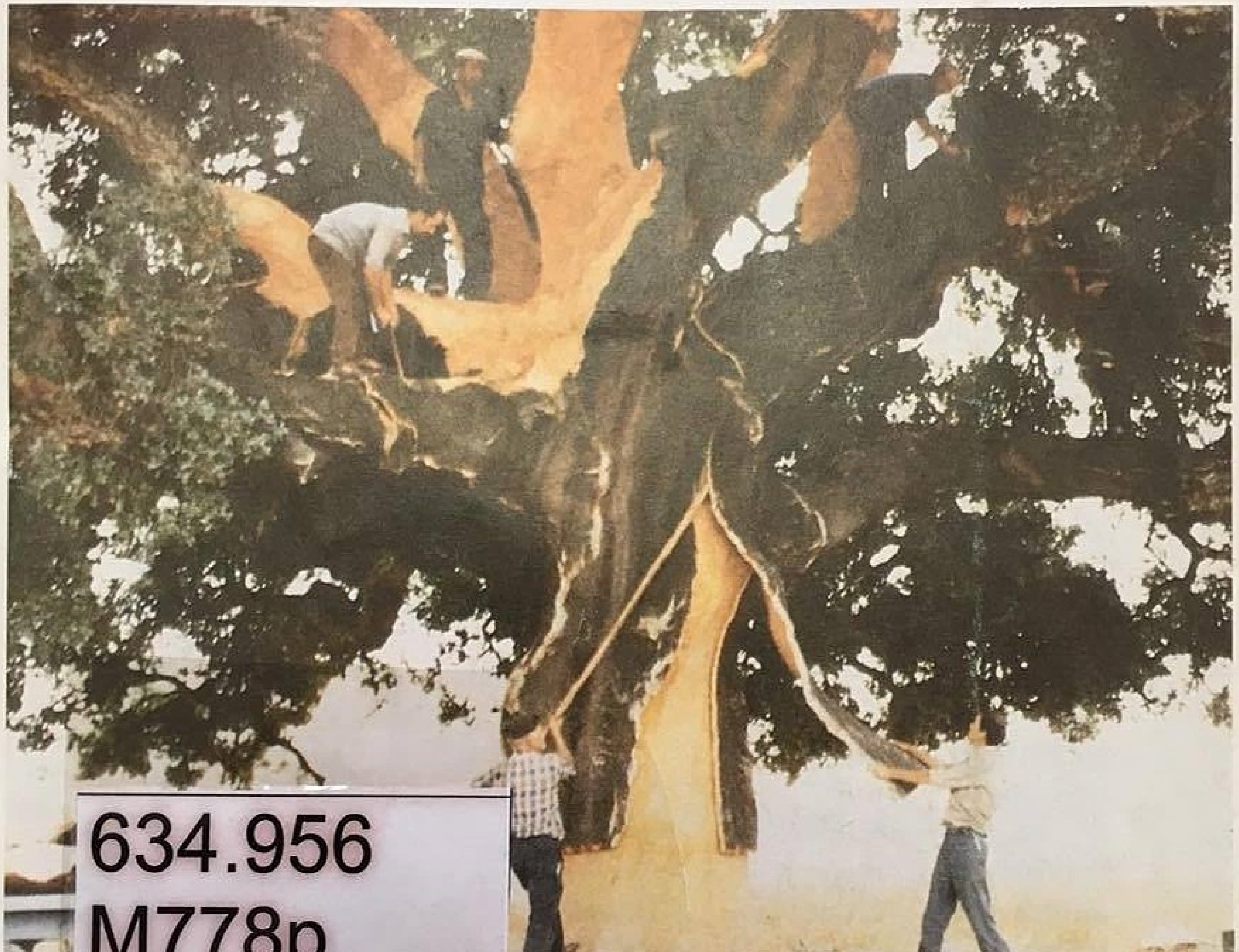
Vázquez-Ayora, G. (1977). Introducción a la Traductología. Washington D.C. Georgetown University Press.

Anexes

HOJAS DIVULGADORAS

Núm. 18-19/90 HD

LA PODA DEL ALCORNOCAL (*QUERCUS SUBER* L.). CUANTIFICACION DE SUS PRODUCTOS



GREGORIO MONTERO GONZALEZ

CIT—INIA Dp. Sistemas Forestales
Carretera de La Coruña Km 7. 28040 Madrid

RAFAEL CURRAS CAYON

Inspección Regional del I.C.O.N.A. Valencia

MINISTERIO DE AGRICULTURA PESCA Y ALIMENTACION
SECRETARIA GENERAL DE ESTRUCTURAS AGRARIAS

LA PODA DEL ALCORNOCAL (*QUERCUS SUBER* L.). CUANTIFICACION DE SUS PRODUCTOS

En la primera parte de esta publicación se presentan una serie de consideraciones de tipo general sobre la poda del alcornoque y sus efectos, basadas en la bibliografía y en la opinión de los autores. En la segunda parte se presentan los datos sobre peso de leña, bornizo y ramillas obtenidos en tres parcelas de experimentación situadas en: la sierra de San Pedro (15 ha), sierra de Sevilla (7,5 ha) y alcornocales de Cádiz (7,5 ha), en las que se determinó el peso de leña, bornizo y gavilla en una muestra de 371 árboles. Los resultados muestran que los porcentajes de bornizo con respecto al peso total de leña crecen cuando aumenta el número de años transcurridos desde la última poda. Las producciones por hectárea, efectuando una poda moderada, varían entre los 1.500 y 9.900 kg/ha. de leña verde y entre 600 y 4.300 kg/ha. de bornizo.

INTRODUCCION

La poda del alcornocal sigue siendo un tema de permanente controversia, tanto en el plano de las ideas como en el de las aplicaciones prácticas. La investigación en España no ha aportado información suficiente, ni siquiera para poder opinar de forma objetiva y racional sobre este importante hecho selvícola y económico que está totalmente integrado en el aprovechamiento habitual de los alcornocales de Extremadura y norte de Huelva y Sevilla. En los alcornocales de Cádiz, Málaga y Cataluña no es habitual la práctica de la poda. En Portugal se hicieron algunas experiencias en la Estación de Experimentación de Alcornoque, entre los años 1930 y 1940, para intentar cuantificar sus efectos sobre el crecimiento del árbol y sobre la producción de corcho y bellota. Los resultados están publicados en los trabajos de Vieira (1932, 1937, 1938 y 1950) y Brito Dos Santos y Rodrigues (1975).

En España el único intento que se conoce es el realizado por el I.F.I.E.-I.N.I.A., dirigido a cuantificar los productos de la poda moderada en los alcornocales de la sierra de San Pedro, sierra de Sevilla y Cádiz, cuyos resultados presentamos en este trabajo.

Este estudio se planteó de forma marginal dentro de un estudio más amplio encaminado a conocer la producción y los mecanismos de regeneración del monte alcornocal. Su publicación parece interesante por cuanto puede ayudar a cuantificar la producción de las podas, que sean realizadas con cierta prudencia, y siempre teniendo en cuenta la dificultad que supone efectuar una correcta estimación cuantitativa y cualitativa de las leñas y bornizo obtenido, ya que depende de variables tales como intensidad de la poda, años transcurridos desde la última e intensidad de la misma, tamaño de las ramas cortadas, etc., que son de difícil medición. De todas formas, en un campo en el que no existe prácticamente ninguna información cuantificada, con cierto rigor y homogeneidad de procedimiento, se considera que es importante dar a conocer los resultados que se obtuvieron en un total de 30 hectáreas podadas, en las que se pesó la leña con y sin bornizo y las ramillas (gavilla) de 371 árboles distribuidos proporcionalmente en todas las clases diamétricas, intentando mantener la misma intensidad y tipo de poda y siguiendo el mismo procedimiento para estimar la cuantía de los productos de las tres zonas.

PODA DE FORMACION

La poda de formación, poco practicada en alcornocales, tiene un alto interés económico a largo plazo, pero su falta de rentabilidad inmediata la hace poco atractiva para los propietarios. En muchos alcornocales se observa un alto porcentaje de árboles con fustes defectuosos, torcidos, con ramas muy bajas, mala disposición de las ramas de primer orden que no permiten subir la altura de descorche, etc. Esta mala configuración de la superficie

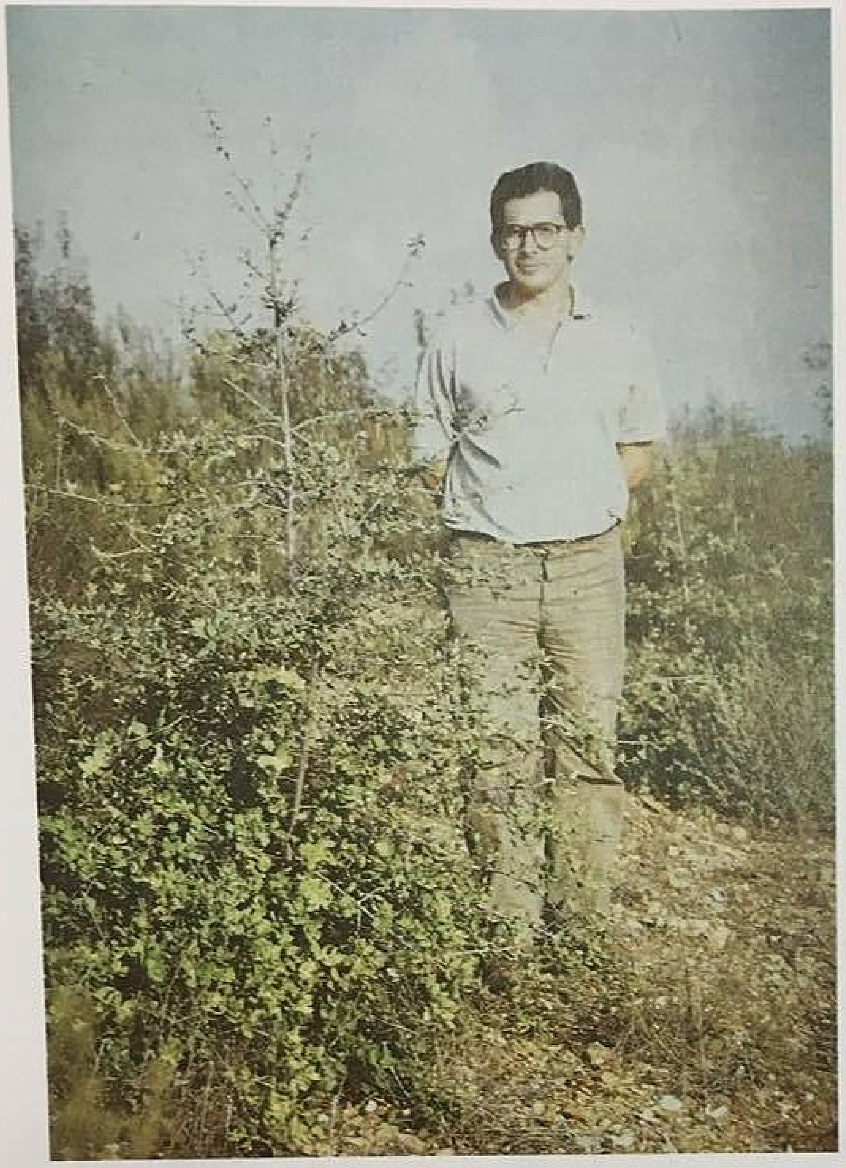


Fig. 1.—Plantación de 6 años en monte. A esta edad, y en condiciones normales de desarrollo, se hace imprescindible la poda de formación y la eliminación de individuos malformados y brotes rastreros, dejando un solo ejemplar por punto. Foto: G. Montero.

potencialmente descorchable reduce la producción, eleva los costos de extracción del corcho, hace imposible la extracción de panas planas y de bordes rectos, que permitan un mejor aprovechamiento del corcho taponable, y aumenta el porcentaje de refugo, debido al pequeño tamaño y a la irregularidad geométrica de las panas.

La poda de formación se hace imprescindible si en el futuro se intenta hacer posible la mecanización del descorche; esta idea se vería favorecida si los árboles tuviesen fustes rectos y lisos. En las condiciones en que se encuentran en la actualidad las superficies descorchadas en la mayoría de los árboles (fustes torcidos, abundancia de abultamientos producidos por heridas de poda y/o descorche, etc.) se hace imposible pensar en una extracción mecanizada.

La poda debe iniciarse en árboles muy jóvenes para evitar malformaciones incorregibles, pero esta forma de proceder puede ser perjudicial si no existe acotamiento al ganado, pues los pequeños árboles podados son doblados con frecuencia por cabras y vacas para comer el ramón de su pequeña copa, causando mayores daños que en las masas no apostonadas y podadas. En las repoblaciones y lugares acotados conviene quitar las ramas bajas, a partir de 3-4 años de edad, con unas tijeras de podar. Si la guía principal se ha perdido, se elige una rama lateral como nueva guía. Las plantas jóvenes muy torcidas se acaban enderezando con el tiempo si son bien podadas y guiadas, y las pequeñas heridas cicatrizan con facilidad.

Si la poda de fomación se hace tarde y en árboles con fustes muy defectuosos y ramas muy gruesas que es necesario eliminar, habrá que ser prudente y no forzar demasiado el objetivo de lograr fustes rectos y lisos en 2,5-3 m de altura, como sería deseable.

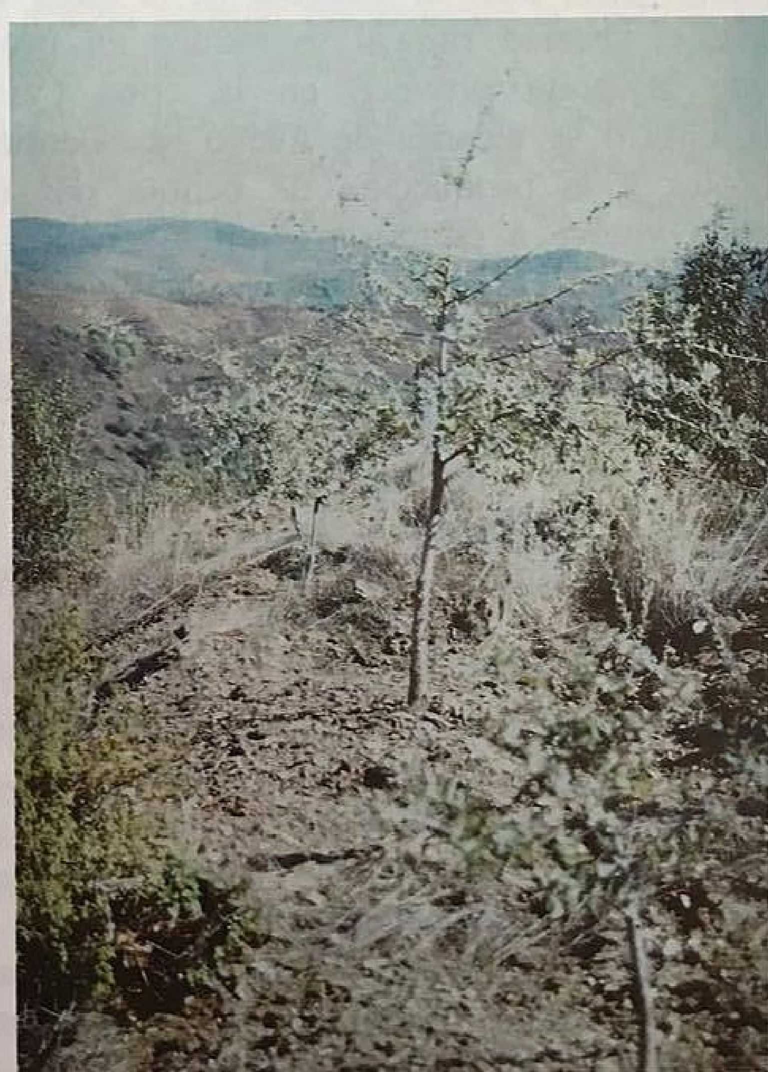


Fig. 2.—Poda de formación en una plantación de 4 años en monte. La altura de poda oscila entre 50 y 80 cm, dependiendo del tamaño de la planta. Foto: G. Montero.

PODA DE ARBOLES ADULTOS

Si se buscan los orígenes de la poda en el alcornoque, se ve que se trata de una emulación de la poda de la encina, buscando una producción de bellota regular y sostenida, cosa que no siempre se consigue en la realidad, la disminución de la cubierta para favorecer el cultivo de cereal de otros tiempos y el ramoneo.

Está demostrado que la producción de bellota se ve favorecida por la presencia de nuevos y vigorosos brotes en la zona periférica de la copa (no de brotes chupones o ladrones). El principal efecto que produce la poda consiste, justamente, en estimular la emisión de nuevos y más vigorosos brotes, al concentrar toda la capacidad productora del árbol en unas cuantas ramas seleccionadas. El desequilibrio se restablece en pocos años, pues la biomasa de la copa va aumentando y parece que el sistema radical se reduce en proporción a la reducción que la poda provocó en la copa (Vieira 1937). Cuando el equilibrio se alcanza de nuevo se ralentiza el crecimiento de los brotes y la producción de bellota por unidad de superficie de copa vuelve a estabilizarse en la cuantía original existente antes de la poda; en este estadio se hace necesario realizar una segunda poda, que habrá de ser repetida periódicamente.

El rebrote vigoroso se produce, en parte, por la concentración de nutrientes en un menor número de ramas; por la eliminación de ramos asombrados y debilitados, cuyo balance energético puede ser negativo, al gastar más en el proceso de respiración que lo que aportan por asimilación; y, fundamentalmente, a costa de las reservas acumuladas en el resto del árbol. Por consiguiente, si la poda es muy intensa se convierte en un proceso de debilitación del árbol, ya que tras el desequilibrio inicial concentra casi todo su potencial en restablecer el equilibrio foliar con la emisión de nuevos brotes, y sólo cuando éste es alcanzado comienza el proceso de acumulación en los tejidos de reserva. Si en este momento se procede a realizar la siguiente poda y a crear de nuevo el desequilibrio buscado para favorecer la emisión de brotes vigorosos, extrayendo nuevamente casi la totalidad de la biomasa foliar acumulada desde la poda anterior, se está forzando al árbol a vivir en un permanente estado de desequilibrio biológico. El rebrote será cada vez menos intenso puesto que el árbol tiene menos reservas acumuladas y son éstas las que en mayor proporción participan en el proceso, el resultado final es que los efectos de la poda son cada vez menos aparentes o visualizables.

Por otra parte, el proceso de frutificación forzado intencionadamente por la poda consume gran cantidad de reservas, carbohidratos, grasas, almidón, etc., que se manifiesta exteriormente el año siguiente a una abundante montanera, por una pérdida de la intensidad de «verdor» e incluso amarilleamiento de las hojas, así como la emisión de menos y más pequeños brotes jóvenes. Las reservas necesarias para una nueva emisión de fruto se van acumulando lentamente, por este motivo, a un año de buena montanera le suele seguir otro de escasa o nula frutificación. Sólo la fertilización adecuada podría atenuar eficazmente la vecería, tal como ocurre en los árboles frutales (Vieira, 1937).

Los efectos de una poda moderada sobre la fructificación, duran pocos años (4-5). Sería conveniente podar moderadamente cada 5 años, pero esta forma de proceder es costosa y generalmente no paga los costos de la operación, por lo cual al propietario sólo le quedan dos opciones: realizar podas más intensas pero a intervalos de tiempo más largos, para que los productos extraidos en la poda puedan subvencionar la operación y los efectos de ésta duren más tiempo, o realizar podas intensas y relativamente frecuentes, a costa de «descapitalizar» la masa, provocando su debilitamiento y prematuro envejecimiento, con consecuencias negativas en la producción de corcho.

Esta especie de círculo vicioso lo descubrió magistralmente Vieira (1937) con las siguientes palabras:

«Se podó inicialmente, para regularizar la producción de fruto, se siguió podando con mayor intensidad para que los productos de la poda (leña y bornizo) compensasen los costos de la operación, se podó después con mayor intensidad aún para obtener del alcornocal una renta suplementaria, y así poco a poco se generalizó, perfeccionó e intensificó la poda excesiva y abusiva».

Este proceso de «huida hacia adelante», mediante el cual se encontró una forma de obtener nuevas e imprevistas producciones del alcornocal, encontró una calurosa acogida entre los propietarios. No se conoce ninguna otra técnica selvícola o cultural que haya sido tan rápidamente divulgada y tan escrupulosamente seguida por los interesados. Pero la poda excesiva no la inventó el selvicultor ni el porquero ni el corchero; la inventó el carbonero, que fue, como dice Vieira, su inventor, divulgador y ejecutor.

Dada la escasa importancia de la producción de bellota dentro de la economía del alcornocal, la poda moderada y frecuente, única capaz de paliar en parte la vecería e incrementar la producción anual de bellota, no se justifica económicamente, y menos en las actuales condiciones socioeconómicas de nuestros alcornocales.

Desde el punto de vista de la producción de fruto, la poda excesiva no es tampoco una operación aconsejable, y nunca puede justificarse como un sistema racional y económico de regularizar la producción de fruto, pues es un hecho aceptado que sólo en muy pequeña medida logra los objetivos de fructificación que algunos ponen como pretexto para su realización. Son bien conocidos, y ampliamente divulgados por algunos autores portugueses, muchos de sus inconvenientes, tales como que disminuye considerablemente la superficie de producción de fruto, con lo cual el efecto visible de una mayor abundancia de bellota en las pocas ramas que quedan no está demostrado que se corresponda con una mayor producción total. No se conoce ningún trabajo que compare la producción de bellota en árboles intensamente podados y en árboles podados moderadamente e incluso sin podar. El resultado es probable que deparase sorpresa a la, algunas veces interesada, creencia popular.

Otro hecho contrastado es que después de una poda intensa se originan períodos de escasa o nula producción de fruto, porque las sustancias nutritivas que deberían ser dedicadas a la fructificación pasan a ser utilizadas, después de la poda excesiva, en la formación de brotes ladrones, en especial, y a la reconstrucción de la copa, en general. Si la poda no hubiese sido excesiva, parte de esas sustancias se habrían consagrado al desarrollo de ramas periféricas más útiles para la fructificación.

Si las podas son frecuentes, la mayoría de los brotes «chupones o ladrones» son cortados en la próxima poda, antes de haber producido bellota en abundancia y cuando muchos de ellos aún tienen una pequeña proporción de bornizo. A estos brotes que se cortan en la siguiente poda y que se han formado principalmente a expensas de las sustancias que el árbol ha ido almacenando durante años se les saca una escasa producción real (bellota y bornizo), con lo cual todo parece indicar que se está siguiendo un proceso de auténtico despilfarro del capital acumulado. Si, por el contrario, en la siguiente poda se cortan las ramas gruesas que quedaron después de la poda anterior y se dejan los brotes jóvenes para que fructifiquen y produzcan bornizo, se está realizando un sistema parecido al de aprovechamiento de brotes de cepa, aunque el recepe se produzca a dos o tres metros de altura (trasmocho). Este sistema, parte de que tendría que ser regulado

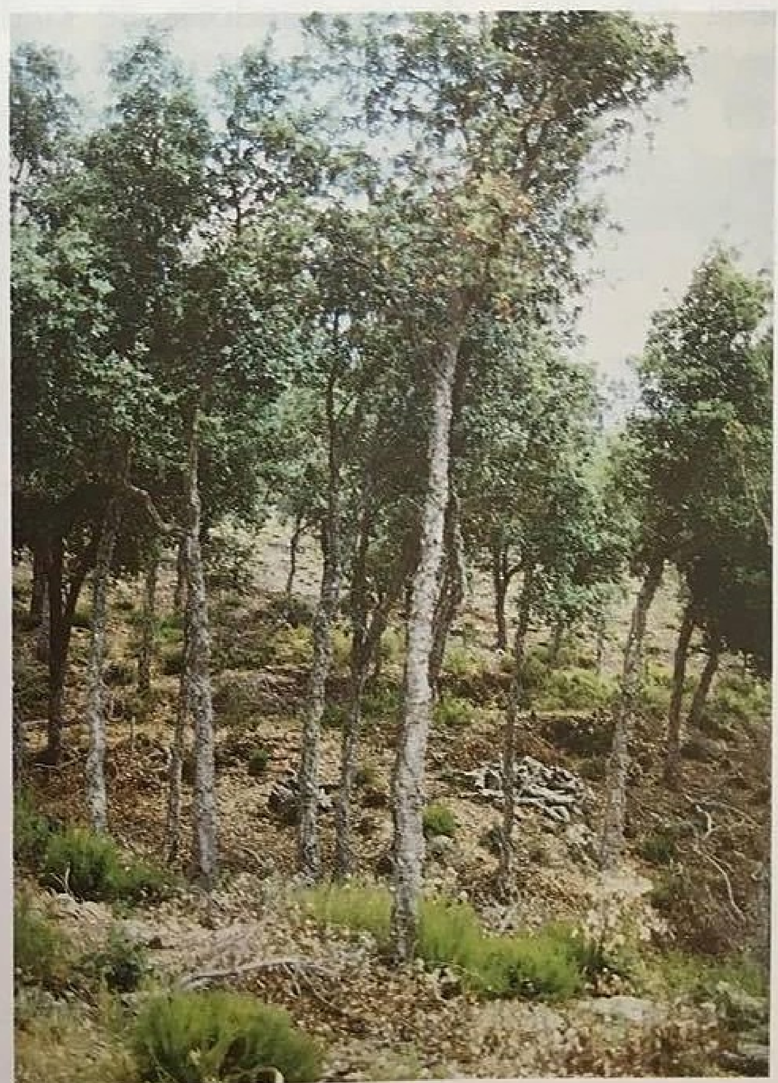


Fig. 3.—Rodal obtenido por regeneración natural, mediante acotamiento al pastoreo. La alta densidad en que se han desarrollado los árboles favorece la rectitud y la altura de los fustes y permite seleccionar los mejores. Una posterior intervención de clara y poda permitirá una nueva selección. Foto: G. Montero.

y estudiado su turno con base en la técnica de aprovechamiento de los tallares o monte bajo, en el sentido forestal de la palabra, no creemos que nadie pueda defenderle como método de aprovechamiento de nuestros alcornocales.

El alcornoque tiene un crecimiento relativamente lento, por lo cual sus masas, que además están muy aclaradas, tienen poca capacidad para producir biomasa, y su explotación racional no soporta intensivas extracciones periódicas de material leñoso, si no es a costa de consumir el capital forestal que la masa ha acumulado durante años. No se puede pensar en realizar podas frecuentes (9-10 años) e intensas, que proporcionen entre 4.000 y 5.000 kg de leña, 1.000-1.300 kg de bornizo y 2.500-3.000 kg de ramillas, para que consiga el propietario una renta neta. Esto supondría que un alcornocal con 40-50 árboles por hectárea habría que producir entre 7,5 y 9,3 tm en 9-10 años.

Si se opta por hacer podas intensivas para la producción de leña y bornizo, desvinculándolas de cualquier otro objetivo, que habitualmente no se consigue, habrá que determinar la capacidad del alcornoque para producir leña en sus ramas; determinar la edad mínima de corta de éstas para que su rendimiento en leña y bornizo sea óptimo (turno); y, en función de estas variables y de los costos de la poda, determinar la rotación o turno de poda más aconsejable. Esta opción tendría que tener en cuenta, además, sus repercusiones en la producción de corcho.

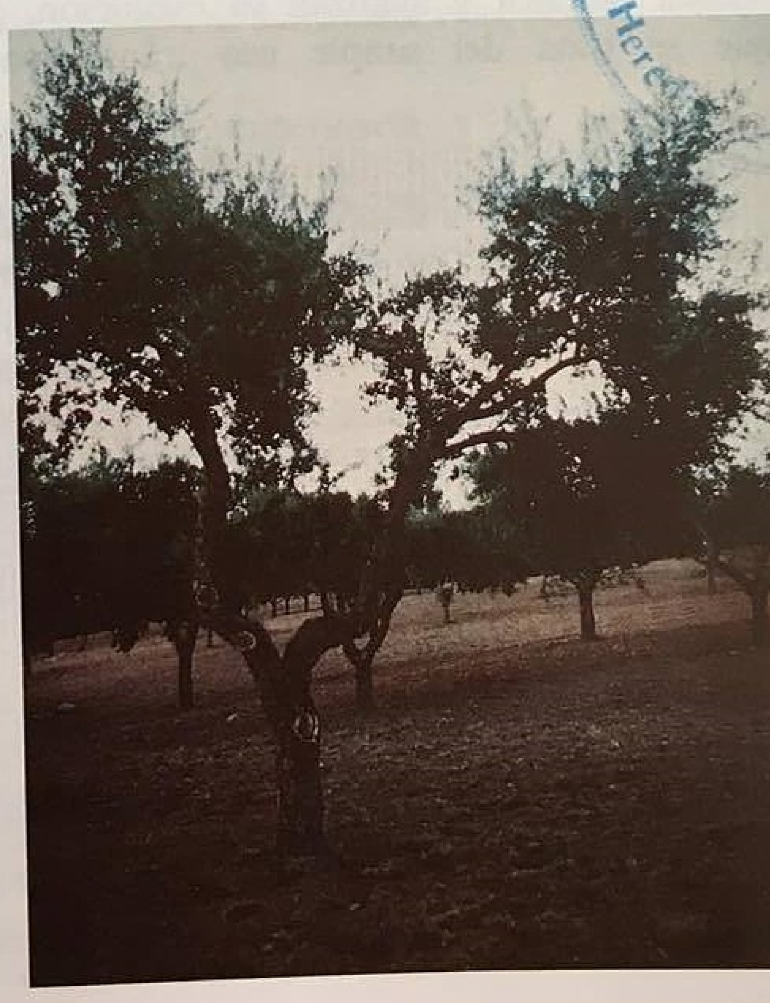
Para terminar con este tema de la influencia desvitalizadora de la poda excesiva sobre el alcornoque, Vieira (1937) concluye sus comentarios con el párrafo que se copia textualmente a continuación:

«La práctica de las podas excesivas, como sistema normal de poda, tiene sobre los árboles una profunda acción desvitalizadora, que se traduce en una menor resistencia a los ataques de plagas y enfermedades, en las condiciones precarias de vegetación y en la menor longevidad del árbol. Desde este punto de vista la poda excesiva afecta gravemente a la economía del alcornocal».

Desde el punto de vista de la producción de corcho, Vieira (1937, 1938) demostró que un alcornocal excesivamente podado produce un 20 por ciento menos que otro de iguales características y en idénticas condiciones de edad —selvícolas y ecológicas— que había sufrido una poda moderada. En estos mismos trabajos, y para las mismas parcelas comparadas para la producción de corcho, indica que el crecimiento en diámetro disminuyó en un 20 por ciento en la parcela excesivamente podada. El crecimiento medio anual del calibre del corcho disminuyó en la proporción que indican las figuras 1 y 2. Los datos fueron obtenidos de una experiencia que duró 12 años (1929-1937).

Otro efecto de la poda excesiva es que el corcho «no se da» en los años próximos a la misma. Por este motivo la poda debe hacerse tres años después del descorche, y cuando esto no es posible debe preceder a éste un mínimo de 3 años. Esta sincronización temporal de poda-descorche también se justifica porque en los años inmediatamente posteriores al descorche el árbol está fisiológicamente débil (crisis del descorche) y la cicatrización de las heridas de poda es más lenta.

Fig. 4.—Plantación de 27 años en monte. La forma del fuste pone de manifiesto los inconvenientes de retrasar excesivamente la poda de formación: las heridas de poda son muy grandes, la bifurcación de las ramas principales se ha producido a poca altura y las formas del fuste y ramas son muy irregulares. Esta poda de formación puede mejorar algo la fisonomía de los árboles, pero no consigue su objetivo de lograr fustes rectos y de 2-3 m de altura. Foto: G. Montero.



En la opinión de numerosos autores, la poda excesiva, vista desde los más diversos ángulos, no tiene otra justificación seria que no sea la renta inmediata, hecho que la justificaría plenamente, igual que se justifica el acto del descorche, si no fuese porque su práctica tiene consecuencias negativas para el conjunto de la economía del alcornocal. Se termina este punto con las mismas palabras con que Vieira comienza su trabajo de 1937, por tener el convencimiento de que sus argumentos siguen siendo válidos en nuestro país en 1989.

«Si los que suponen la poda excesiva como una operación cultural defendible, consagrada por la práctica y por la experiencia de muchos años; si los que ven benévolamente esta devastación tremenda, como dictada por el estudio y observación del podador, por la sabiduría acumulada en el correr de los tiempos, y como traducción de una necesidad de los árboles; en fin, si los partidarios de la poda excesiva descienden a los orígenes de tan nefasta práctica y analizan su evolución, verificarán, tristemente, que se trata del simple uso transformado en abuso. Donde

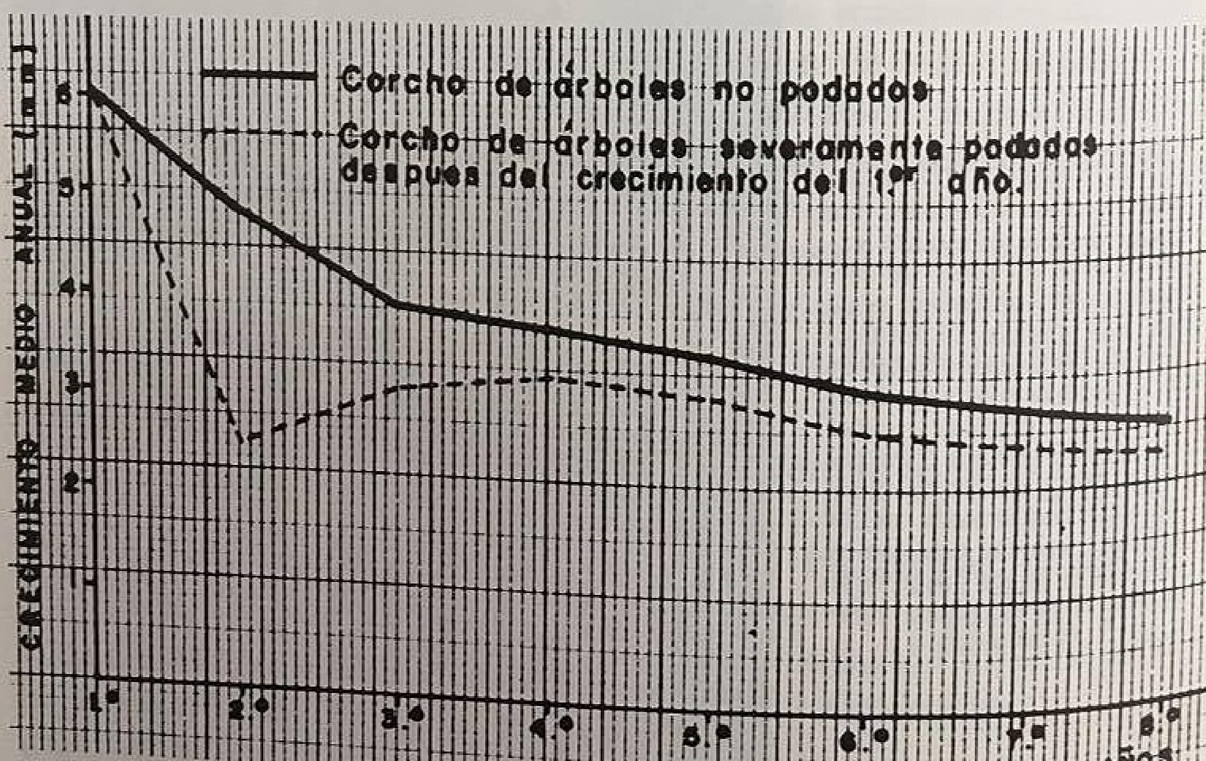


Fig. 5.—Curvas de crecimiento del corcho procedente de árboles no podados e intensamente podados (según Vieira, 1938).

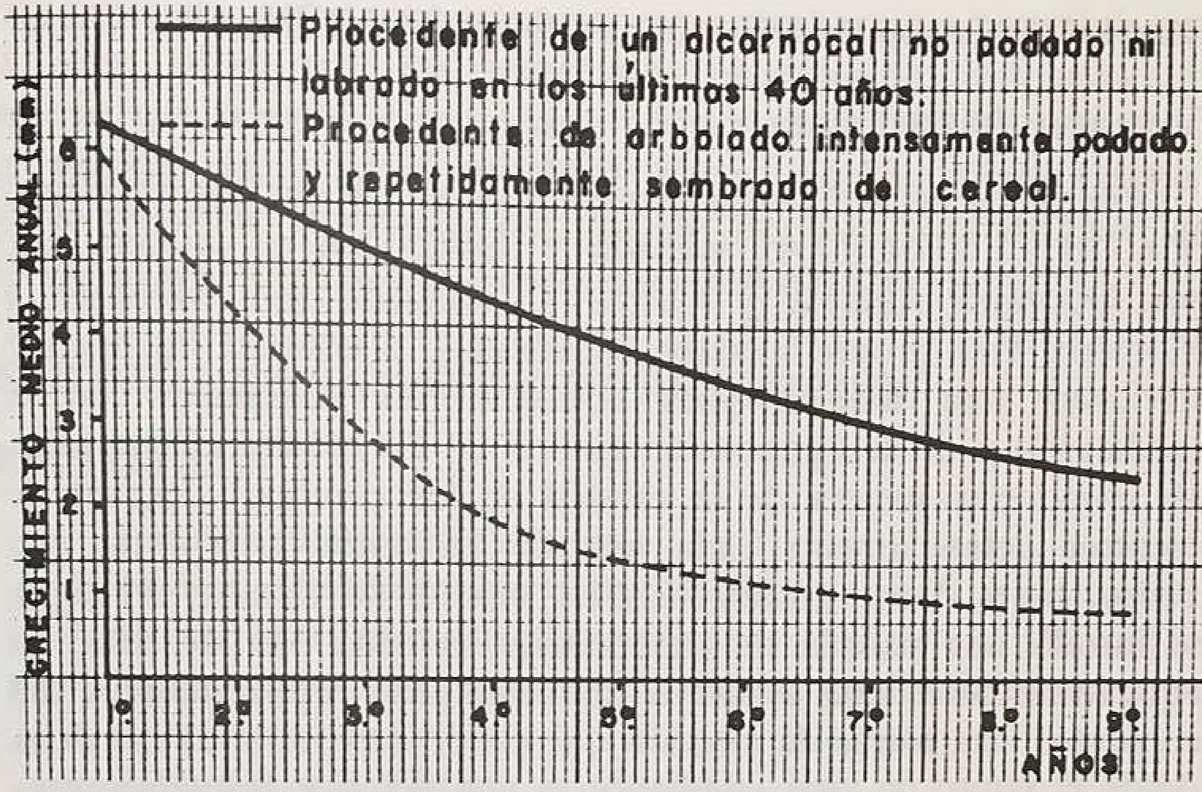


Fig. 6.—Curvas de crecimiento del corcho (según Vieira, 1951).

buscaban el viejo saber de la experiencia y los hechos sólo encontrarán maliciosa imprudencia».

Cuando se habla de poda excesiva, se alude a podas realizadas sistemáticamente y que afectan a más de un 30 por ciento del total de ramas del árbol, sin tener en cuenta la edad ni las condiciones vegetativas de éste, es decir, poda de la misma intensidad en árboles jóvenes que en adultos y en los viejos y decrépitos, y realizadas periódicamente como sistema habitual. Esta forma de proceder nada tiene que ver con las podas de rejuvenecimiento, que siendo muy intensas afectan solamente a árboles envejecidos y suelen aplicarse una sola vez al final de la vida del árbol.

La decisión de cómo y cuánto podar supone una opción de carácter económico que debe tomar el propietario, sujetándose en todo momento a las normas selvícolas establecidas por la Administración Forestal. En todo caso, se deben tener en cuenta los argumentos científico-técnicos necesarios para posibilitar la incorporación de una mayor objetividad y racionalidad en la toma de decisiones.

CUANTIFICACION DE LOS PRODUCTOS DE LA PODA

Elección de parcelas

Los datos de la muestra proceden de un proyeto de Investigación del I.F.I.E.-I.N.I.A., iniciado y dirigido en su primera fase por González Aldama y Curras y finalizado por Montoya y Montero. Este proyecto estaba encaminado a conocer las normas selvícolas más idóneas para conseguir un incremento de la producción y de la regeneración natural de los montes alcornocales, así como una mejora de la calidad de los corchos. Después de recorrer detenidamente cada una de las zonas (sierra de San Pedro, sierra Norte de Sevilla y los montes de Cádiz y Málaga), se instaló una parcela de experiencias en cada una de ellas, en aquellos montes que se creyó que eran más representativos del conjunto. Esta forma de elección que puede parecer poco ortodoxa desde el punto de vista estadístico es una práctica frecuentemente usada en los estudios forestales, y está avalada por la eficiencia de sus resultados en numerosos trabajos.

Objetivos

La realización de las podas y medición de productos en estas parcelas se hizo dentro de un conjunto de trabajos o actuaciones selvícolas desbroces, laboreos, fertilizaciones, etc.), cuyo objetivo era conocer e incrementar la producción del monte alcornocal y su regeneración. Es decir, la experiencia de poda no era una experiencia con objetivos propios, sino que formaba parte de otra de mayor alcance. Se consideró que la poda debía ser moderada e inspirada en las normas dadas por los autores portugueses.

Este tipo de podas ofrecen rentas inmediatas pequeñas y pueden llegar a no cubrir costos, y éste es el aspecto más grave del problema, porque mientras que el propietario pueda realizar podas de suficiente intensidad para que la renta de sus productos le reporte unos beneficios netos, será ocioso que nadie intente convencerles de que los inconvenientes o ventajas que en el futuro pueda reportarle la realización de podas menos intensas o moderadas deben guiar su actuación inmediata. Para la solución del problema habrá que poner de acuerdo los intereses selvícolas a largo plazo con los inmediatos económicos, buscando un sistema que permita al propietario obtener algún beneficio causando el mínimo perjuicio al arbolado. Estos criterios, y no razones exclusivamente selvícolas, han servido de base para realizar las podas cuyos resultados exponemos a continuación.

MUESTRA DE LA SIERRA DE SAN PEDRO

Localización

* Término municipal: Cáceres.
* Sistema montañoso: sierra de San Pedro.
* Monte: Moro Alto del Mayoralgo.
* Paraje: entre los puertos «El Moro» y «El Marqués», en ladera norte de la sierra.
* Altitud media: 470 m.
* Pendiente media: 30%.

Características selvícolas

Descripción del sitio de muestra

* **Densidad media:**
  — Arboles en fábrica: 136/ha.
  — Macheros: 188/ha.
* **Fracción de cabida cubierta (Fcc):**
  — Máxima: 0,64.
  — Mínima: 0,16.
  — Media: 0,43.
* **Superficie de decorche media/ha:** 274 m^2.
* **Coeficiente de descorche:**
  — Máximo: 5,6.
  — Mínimo: 1,9.
  — Medio: 2,3.
* **Superficie podada: 15 ha.**
* **Número de árboles podados: 2.047.**

Años transcurridos desde la última poda: 24.

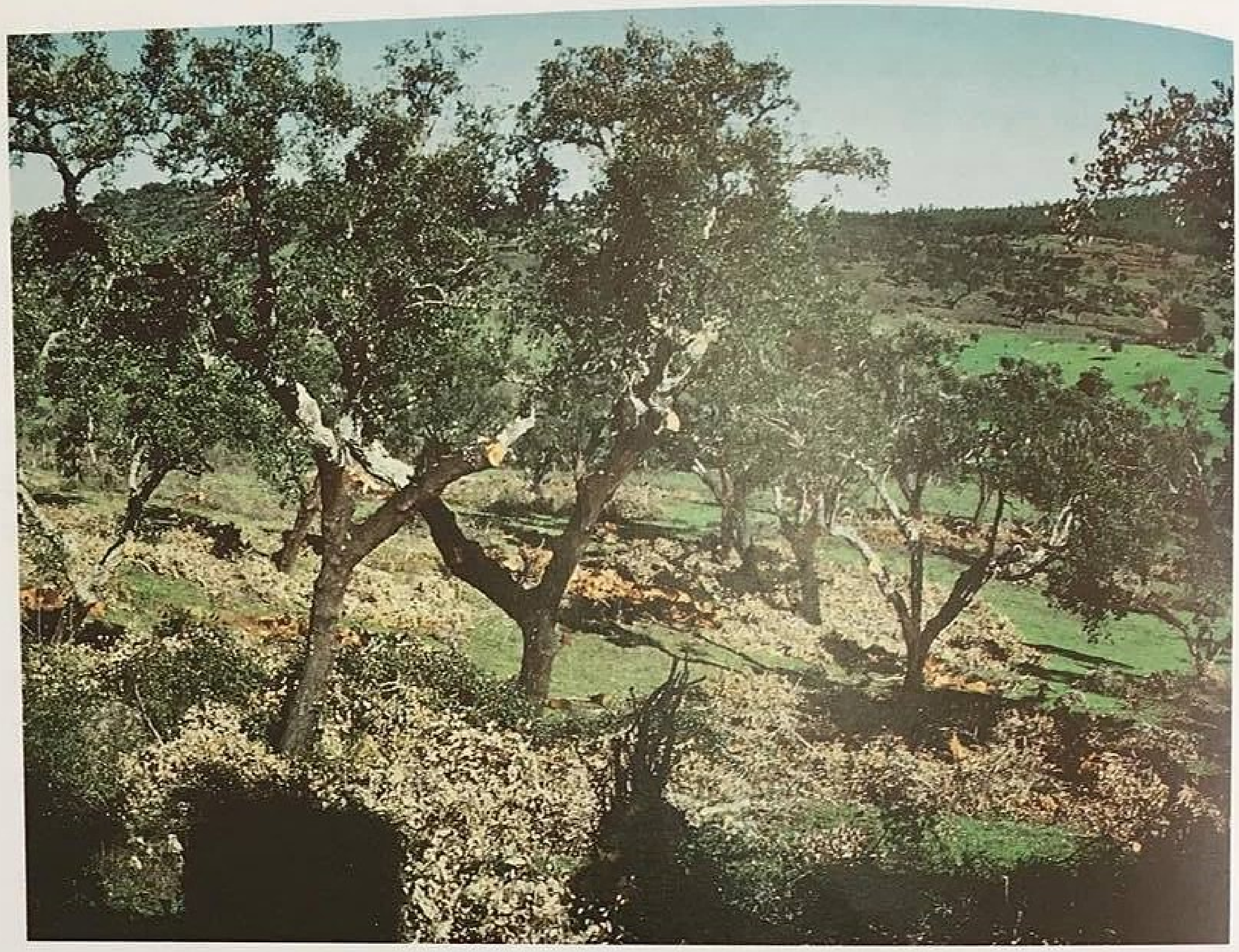


Fig. 7.—Poda en un alcornocal adulto con excelente estado vegetativo. Este tipo de podas fuertes, que afectan a ramas muy gruesas, crean pudriciones que acortan la vida del árbol y producen abundantes brotes chupones. Si se repiten en períodos cortos (9-10 años) terminan por eliminar la práctica totalidad de las ramas adultas y convierten al árbol en un trasmocho. Foto: G. Montero.

Características selvícolas generales de la zona que pretende representar la muestra

Dentro de esta zona son claramente diferenciales los alcornocales que se hallan en forma adehesada y ocupan las zonas de relieve más suave, y los de serranía, que se localizan en las zonas más abruptas y de mayor pendiente.

En los primeros ha sido muy intensa la acción del hombre, que durante siglos ha venido cultivando periódicamente el suelo para la producción de cereales y pastos, sometiéndolo después a un intenso pastoreo hasta que el matorral lo invadía de nuevo. La alternancia de este ciclo crea serias dificultades a la regeneración natural, que es prácticamente nula en este tipo de masas, las cuales se van aclarando paulatinamente hasta convertirse en masas fósiles, pues los pocos pies que quedan en ellas son generalmente de avanzada edad, y terminarán por desaparecer si no se ayuda a la regeneración natural.

Además en estos momentos la producción de pasto es escasa y periódica, pues el pasto aparece únicamente cuando el suelo se limpia de matorral, y siempre formado por pastos ralos, estacionales, agostantes y de poca producción; salvo pequeñas zonas de vaguadas en las que se han acumulado elementos finos del suelo, por lavado de las partes más altas, y que suelen contar con un cierto grado de humedad edáfica.

En los alcornocales, que se pudieran llamar de sierra, la acción del hombre ha sido mucho menos intensa, formando masas puras o casi puras en las partes alta y media de las laderas. A medida que se aproximan a la ladera se van mezclando cada vez más con la encina y algún quejigo, hasta terminar

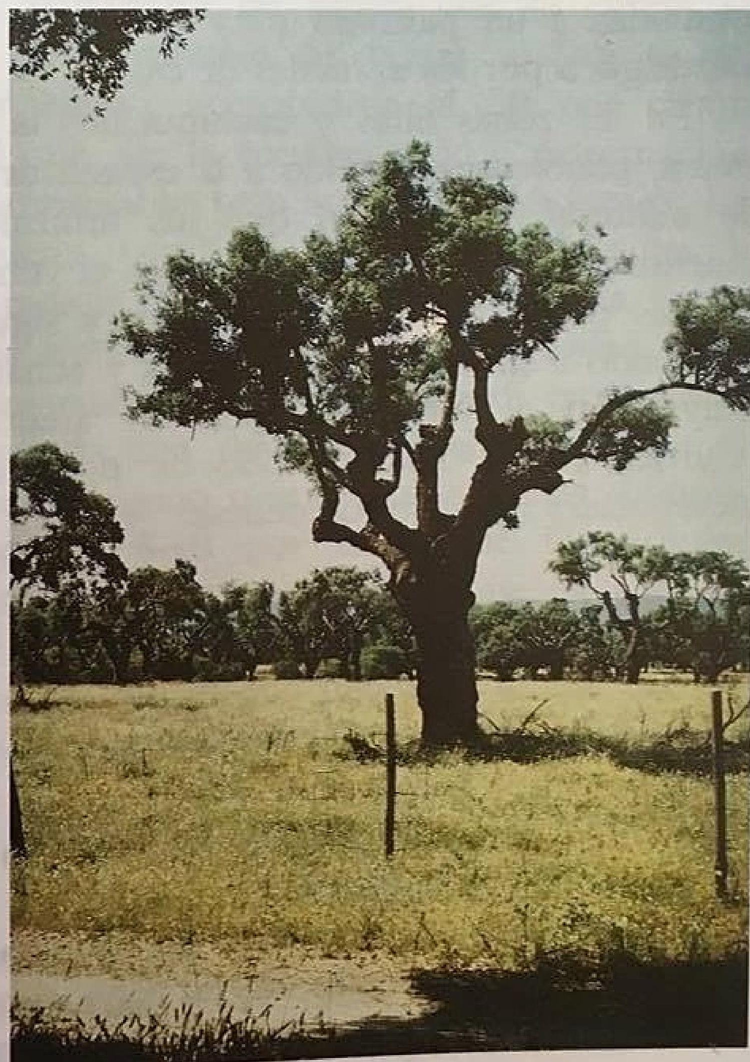


Fig. 8.—Las podas fuertes y repetidas convierten al árbol en un trasmocho, bajando la producción de corcho y bellota. El efecto beneficioso del árbol sobre el pasto puede reducirse significativamente. Foto: G. Montero.

siendo dominados o totalmente sustituidos por la encina en las llanuras y en los fondos de los valles. Esto es debido, probablemente, a que en estas zonas de acumulación de elementos finos ha dado origen a suelos con poca aireación que son más aptos para la encina que para el alcornoque.

En general el alcornoque alcanza buen desarrollo en las partes bajas y media de las laderas, y menor a medida que asciende hacia las cumbres; en zonas próximas a éstas y en las zonas cacumunales es muy frecuente que el suelo posea escasa profundidad y esta circunstancia, unida al azote del viento, es la causa de que las masas sean más claras y los árboles de peor porte y pequeñas dimensiones, apareciendo a veces casi ahogados por el matorral.

La regeneración natural es satisfactoria en las masas situadas en las partes media y baja de las laderas, en las que no se suelen practicar el cultivo de cereales y pasto, siempre que no estén sometidas a un pastoreo muy intenso y que no sea excesivo el mordisqueo por los animales de caza.

En las zonas altas y cacumunales la regeneración natural es escasa, posiblemente debido a la escasez de suelo y a la abundancia de matorral, que hacen que los brinzales de uno o dos años mueran casi en su totalidad durante el verano por falta de agua.

Las podas suelen ser excesivas, y siguen técnicas defectuosas, tendiendo a formar copas amplias y achaparradas, dejando ramas muy bajas y formando casi un anillo alrededor del tronco (Curras, 1972). Este método de poda es más acusado en los alcornocales llamados de dehesa.

PRODUCCION DE LA PODA

Tipo de poda

El tipo de poda aplicada consistió, en general, en eliminar las ramas bajas (sobaqueras o cabriteras), siempre que ello fue posible, reducir el diámetro de la copa, dejar algunas ramas dirigidas hacia el centro de la copa con objeto de conseguir el asombramiento de las ramas de primer orden y un porte redondeado de la copa del árbol. Para evitar pudriciones se respetaron las ramas cuyo corte quedase horizontal (al cielo) o presentasen peligro de acumulación de aguas de lluvia. Se procuró, especialmente, conseguir un equilibrio en la constitución de la copa, dejando en cada rama de primer orden una cantidad de follaje «proporcional» a su diámetro máximo que debían tener las ramas a cortar, siguiendo el criterio general de no cortar ramas con más de 20 centímetros en la base, ni aquellas que estuviesen insertadas en ramas descorchadas. A las ramas que quedaron se les hizo una limpieza de ramallos secos, debilitados, etc. (Curras, 1972).

Intensidad de la poda

La intensidad de la poda en esta especie es difícil de cuantificar, y depende de la cantidad de ramas que tenga el árbol antes de la poda y del porcentaje de ramas que se cortan al efectuarla. En términos de porcentaje de ramas se intentó no sobrepasar el 20-25 por ciento, acercándose al 30 por ciento solamente en algún árbol que por la configuración o deformación de su copa se creyese aconsejable para su desarrollo futuro. La fracción de cabida cubierta (medida árbol a árbol, antes y después de la poda) se redujo en un 30 por ciento. Esta fuerte reducción se debió más al tipo de poda que a la intensidad de la misma. Una regla internacionalmente admitida por los especialistas es que la intensidad ideal de una poda es aquella a la que el árbol responde no echando ninguno o muy pocos brotes «chupones». En este caso sólo un 8-10 por ciento de los árboles brotaron con relativa intensidad, lo cual indica que en ellos la poda fue excesiva; en el resto, o no salieron brotes chupones o salió alguno muy debilmente, por lo que puede deducirse que en ellos la intensidad de la poda fue la correcta.

Toma de datos

La parcela de experiencias de 15 ha de superficie estaba dividida en 15 subparcelas de 1 ha cada una. Conocida la distribución diamétrica de cada parcela, se eligió una muestra al azar del 10 por ciento de los árboles de cada clase de circunferencia. En las clases con menos de 10 árboles se tomó un mínimo de un árbol para la muestra. La muestra total resultante para toda la parcela fue de 232 árboles, y en cada uno de ellos se midieron las siguientes variables:

- Circunferencia normal.
- Superficie de la proyección de la copa, antes y después de la poda.
- Kilos de leña gruesa con bornizo producidos por la poda. Se consideró como leña gruesa todas aquellas ramas con una cantidad apreciable de bornizo, lo que suele coincidir con ramas de más de 4-5 centímetros de diámetro. El resto, las ramillas delgadas (gavillas), fueron estimadas tal como se indica en el punto siguiente.

Determinación de los porcentajes de bornizo, leña sin bornizo y gavilla

Para la determinación de estos porcentajes se hicieron cinco (5) lotes de 100 kg de leña con bornizo, procurando coger ramas de todos los diámetros y de distintos árboles. Las ramillas delgadas (gavilla) procedentes de los 100 kg de leña se pesaron aparte para determinar cuántos kilos de gavilla se producen por cada 100 kg de leña con bornizo, y este porcentaje se aplicó a cada uno de los árboles de la muestra para determinar el peso de gavilla producido por cada árbol. Posteriormente se desbornizaron los 100 kg de leña y se pesó, por un lado la leña sin bornizo, y por otro el bornizo, así determinamos el porcentaje de bornizo en leña. Los resultados medios obtenidos fueron los siguientes:

- Por cada 100 kg de leña con bornizo se obtuvieron 68,25 de gavilla.
- Por cada 100 kg de leña con bornizo se obtuvieron 69,5 kg de leña sin bornizo y 26,75 kg de bornizo. La pérdida por pica y pela fue de 3,75 kg.

Estos porcentajes se aplicaron al peso de leña con bornizo que había producido cada árbol de la muestra, para calcular los valores modulares por clases de circunferencia (cuadro CC-1).

Cuadro CC-1. LEÑA, BORNIZO Y GAVILLA POR ARBOL Y CLASES DE CIRCUNFERENCIAS (CAP)

Clase de CAP. (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
25-34	2,6	1,8	0,7	1,8
35-44	3,0	2,1	0,8	2,0
45-54	5,8	4,0	1,6	3,9
55-64	13,2	9,2	3,5	9,0
65-74	29,4	20,5	7,9	20,1
75-84	41,2	28,6	11,0	28,1
85-94	68,7	47,7	18,4	46,9
95-104	74,8	52,0	20,0	51,1
105-114	95,6	66,4	25,6	65,2
115-124	102,7	70,9	27,5	70,1
125-134	115,5	79,7	30,9	78,8
135-144	125,5	86,6	33,6	85,6
145-154	134,6	92,9	36,0	91,9
155-164	164,7	113,6	44,1	112,4
165-174	195,3	134,7	52,2	133,3
175-184	198,7	137,1	53,2	135,6
185-194	209,0	144,2	55,9	142,6
195-204	214,1	147,7	57,3	146,1

Cuadro CC-2. PESO EN VERDE (KG) DE LEÑA, BORNIZO Y GAVILLA POR HECTAREA Y POR ARBOL

	Valores por Hectárea						Valores Medios por árbol		
Subparcela	N.º de árboles (ha)	CAP media (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
1	58	95	3.069	2.132	820	2.094	37	14	36
2	89	89	3.624	2.518	969	2.473	28	11	28
3	93	81	3.327	2.312	890	2.270	25	10	24
4	109	89	4.784	3.325	1.280	3.265	31	12	30
5	114	91	4.908	3.411	1.313	3.349	30	12	29
6	122	94	7.602	5.283	2.033	5.188	43	17	42
7	126	83	4.262	2.962	1.140	2.909	24	9	23
8	126	103	7.680	5.337	2.054	5.241	42	16	41
9	139	101	8.187	5.690	2.190	5.588	41	16	40
10	154	90	6.917	4.808	1.850	4.721	31	12	30
11	157	97	8.593	5.972	2.299	5.865	38	15	37
12	169	94	7.830	5.442	2.094	5.344	32	12	31
13	173	98	9.272	6.444	2.480	6.328	37	14	36
14	182	92	8.495	5.904	2.272	5.797	32	12	31
15	236	88	9.911	6.888	2.651	6.765	29	11	28

Dado que cada subparcela tenía distinto número de árboles, y de distinto tamaño, se incluyen las producciones obtenidas en cada una de ellas por considerar que con ello se obtiene una información más completa sobre la producción de la poda (cuadro CC-2). Una vez finalizada la poda de toda la parcela se pesó la leña sin bornizo, y el bornizo por separado, para ser abonados por el comprador; la diferencia entre el peso total real y el estimado por la muestra no llegó al 2 por ciento.

MUESTRA DE LA SIERRA DE SEVILLA

Localización

* **Término Municipal:** Constantina.
* **Sistema montañoso:** Sierra Morena.
* **Monte:** monte público El Robledo.
* **Paraje:** Tramo XIII.
* **Altitud media:** 700 m.
* **Pendiente media:** 20%.

Características selvícolas

Descripción del sitio de muestra

* **Densidad media:**
  — Arboles en fábrica: 59/ha.
  — Macheros: 97 ha.
* **Fracción de cabida cubierta media (Fcc):**
  — Máxima: 0,46.
  — Mínima: 0,22.
  — Media: 0,32.
* **Superficie de descorche media/ha:** 340 m^2.
* **Coeficiente de descorche:**
  — Máximo: 3,7.
  — Mínimo: 2,1.
  — Medio: 3,3.
* **Superficie podada:** 7,5 ha.
* **Número árboles podados:** 442.
* **Años transcurridos desde la última poda:** 15.

Características selvícolas generales de la zona que pretende representar la muestra

En estos alcornocales el matorral cubre prácticamente el suelo, por lo cual es frecuente la práctica de la roza del matorral como defensa del fuego y para facilitar el aprovechamiento de la montanera y el poco pasto que produce.

A pesar del aprovechamiento de la montanera, su regeneración natural es aceptable, debido en gran parte a la protección que presta el matorral a las bellotas caídas al suelo.

Por lo general, estos alcornocales están situados sobre terrenos moderadamente accidentados, y sus pies tienen un fuste esbelto y la copa bien desarrollada, siendo su espesura claramente incompleta en la mayoría de las masas.

Tradicionalmente las podas se han hecho eliminando las ramas jóvenes dirigidas hacia arriba, originadas por brotes «chupones» surgidos como consecuencia de podas anteriores, dejando

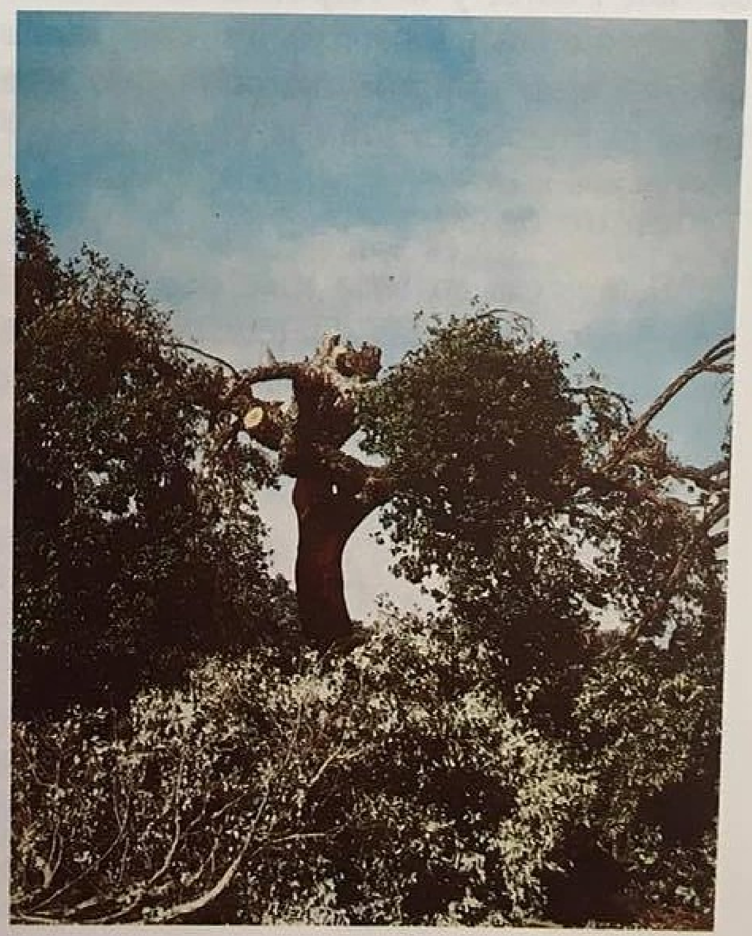


Fig. 9.—La poda brutal no constituye una línea general de actuación en nuestros alcornocales, pero tampoco puede ser calificada como un hecho aislado. Abundan los ejemplos de este tipo, y, a veces, hasta se intentan justificar. Foto: F. Carrascosa.

aquellas que van hacia el exterior de la copa; puede decirse que el árbol quedaba desramado en el centro y vertido en el círculo exterior. Las razones de esta técnica han sido siempre de tipo económico inmediato y carentes de fundamento selvícola y de la mínima visión de futuro. Prácticamente sólo se cortan las ramas que son cómodas de cortar y aquellas que por su grosor proporcionan apreciables cantidades de leña y bornizo.

PRODUCCION DE LA PODA

Tipo de poda

El tipo de poda se realizó siguiendo las mismas directrices y persiguiendo los mismos objetivos que hemos descrito para la muestra de la sierra de San Pedro - Cáceres.

Intensidad de la poda

Se siguió el mismo criterio descrito para la zona de la sierra de San Pedro, y la respuesta de la masa fue semejante en cuanto al rebrote. Algunos árboles con ramas de primer orden muy horizontales, tomaron un porte que se asemejaba a un «candelabro», al intentarles subir la copa.

Toma de datos

Semejante en todo a lo descrito para la zona de la sierra de San Pedro, sin más diferencia que el tamaño de la parcela, que en este caso era de 7,5 ha y dividida en 15 subparcelas de 0,5 ha. El número de árboles en los que se pesó la leña con bornizo procedente de la poda fue de 67 y el total podados de 442.

Determinación de los porcentajes de bornizo, leña sin bornizo y gavilla

Siguiendo el mismo procedimiento que en la zona de la sierra de San Pedro se determinaron los siguientes porcentajes:

- 100 kg de leña con bornizo dieron 62 kg de gavilla.
- 100 kg de leña con bornizo dieron 70,5 kg de leña sin bornizo y 25,25 kg de bornizo. La pérdida por pica y pela fue de 4,25 kg.

Cuadro SE-1. PESO EN VERDE (KG) DE LEÑA, BORNIZO Y GAVILLA POR ARBOL Y CLASES DE CIRCUNFERENCIAS (CAP).

Clase de CAP. (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
45-54	16,7	11,8	4,2	10,3
55-64	35,0	24,7	8,8	21,7
65-74	49,9	32,2	12,5	30,9
75-84	64,6	45,5	16,3	40,1
85-94	97,7	68,9	24,7	60,6
95-104	103,1	72,7	26,0	63,9
105-114	115,6	81,5	29,2	71,7
115-124	130,4	91,9	32,9	80,8
125-134	164,7	116,1	41,6	102,1
135-144	205,0	144,5	51,8	127,1
145-154	216,0	152,3	54,5	133,9
155-164	237,5	167,4	60,0	147,2
165-174	243,5	171,7	61,5	151,0
175-184	281,7	198,6	71,1	174,6
185-194	298,5	210,4	75,4	185,1
195-204	308,7	217,6	77,9	191,4

Cuadro SE-2. PESO EN VERDE (KG) DE LEÑA, BORNIZO Y GAVILLA POR HECTAREA Y POR ARBOL

	Valores por Hectárea						Valores Medios por árbol		
Subpar-cela	N.º de árboles (ha)	CAP media (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
1	32	154	3.243	2.286	819	2.010	71	26	63
2	36	131	2.999	2.114	757	1.859	59	21	52
3	42	154	5.313	3.745	1.354	3.294	89	32	78
4	48	101	1.934	1.363	488	1.199	28	10	25
5	50	107	2.527	1.781	630	1.567	36	13	31
6	54	88	2.347	1.655	593	1.455	31	11	27
7	60	123	3.725	2.626	941	2.310	44	16	38
8	62	141	5.793	4.084	1.463	3.592	66	24	58
9	64	109	3.212	2.264	811	1.991	35	13	31
10	66	130	4.651	3.279	1.174	2.884	50	18	44
11	68	102	2.947	2.078	744	1.827	31	11	27
12	68	101	2.602	1.834	657	1.613	27	10	24
13	70	113	3.273	2.307	826	2.029	33	12	29
14	74	94	2.384	1.681	602	1.478	23	8	20
15	90	101	3.473	2.448	877	2.153	27	10	24

Como en el caso anterior, estos porcentajes se aplicaron al peso de leña con bornizo que había producido cada árbol de la muestra, y así se calculaban los valores modulares por clases de circunferencia (cuadro SE-1). En el cuadro SE-2 se dan los valores por hectárea referidos a cada una de las 15 subparcelas.

MUESTRA DE LOS ALCORNOCALES DE CADIZ

Localización

* **Término Municipal:** Los Barrios.
* **Sistema montañoso:** Penibético. Sierra Montecoche.
* **Monte:** Las Presillas.
* **Paraje:** La Polvorilla.
* **Altitud media:** 125 m.
* **Pendiente media:** 25%.

Características selvícolas

Descripción del sitio de muestra

* **Densidad:**
  — Arboles en fábrica: 73/ha.
  — Macheros: 16/ha.
* **Fracción de cabida cubierta media (Fcc):**
  — Máxima: 0,64.
  — Mínima: 0,31.
  — Media: 0,50.
* **Superficie de descorche media:** 305 m²/ha.
* **Número de árboles podados:** 544.
* **Años transcurridos desde la última poda:** 43.

Características selvícolas generales de la zona que pretende representar la muestra

La circunstancia de que la mayor parte de los alcornocales de este tipo se encuentren situados sobre laderas de relieve muy accidentado y abundantes afloramientos rocosos, es la causa de que sus estratos arbustivo y subarbustivo se encuentren menos alterados que los de otras masas, si bien el pastoreo con ganado cabrío, los incendios y las rozas han influido indudablemente en su composición y desarrollo, creándose grandes claros desprovistos de alcornoque que han sido invadidos por el matorral.

El matorral alcanza gran desarrollo y densidad, llegando a cubrir totalmente el suelo, al que invade de nuevo en muy pocos años después del desbroce, laboreo o incendio.

La vegetación herbácea es casi inexistente en las zonas cubiertas por el matorral descrito, limitándose a ocupar los claros que éste deja, y aparece pujante en las inmediaciones de los cursos de agua, fondos de valles y otros lugares con abundante humedad edáfica.

El alcornoque puebla las abruptas laderas de las serranías antes citadas, extendiéndose en ellas desde el nivel del mar a los

Fig. 10.—La respuesta de la poda excesiva es siempre un aparente rejuvenecimiento del árbol. Realmente se trata de una respuesta al desequilibrio traumático entre el sistema radical y aéreo, del cual los dos salen perjudicados. Foto: F. Carrascosa.

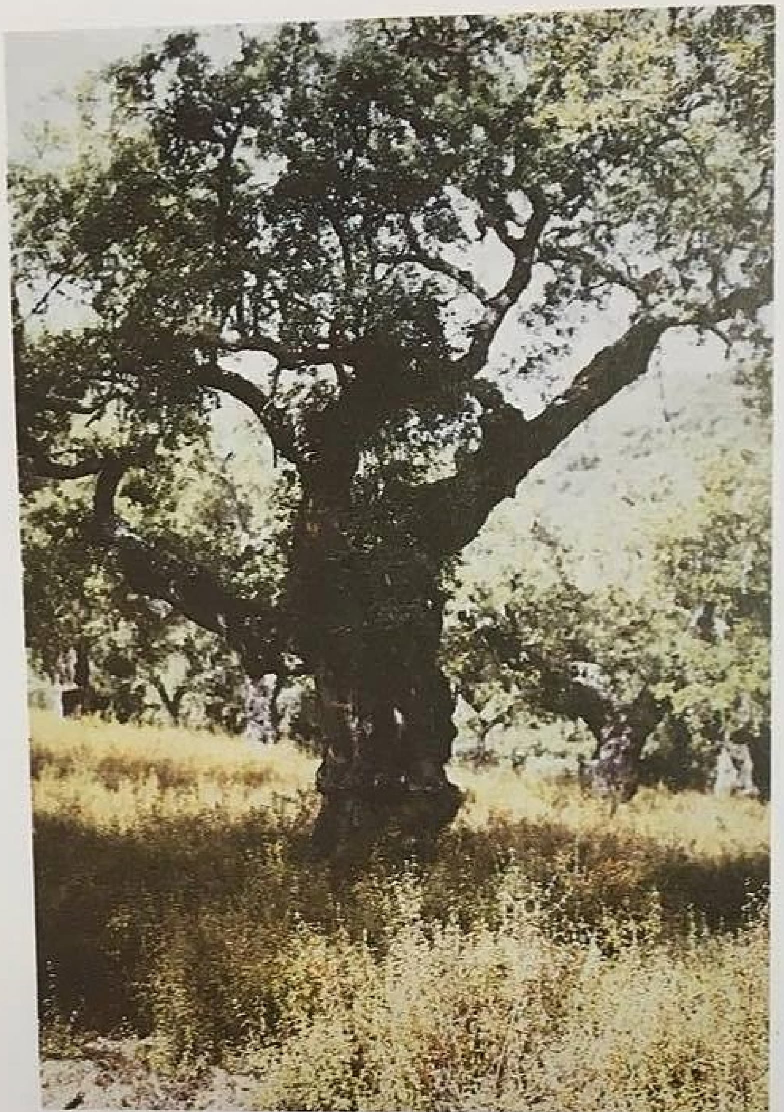


Fig. 11.—Las llamadas podas de rejuvenecimiento sólo tienen sentido en árboles muy viejos, y sus efectos son más aparentes que reales. Foto: G. Montero.

1.300 m de altitud. Alcanza buen porte y desarrollo, con fustes esbeltos y copas más bien recogidas. La espesura es muy variable de unos alcornocales a otros a causa de las irregularidades del relieve y los suelos, que hacen que se distingan perfectamente los alcornocales de «bujeo»; los de «pedriza», con árboles más pequeños, más claros, con mucho matorral y sin la presencia de *Quercus canariensis* Willd; y los de «canuto», con árboles esbeltos, y abundantes pies de *Quercus canariensis* Willd. La poda es poco frecuente en esta zona y nunca se hacen podas tendentes a abrir la copa para favorecer la frutificación.

PRODUCCION DE LA PODA

El tipo y la intensidad de la poda, la toma de datos y la determinación de los porcentajes de leña, bornizo y gavilla se realizaron siguiendo el procedimiento antes citado.

El número de árboles medidos en la muestra fue de 73 y los porcentajes de leña, bornizo y gavilla fueron los siguientes:

- 100 kg de leña con bornizo dieron 65 kg de gavilla.
- 100 kg de leña con bornizo dieron 68 kg de leña sin bornizo y 30 kg de bornizo. La pérdida por pica y pela fue de 2,0 kg.

Cuadro CA-1. PESO EN VERDE (KG) DE LEÑA, BORNIZO Y GAVILLA POR ARBOL Y CLASES DIAMETRICAS

Clase diamétrica (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
15-24	53,0	36,0	15,9	34,4
25-34	65,3	44,4	19,6	42,4
35-44	173,8	118,2	52,1	113,0
45-54	246,8	167,8	74,0	160,4
55-64	374,0	254,3	112,2	243,1
65-74	567,5	385,9	170,2	368,8
75-84	635,0	413,8	190,5	412,7

Cuadro CA-2. PESO EN VERDE (KG) DE LEÑA, BORNIZO Y GAVILLA POR HECTAREA Y POR ARBOL

	Valores Medios por Hectárea						Valores Medios por árbol		
Subparcela	N.º de árboles (ha)	Diámetro medio (cm)	Leña con bornizo (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)	Leña sin bornizo (kg)	Bornizo (kg)	Gavilla (kg)
1	54	52,1	10.570	7.187	3.171	6.870	133	59	127
2	56	49,2	8.882	6.040	2.665	5.773	108	48	103
3	58	39,9	5.176	3.520	1.553	3.364	61	27	58
4	58	43,6	6.095	4.145	1.828	3.962	71	31	68
5	58	50,0	9.916	6.743	2.975	6.445	116	51	111
6	60	45,1	7.929	5.392	2.379	5.154	90	40	86
7	64	51,0	10.683	7.264	3.205	6.944	113	50	108
8	66	45,5	9.769	6.643	2.931	6.350	101	44	96
9	70	47,4	12.431	8.453	3.729	8.080	121	53	115
10	72	47,1	10.918	7.424	3.275	7.096	103	45	99
11	82	47,1	11.977	8.144	3.593	7.785	99	44	95
12	88	50,4	14.572	9.909	4.372	9.472	113	50	108
13	92	41,5	10.292	6.998	3.088	6.690	76	34	73
14	96	40,8	10.325	7.021	3.097	6.711	73	32	70
15	114	40,6	12.063	8.203	3.619	7.841	72	32	69

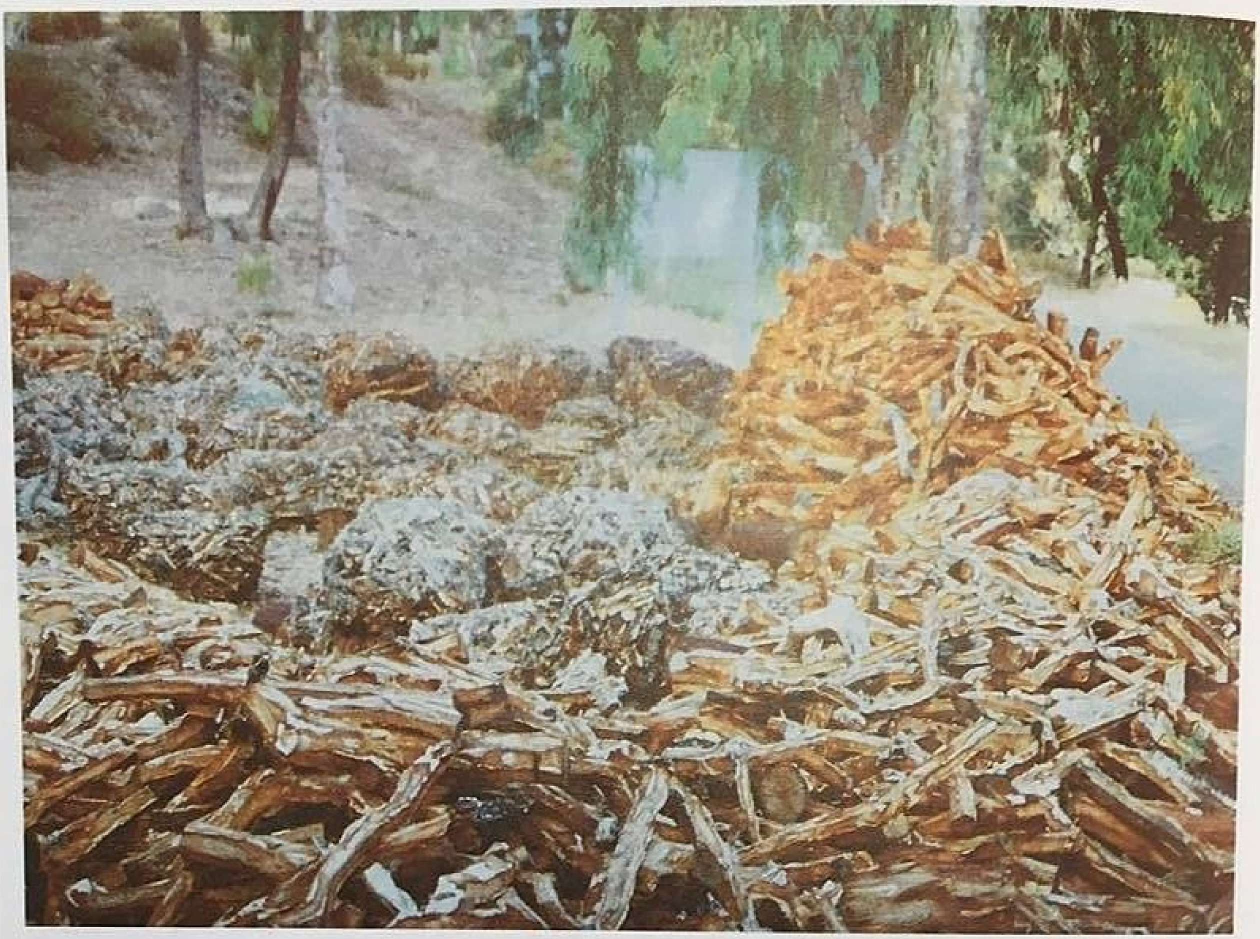


Fig. 12.—El valor de los productos de la poda (leña y bornizo), la facilidad del laboreo con tractor y la producción estacional de pasto y cereal son hechos que ayudan a comprender la realización de podas excesivas, mejor que los objetivos selvícolas que habitualmente se argumentan para justificarlas. Foto: G. Montero.

Estos porcentajes fueron aplicados al peso de la leña con bornizo que había producido cada árbol de la muestra, para calcular los valores modulares por clases diamétricas, no circunferencia (cuadro CA-1) y para obtener la producción por hectárea de cada una de las 15 parcelas de 5.000 m^2 en que estaba dividida la parcela de experiencias (cuadro CA-2).

COMENTARIOS SOBRE LOS CUADROS

Aunque los cuadros son suficientemente sencillos y claros para interpretar los resultados con su simple observación, he aquí algunos comentarios que pueden proporcionar al lector una mayor información:

— Los porcentajes de bornizo respecto al peso de leña con bornizo crecen cuando aumenta el número de años transcurridos desde la última poda. Esto puede significar que a igualdad de grosor de las ramas, las más viejas tienen un mayor porcentaje de bornizo. El grosor de las ramas cortadas también puede influir, pues es sabido que el porcentaje de corcho baja cuando crece el diámetro de éstas; pero esta variable no creemos que haya tenido mucha influencia, ya que generalmente todas las ramas tenían menos de 20 cm de diámetro en la base.

— El porcentaje de ramillas delgadas respecto al de leña se mantiene relativamente próximo en las tres zonas.

— Los valores modulares dependen de la densidad de la masa; Cáceres, con mayor densidad, tiene los valores más

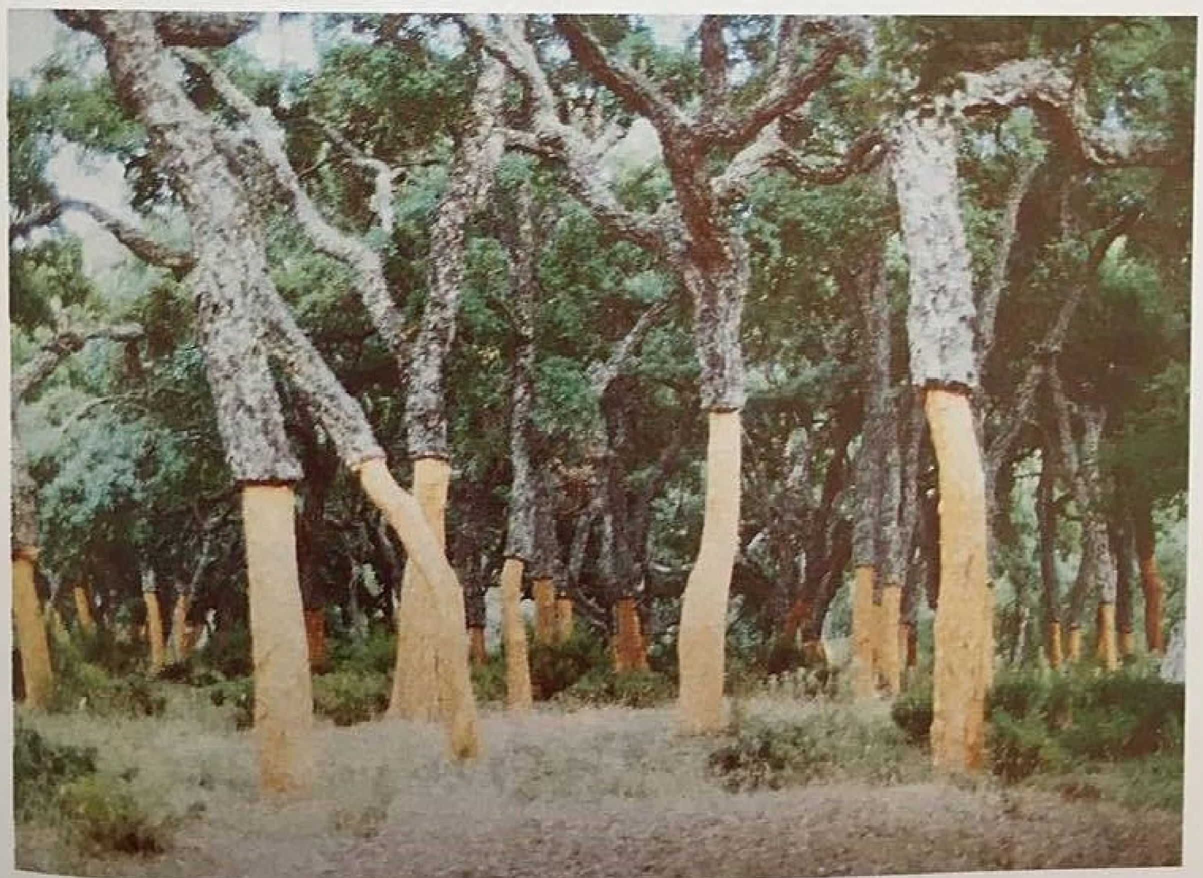


Fig. 13.—En esta masa de 90-100 años sólo se ha realizado una poda de formación. Es un error pensar en la poda como única forma de mantener el vigor y la sanidad del alcornocal. Masas como ésta mantienen un excelente estado vegetativo y sanitario, aun cuando estén demasiado densas. Foto: G. Montero.

bajos, debido a que los árboles que crecen más densos tienen las copas más pequeñas.

— Los valores medios por árbol son menores en los montes de Cáceres que en los de Sevilla, y en estos últimos que en los montes de Cádiz. Esta variación depende del tamaño de los árboles (los de la sierra de San Pedro son más delgados) y también del número de años transcurridos desde la última poda. En el monte de Los Barrios-Cádiz hacía 43 años que no se podaba, y parece, además, que la anterior poda fue sumamente moderada, por este motivo no es raro que sus árboles hayan dado mayor cantidad de productos que en las otras dos zonas.

— Los valores por hectárea son muy variables y dependen lógicamente del número de árboles/ha, del grosor de éstos y del número de años transcurridos desde la última poda. Cuanto más frecuentes sean las podas, menores serán las cantidades de leña y bornizo obtenidas en ellas.

Foto portada cedida por el Instituto de Promoción del Corcho (IPROCOR).

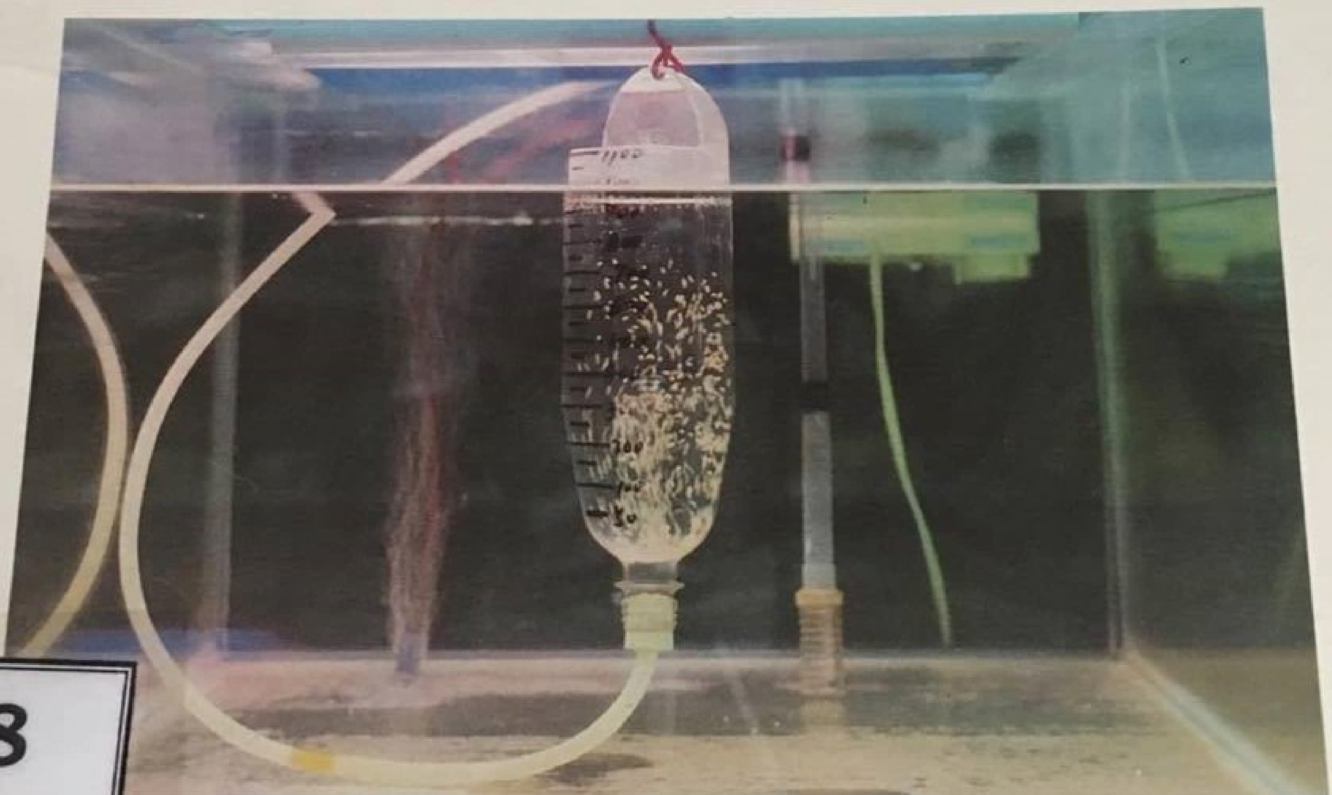
MINISTERIO DE AGRICULTURA PESCA Y ALIMENTACION
DIRECCION GENERAL DE INVESTIGACION Y CAPACITACION AGRARIAS
SERVICIO DE EXTENSION AGRARIA
Corazón de María, 8 - 28002-Madrid

I.S.B.N.: 84-341-0710-4. N.I.P.O.: 253-90-002-X - Depósito legal: M. 7.966 - 1991 (38.000 ejemplares)
Imprime: Neografis, S. L. - Santiago Estévez, 8 - 28019 Madrid

ICLARM TECHNICAL REPORTS 14

Experimental rearing of Nile tilapia fry (*Oreochromis niloticus*) for saltwater culture

Wade O. Watanabe
Ching-Ming Kuo
Mei-Chan Huang



COUNCIL FOR AGRICULTURAL PLANNING AND DEVELOPMENT
TAIPEI, TAIWAN

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MANILA, PHILIPPINES

Experimental rearing of Nile tilapia fry *(Oreochromis niloticus)* for saltwater culture

Wade O. Watanabe
Ching-Ming Kuo
and
Mei-Chan Huang

1984

COUNCIL FOR AGRICULTURAL PLANNING AND DEVELOPMENT
TAIPEI, TAIWAN

INTERNATIONAL CENTER FOR LIVING AQUATIC RESOURCES MANAGEMENT
MANILA, PHILIPPINES

Experimental rearing of Nile tilapia fry *(Oreochromis niloticus)* for saltwater culture

WADE O. WATANABE
CHING-MING KUO
AND
MEI-CHAN HUANG

1984

Published jointly by the Council for Agricultural Planning and Development, Executive Yuan, 37 Nan Hai Road, Taipei, Taiwan and International Center for Living Aquatic Resources Management, MCC P.O. Box 1501, Makati, Metro Manila, Philippines

Printed in Manila, Philippines

Watanabe, W.O., C-M Kuo and M-C. Huang. 1984. Experimental rearing of Nile tilapia fry *(Oreochromis niloticus)* for saltwater culture. ICLARM Technical Reports 14, 28 p. Council for Agricultural Planning and Development, Taipei, Taiwan and International Center for Living Aquatic Resources Management, Manila, Philippines.

Cover: An incubator of the type used for experimental rearing of *O. niloticus* in various salinities.

ISSN 0115-5547
ISBN 971-1022-11-7

ICLARM Contribution No. 208.

Table of Contents

Experimental Rearing of Nile Tilapia Fry (*Oreochromis niloticus*) for Saltwater Culture

WADE O. WATANABE
ICLARM Postdoctoral Research Fellow
1439-B Alewa Drive
Honolulu, Hawaii 96817, U.S.A.

CHING-MING KUO
Senior Scientist
International Center for Living Aquatic Resources Management
MCC P.O. Box 1501, Makati, Metro Manila
Philippines

MEI-CHAN HUANG
ICLARM Research Assistant
National Sun Yat-Sen University
Kaohsiung, Taiwan

WATANABE, W.O., C-M. KUO and M-C. HUANG. 1984. Experimental rearing of Nile tilapia fry *(Oreochromis niloticus)* for saltwater culture. ICLARM Technical Reports 14, 28 p. Council for Agricultural Planning and Development, Taipei, Taiwan and International Center for Living Aquatic Resources Management, Manila, Philippines.

Abstract

Fertilized eggs of the Nile tilapia (*Oreochromis niloticus* L.) spawned in freshwater, were removed from mouthbrooding females one day post-spawning and artificially incubated at elevated salinities. Mortality during artificial incubation occurred primarily during early development and generally increased with increasing incubation salinity. At six days post-hatching, mean survivals of 85.5, 84.4, 82.5, 56.3, 37.9, 20.0 and 0% were recorded for broods incubated at salinities of 0, 5, 10, 15, 20, 25 and 32 ppt, respectively. Fertilized eggs exhibited a 96-hour median lethal salinity (MLS-96) of 18.9 ppt, identical to that of 7 to 120-day old fry and fingerlings. Fertilized eggs, however, exhibited a much higher median survival time (ST_{50} = 978 min) than 7 to 395-day old fry and fingerlings (ST_{50} = 28.8 – 179.0 min), reflecting the ability of eggs to survive direct seawater transfer for longer periods of time than fry or fingerlings.

The reproductive performance of yearling *O. niloticus* broodstock was monitored under laboratory conditions at various salinities and results compared with the performance of an older (two to three-year) broodstock in freshwater. Spawning was observed in salinities ranging from freshwater to full seawater (32 ppt). Mean hatching successes were similar for eggs spawned by yearling females in freshwater (30.9%), 10 ppt (32.7%) and 15 ppt (36.9%). Extremely poor hatching success was obtained with eggs spawned in full seawater. Mean hatching success was considerably higher for eggs spawned at 5 ppt (51.6%) and compared with that obtained with eggs spawned by older females in freshwater (54.2%). Seasonal egg and fry production per female was much greater in the older broodstock in freshwater than in yearling females in any salinity. However, seasonal egg and fry production per unit weight was greater in yearling females in salinities of 5 to 15 ppt than in older females in freshwater.

The salinity tolerance of fry spawned at various salinities and fry spawned in freshwater but hatched at various salinities, was determined using the median survival time (ST_{50}), mean survival time (MST) and 96-hour median lethal salinity (MLS-96) indices. For comparative purposes, fry spawned and hatched in freshwater were acclimatized to various salinities and their salinity tolerances likewise determined. Fry salinity tolerance progressively increased with increasing salinity of spawning, hatching, or acclimatization. However, at equivalent salinity, early exposure (spawning) produced progeny of comparatively higher salinity tolerance than those spawned in freshwater and hatched at elevated salinity. Similarly, at equivalent salinity, progeny spawned in freshwater but hatched at elevated salinity exhibited higher salinity tolerance than those spawned and hatched in freshwater, then acclimatized to an elevated salinity.

The utility of these methods of early salinity exposure toward the saltwater culture of tilapias is discussed.

Introduction

Although tilapia culture is limited primarily to freshwater and low salinity brackishwater at present, it has been widely suggested that euryhaline tilapias could be cultured in higher salinity brackishwater and marine systems, thereby enabling their exploitation in arid lands and coastal areas. The realization of these important objectives has been impeded by an inadequate research base on their biology and culture with respect to salinity tolerance. For recent reviews see Chervinski (1982) and Payne (1983).

The general approach to saltwater tilapia culture has been to produce seed and juveniles in freshwater, followed by growout in brackishwater or seawater. In an earlier study (Watanabe et al., 1984), ontogenic changes in salinity tolerance were observed in several tilapia species. In *Oreochromis niloticus* and *O. aureus,* salinity tolerance increased from relatively low values over the initial 45 to 60 days post-hatching, to maximal values from 150 to 180 days post-hatching. Hybrid progeny of *O. mossambicus* (♀) X *O. niloticus* (♂) exhibited a comparatively faster rate of increase in tolerance with age. These ontogenic changes in salinity tolerance were determined to be more closely related to body size than to chronological age. Assuming that maximal survival and growth in seawater would result if transfer from freshwater was implemented at the size of maximum salinity tolerance, these results have provided a rational basis for selecting the optimal time for transfer of freshwater-spawned and reared stocks to seawater for growout.

A knowledge of optimal transfer size also minimizes freshwater requirements by allowing the culturist to implement transfer at the earliest possible time. However, when freshwater is severely limited, costs associated with spawning and early rearing in freshwater may still outweigh the benefits of improved survival and growth attributable to this approach. Furthermore, the amount of fish that can be produced in freshwater can limit total production, as has been demonstrated for salmon (Landless and Jackson 1976).

An alternative approach to the problem of saltwater tilapia culture is to expose the fish to low concentrations of seawater at very early stages of their life cycle in order to pre-adapt them to subsequent rearing at higher salinities. This approach may involve, for example, the exposure of freshwater-spawned and hatched progeny to elevated salinities soon after hatching. Exposure may be performed at an even earlier stage of development by removing fertilized eggs from the mouth of the parent female for artificial incubation and hatching at elevated salinities. Alternatively, if successful spawning is achieved at elevated salinities, the eggs are exposed to a saline environment immediately after oviposition when they leave the ovarian fluid. A knowledge of the relative effects of these various methods of early exposure on the salinity tolerance of resultant progeny would be of considerable practical importance to the saltwater tilapia culturist.

The present study represents a preliminary evaluation of the utility of these various approaches of early salinity exposure for saltwater culture of tilapias. The reproductive performance of the Nile tilapia *(Oreochromis niloticus* L.*)* was monitored under laboratory conditions at various salinities, and the salinity tolerance of progeny determined. Survivorship of fertilized eggs, spawned

The salinity tolerance of fry spawned at various salinities and fry spawned in freshwater but hatched at various salinities, was determined using the median survival time (ST_{50}), mean survival time (MST) and 96-hour median lethal salinity (MLS-96) indices. For comparative purposes, fry spawned and hatched in freshwater were acclimatized to various salinities and their salinity tolerances likewise determined. Fry salinity tolerance progressively increased with increasing salinity of spawning, hatching, or acclimatization. However, at equivalent salinity, early exposure (spawning) produced progeny of comparatively higher salinity tolerance than those spawned in freshwater and hatched at elevated salinity. Similarly, at equivalent salinity, progeny spawned in freshwater but hatched at elevated salinity exhibited higher salinity tolerance than those spawned and hatched in freshwater, then acclimatized to an elevated salinity.

The utility of these methods of early salinity exposure toward the saltwater culture of tilapias is discussed.

Introduction

Although tilapia culture is limited primarily to freshwater and low salinity brackishwater at present, it has been widely suggested that euryhaline tilapias could be cultured in higher salinity brackishwater and marine systems, thereby enabling their exploitation in arid lands and coastal areas. The realization of these important objectives has been impeded by an inadequate research base on their biology and culture with respect to salinity tolerance. For recent reviews see Chervinski (1982) and Payne (1983).

The general approach to saltwater tilapia culture has been to produce seed and juveniles in freshwater, followed by growout in brackishwater or seawater. In an earlier study (Watanabe et al., 1984), ontogenic changes in salinity tolerance were observed in several tilapia species. In *Oreochromis niloticus* and *O. aureus,* salinity tolerance increased from relatively low values over the initial 45 to 60 days post-hatching, to maximal values from 150 to 180 days post-hatching. Hybrid progeny of *O. mossambicus* (♀) X *O. niloticus* (♂) exhibited a comparatively faster rate of increase in tolerance with age. These ontogenic changes in salinity tolerance were determined to be more closely related to body size than to chronological age. Assuming that maximal survival and growth in seawater would result if transfer from freshwater was implemented at the size of maximum salinity tolerance, these results have provided a rational basis for selecting the optimal time for transfer of freshwater-spawned and reared stocks to seawater for growout.

A knowledge of optimal transfer size also minimizes freshwater requirements by allowing the culturist to implement transfer at the earliest possible time. However, when freshwater is severely limited, costs associated with spawning and early rearing in freshwater may still outweigh the benefits of improved survival and growth attributable to this approach. Furthermore, the amount of fish that can be produced in freshwater can limit total production, as has been demonstrated for salmon (Landless and Jackson 1976).

An alternative approach to the problem of saltwater tilapia culture is to expose the fish to low concentrations of seawater at very early stages of their life cycle in order to pre-adapt them to subsequent rearing at higher salinities. This approach may involve, for example, the exposure of freshwater-spawned and hatched progeny to elevated salinities soon after hatching. Exposure may be performed at an even earlier stage of development by removing fertilized eggs from the mouth of the parent female for artificial incubation and hatching at elevated salinities. Alternatively, if successful spawning is achieved at elevated salinities, the eggs are exposed to a saline environment immediately after oviposition when they leave the ovarian fluid. A knowledge of the relative effects of these various methods of early exposure on the salinity tolerance of resultant progeny would be of considerable practical importance to the saltwater tilapia culturist.

The present study represents a preliminary evaluation of the utility of these various approaches of early salinity exposure for saltwater culture of tilapias. The reproductive performance of the Nile tilapia *(Oreochromis niloticus* L.) was monitored under laboratory conditions at various salinities, and the salinity tolerance of progeny determined. Survivorship of fertilized eggs, spawned in freshwater but removed from the mouth of the parent female and artificially incubated at various salinities, was also evaluated, and the salinity tolerance of resultant fry determined. The salinity tolerance of fry spawned and hatched in freshwater but subsequently acclimatized to various salinities was also determined. Finally, the salinity tolerances of fry subjected to these various methods of early exposure were compared.

Materials and Methods

The experiments described in this report were conducted at the National Sun Yat-Sen University, Institute of Marine Biology, Kaohsiung, Taiwan, from March to December 1983.

SPAWNING IN FRESHWATER LABORATORY AQUARIA

The adult Nile tilapia *(Oreochromis niloticus)* broodstock used originated from captive experimental stocks held in freshwater at the Taiwan Fisheries Research Institute (Lukang and Tainan Branches). Individuals were examined to ensure conformity with known species-specific morphological characteristics including head configuration, mature coloration, and caudal fin barring (Lee 1979). Fuller descriptions have now been published in Trewavas (1983). Breeders ranged in size from 99 to 277 g in initial body weight.

Spawnings were conducted in freshwater in indoor 120-liter glass aquaria (60 x 60 x 40 cm) at 24 to 31°C, under natural photoperiod with diffused sunlight through several laboratory windows. A semi-closed recirculation system was employed with water constantly recirculated by airlift through box-type gravel filters situated inside each aquarium. Feces were siphoned out periodically and approximately one-half of the tank volume was replaced with tap water each week.

Fish were fed twice daily *ad libitum* a pelletized commercial tilapia diet (Tong Bao Company, Tainan, Taiwan) containing 24% protein.

In each aquarium, one male was stocked with one to three individually-tagged females. The pre-maxilla was removed from all males in order to reduce female mortality due to aggressive nipping (Lee 1979). Aquaria were checked daily for spawning activity and the spawner and date of observation of each spawn were recorded whenever mouthbrooding was observed.

HATCHING SUCCESS OF FERTILIZED EGGS SPAWNED IN FRESHWATER BUT ARTIFICIALLY INCUBATED AT VARIOUS SALINITIES

Eggs were removed from female mouthbrooders approximately one day post-spawning, counted, then evenly distributed into artificial incubators in various salinities (0, 5, 10, 15, 20, 25, and 32 ppt). The number of eggs ranged from 164 to 224 per incubator. Eggs were transferred directly from freshwater to the salinity of incubation. Water of varying salinities was prepared by diluting seawater obtained from the Hsitzewan Beach in Kaohsiung with tap water. Both seawater and tap water were conditioned by airlift recirculation through a 6-cm bed of oyster shells for several days prior to use.

Artificial incubators were fashioned from 1.2-l clear plastic bottles having a cylindrical base and a cone-shaped section near the spout (see Plate 1). A half section was removed from the bottle base to create an opening for placement and removal of eggs and fry and a concave, perforated disc was fitted near the spout to serve as a shower device. The incubator was suspended (spout down) from a PVC pipe support in a 100-l tank containing approximately 80 l of water of appropriate salinity. A continuous current of filtered, recirculated water from an electrically operated external aquarium filter was provided to the incubator through a tygon tube connected to the bottle spout by means of a rubber stopper. Flow rate of water through the incubator was adjusted to approximately 1.75 l/min by adjusting the degree of incubator submergence, thereby regulating the amount of water vented through ports preceding the incubator inlet point. This was achieved either by adjusting the length of the suspension wire or by adjusting the tank water level. Incubated eggs were maintained in suspension by the constant flow of water through the incubator.

in freshwater but removed from the mouth of the parent female and artificially incubated at various salinities, was also evaluated, and the salinity tolerance of resultant fry determined. The salinity tolerance of fry spawned and hatched in freshwater but subsequently acclimatized to various salinities was also determined. Finally, the salinity tolerances of fry subjected to these various methods of early exposure were compared.

Materials and Methods

The experiments described in this report were conducted at the National Sun Yat-Sen University, Institute of Marine Biology, Kaohsiung, Taiwan, from March to December 1983.

SPAWNING IN FRESHWATER LABORATORY AQUARIA

The adult Nile tilapia *(Oreochromis niloticus)* broodstock used originated from captive experimental stocks held in freshwater at the Taiwan Fisheries Research Institute (Lukang and Tainan Branches). Individuals were examined to ensure conformity with known species-specific morphological characteristics including head configuration, mature coloration, and caudal fin barring (Lee 1979). Fuller descriptions have now been published in Trewavas (1983). Breeders ranged in size from 99 to 277 g in initial body weight.

Spawnings were conducted in freshwater in indoor 120-liter glass aquaria (60 x 60 x 40 cm) at 24 to 31°C, under natural photoperiod with diffused sunlight through several laboratory windows. A semi-closed recirculation system was employed with water constantly recirculated by airlift through box-type gravel filters situated inside each aquarium. Feces were siphoned out periodically and approximately one-half of the tank volume was replaced with tap water each week.

Fish were fed twice daily *ad libitum* a pelletized commercial tilapia diet (Tong Bao Company, Tainan, Taiwan) containing 24% protein.

In each aquarium, one male was stocked with one to three individually-tagged females. The pre-maxilla was removed from all males in order to reduce female mortality due to aggressive nipping (Lee 1979). Aquaria were checked daily for spawning activity and the spawner and date of observation of each spawn were recorded whenever mouthbrooding was observed.

HATCHING SUCCESS OF FERTILIZED EGGS SPAWNED IN FRESHWATER BUT ARTIFICIALLY INCUBATED AT VARIOUS SALINITIES

Eggs were removed from female mouthbrooders approximately one day post-spawning, counted, then evenly distributed into artificial incubators in various salinities (0, 5, 10, 15, 20, 25, and 32 ppt). The number of eggs ranged from 164 to 224 per incubator. Eggs were transferred directly from freshwater to the salinity of incubation. Water of varying salinities was prepared by diluting seawater obtained from the Hsitzewan Beach in Kaohsiung with tap water. Both seawater and tap water were conditioned by airlift recirculation through a 6-cm bed of oyster shells for several days prior to use.

Artificial incubators were fashioned from 1.2-l clear plastic bottles having a cylindrical base and a cone-shaped section near the spout (see Plate 1). A half section was removed from the bottle base to create an opening for placement and removal of eggs and fry and a concave, perforated disc was fitted near the spout to serve as a shower device. The incubator was suspended (spout down) from a PVC pipe support in a 100-l tank containing approximately 80 l of water of appropriate salinity. A continuous current of filtered, recirculated water from an electrically operated external aquarium filter was provided to the incubator through a tygon tube connected to the bottle spout by means of a rubber stopper. Flow rate of water through the incubator was adjusted to approximately 1.75 l/min by adjusting the degree of incubator submergence, thereby regulating the amount of water vented through ports preceding the incubator inlet point. This was achieved either by adjusting the length of the suspension wire or by adjusting the tank water level. Incubated eggs were maintained in suspension by the constant flow of water through the incubator.

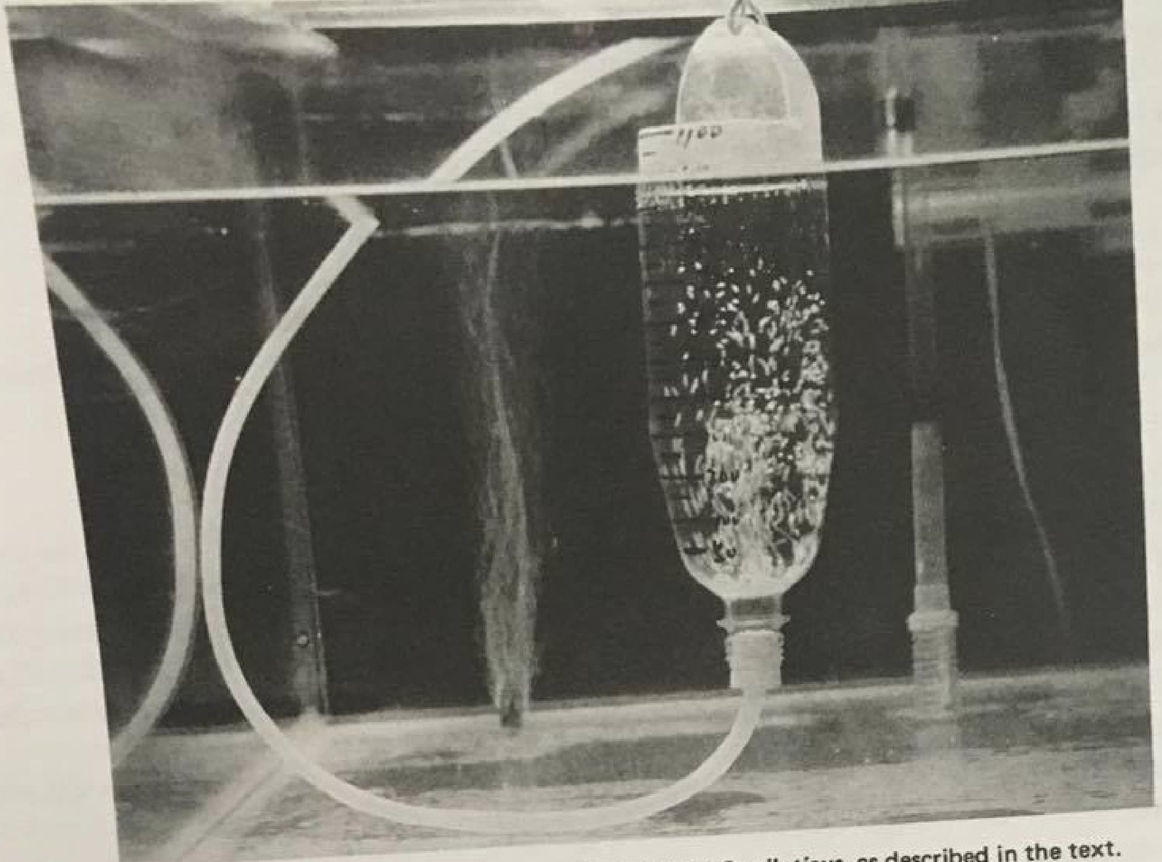


Plate 1. Incubator used for experimental breeding of *O. niloticus*, as described in the text.

Incubation was conducted at 27.2 to 31.5°C. Dead embryos and larvae were counted and removed daily. Dissolved oxygen, pH, total NH_4-N and total NO_2-N were monitored in each incubator on alternate days. Dissolved oxygen (DO) levels were maintained near air saturation (6.3 to 8.5 ppm) and pH ranged from 8.0 to 8.5 during incubation in all salinities. Total NH_4-N and NO_2-N concentrations did not exceed 0.06 and 0.02 mg/l, respectively, in any salinity during incubation.

Hatching occurred approximately three days post-spawning. Hatched larvae were allowed to remain in the incubators until yolk sac absorption was completed at approximately six to seven days post-hatching. The salinity tolerance of seven-day old fry was determined using the MST, ST_{50} and MLS-96 indices described below.

REPRODUCTIVE PERFORMANCE OF YEARLING *O. NILOTICUS* IN LABORATORY AQUARIA AT VARIOUS SALINITIES

Twenty-five *O. niloticus* individuals (mean initial length, weight: 7.2 cm, 6.2 g) from a single brood, spawned and reared in freshwater until 232 days post-hatching, were acclimatized to seawater (32 ppt) over a period of six days at a rate of approximately 5 ppt per day. A control group consisting of 25 individuals (mean initial length, weight: 6.9 cm, 5.3 g) of the same brood was retained in freshwater. Seawater-acclimatized and control groups were both held in white 100-l plastic aquaria under semi-closed system conditions as described earlier.

At 40 days following initiation of acclimatization (272 days post-hatching), one female in the seawater-acclimatized group (length, weight: 9.6 cm, 12.6 g) was observed to be mouthbrooding eggs. The eggs were removed from the mouth of the female and artificially incubated in seawater (32 ppt) although no embryonic development was observed. At 118 days, following initiation of acclimatization (350 days post-hatching), another female in the seawater-acclimatized group (length, weight: 10.0 cm, 16.0 g) was observed mouthbrooding. No embryonic development was observed during artificial incubation. One female in the freshwater control group (length, weight: 11.0 cm, 18.8 g) was observed to be mouthbrooding eggs at 312 days post-hatching, although eggs were not removed for artificial incubation. Such reproductive activity in full seawater suggested the feasibility of comparing the reproductive performance of seawater-acclimatized individuals following re-acclimatization to reduced salinities.

Seawater-acclimatized individuals (mean initial length, weight: 9.9 cm, 16.6 g) were subsequently distributed to salinities of 32, 15, 10, and 5 ppt and their reproductive performance monitored parallel to that of the freshwater controls. Spawnings were conducted in indoor 120-l glass aquaria at 27.0-30.2°C, under natural photoperiod conditions. Semi-closed system conditions were employed as described earlier. Approximately one-third of the tank volume was replaced with conditioned water of equivalent salinity each week. Three individually-tagged females and three males were maintained in each aquarium. Each tank was observed daily for spawning activity. Whenever a female was observed to be mouthbrooding, spawner and spawn date were recorded. Eggs were removed from the mouth approximately one day post-spawning and artificially incubated at equivalent salinity. Incubators were monitored daily in order to establish date of hatching (age 0 days). Hatched larvae were allowed to remain in the incubators until yolk sac absorption was completed at approximately six to seven days post-hatching. The salinity tolerance of six to nine-day old fry was determined using the MST, ST_{50} and MLS-96 indices described below.

SALINITY TOLERANCE OF FRESHWATER-SPAWNED AND HATCHED FRY ACCLIMATIZED TO VARIOUS SALINITIES

O. niloticus fry (4 to 10 days post-hatching) of a single brood spawned and hatched in freshwater were transferred directly to acclimatization salinities of 5, 10 and 15 ppt. Seven to eight days following transfer, the salinity tolerance of the fry was determined using the MST and ST_{50} indices described below. Fish were fed daily *ad libitum* the pelletized commercial tilapia diet during the acclimatization period. Feeding was discontinued beginning on the day of tolerance testing.

SALINITY TOLERANCE INDICES

Seawater was obtained from Hsitzewan Beach in Kaohsiung and filtered by recirculation through a 6-cm bed of oyster shells for several days prior to use. Water of varying salinities was prepared by diluting filtered seawater with tap water similarly conditioned by recirculation through oyster shells.

All salinity tolerance tests were conducted in white 20-l plastic aquaria, under closed-system conditions. In each aquarium water was recirculated by airlift through an internal box-type gravel filter.

Several tests were employed as practical indices of salinity tolerance:

(1) Median Lethal Salinity-96 hours (MLS-96) defined as the salinity at which survival falls to 50% 96 hours following direct transfer from the salinity to which the brood had been pre-exposed (during spawning, hatching, or acclimatization) to varying test salinities (0, 7.5, 15, 17.5, 20, 22.5, 25, 27.5, 30 and 32 ppt). A sample of 25-30 individuals was weighed and measured in order to establish mean body length, weight and condition factor of the experimental brood. Individual fish were blotted with tissue before weighing. Total length was determined to the nearest 0.01 cm. Condition factor (K) was calculated from the formula ($K = W/L^3 \times 100$), where W denotes weight in grams and L denotes total length in centimeters. Ten to twenty individuals were transferred from salinity of pre-exposure directly into each of the test salinities. Dead individuals were counted and removed daily over a period of four days (96 hours). Final survival (percent) in each test salinity was calculated as the sum of the number of days each individual survived, divided by the product of total experimental days (4) and initial number of fish. Percentage survival was then plotted against the salinity of transfer and MLS-96 determined as the salinity at which survival fell to 50%.

(2) Mean Survival Time (MST) defined as the mean survival time for all individuals in an experimental group over a 96-hour period following direct transfer from salinity of pre-exposure to full seawater (32 ppt). Twenty-five individuals were employed for each trial. Dead individuals were removed as soon as they succumbed to salinity stress and time of death, body length and body weight were recorded. Cessation of opercular movements and failure to respond to gentle prodding were the criteria used for death.

(3) Median Survival Time (ST_{50}) defined as the time at which survival falls to 50% following direct transfer from salinity of pre-exposure to full seawater.

Direct transfers between salinity of pre-exposure and the test salinities were performed under isothermal conditions. Experiments were conducted at temperatures of 27 to 30.2°C. Temperatures were recorded daily during tolerance testing. Dissolved-oxygen levels were maintained near air saturation (6.0-8.6 ppm) at all temperatures and salinities.

Results and Discussion

HATCHING SUCCESS OF FERTILIZED EGGS SPAWNED IN FRESHWATER BUT ARTIFICIALLY INCUBATED AT VARIOUS SALINITIES

Fig. 1 presents a generalized survivorship pattern for fertilized *O. niloticus* eggs 96 hours following direct transfer from the freshwater spawning medium to artificial incubators in various salinities. Eggs were removed from the mouth of the parent female approximately one day post-spawning. This survivorship pattern resulted in a MLS-96 of 18.9 ppt (range = 16.0 – 27.6 ppt, n = 4). For comparative purposes, a generalized survivorship pattern for 7 to 120-day old freshwater-spawned and reared *O. niloticus* fry and fingerlings, 96 hours following direct transfer to various salinities, is superimposed in Fig. 1.

Although both patterns showed an identical MLS-96 value of 18.9 ppt, some important differences between these patterns are evident. Variations between broods with respect to survival in any given salinity were more pronounced for developing embryos (i.e., fertilized eggs) than for fry and fingerlings. Appreciable embryo mortality occurred in all salinities, including freshwater. However, embryos were better able to tolerate direct transfer to salinities of 20 ppt and above. For example, no fry or fingerlings from 7 to 120 days old survived 96 hours following direct transfer to 25 ppt. In comparison, a mean survival of 20.5% was recorded for embryos 96 hours following direct transfer to this salinity. No embryos survived 96 hours following direct transfer to full seawater (32 ppt). However, it is evident from the daily survivorship pattern of embryos transferred directly to full seawater (Fig. 2) that there was some survival for as long as 48 hours following transfer. Embryos survived direct seawater transfer for much longer periods of time than 7 to 395-day old fry and fingerlings, which survived for a maximum of five hours following direct seawater transfer at comparable temperatures. The survivorship pattern for embryos transferred directly to full seawater (Fig. 2) results in a median survival time (ST_{50}) of 978 min, a value far greater than those observed for 7 to 395-day old *O. niloticus* fry and fingerlings, which ranged from 28.8 to 179.0 min (Watanabe et al. 1984).

Daily survival of freshwater-spawned *O. niloticus* eggs during artificial incubation in various salinities is presented in Table 1. These survivorship patterns are illustrated in Fig. 2. As these results show, mortality during artificial incubation occurred primarily during early development from day of removal through one day post-hatching. Mortality generally increased with increasing salinity and was particularly heavy in the higher salinities of 20 to 32 ppt. In full seawater, (32 ppt), there was no survival during this period. After the first day of incubation (age one day), survival remained relatively high (range 85.4-94.0%) in all salinities up to 25 ppt. In full seawater, however, mean survival fell to 25.5% during this period. Differential mortality in the various salinities became gradually more pronounced over the second and third day of incubation so that distinct differences

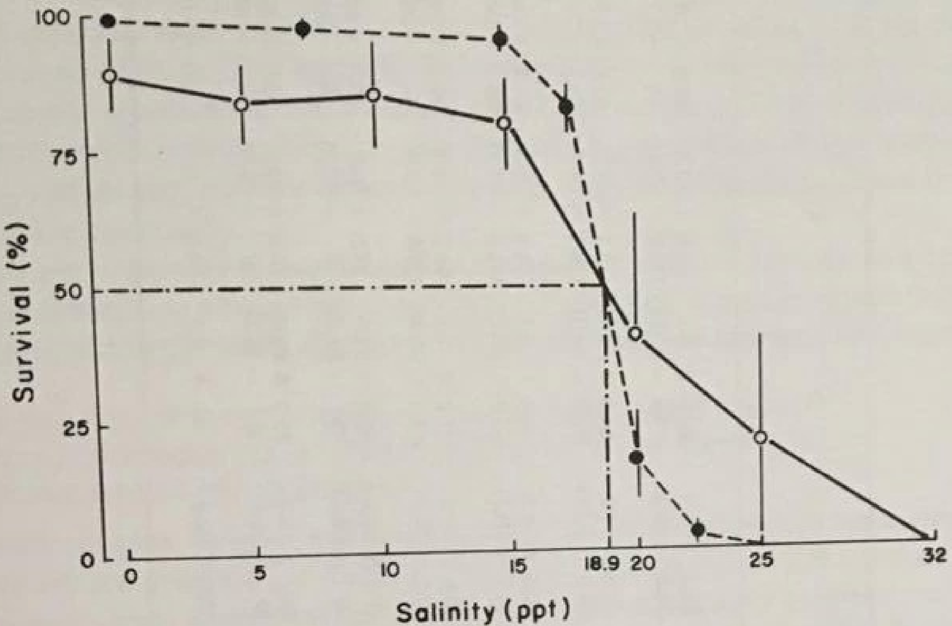


Fig. 1. Survivorship of freshwater-spawned eggs (○) and 7 to 120-day old freshwater-spawned and reared fry and fingerlings (●) of *O. niloticus,* 96 hours following direct transfer to various salinities. Eggs were removed from the mouth of the parent female approximately one day post-spawning. Each plotted point represents the mean value for four determinations for eggs and 20 determinations for fry and fingerlings. Vertical bars represent ± S.E.M. (Standard Error of the Mean). Both survivorship patterns result in a MLS-96 of 18.9 ppt.

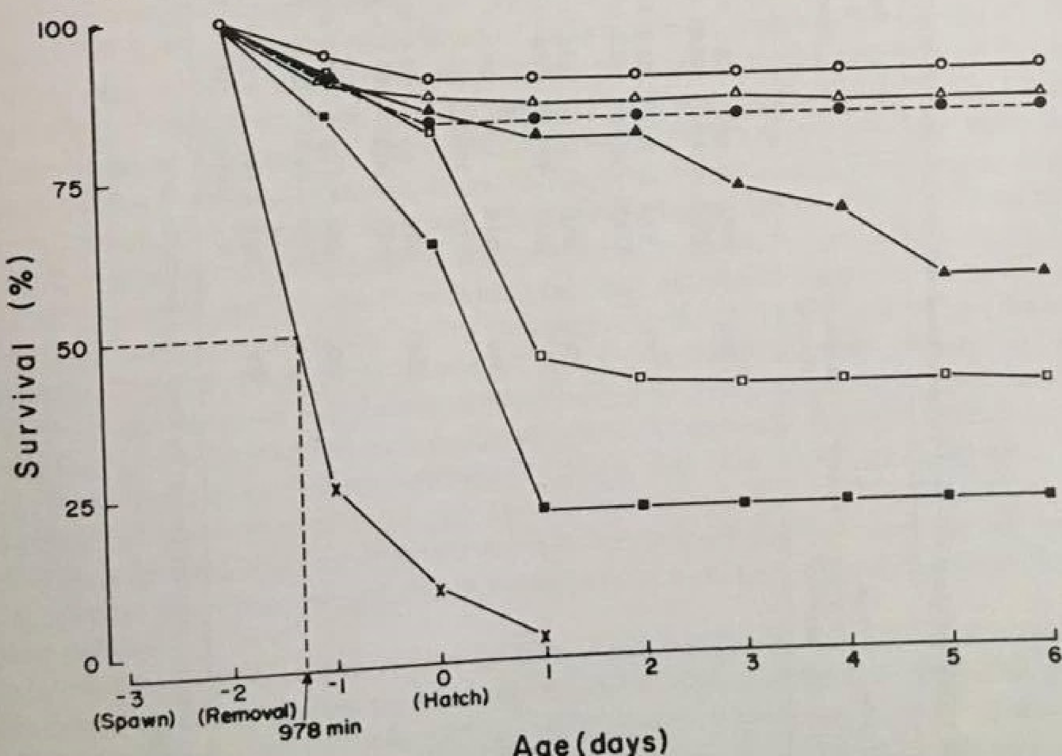


Fig. 2. Survivorship of freshwater-spawned *O. niloticus* eggs, artificially incubated at various salinities (freshwater (○), 5 ppt (●), 10 ppt (△), 15 ppt (▲), 20 ppt (□), 25 ppt (■), 32 ppt (X)). Plotted points represent mean values of Table 1.

Table 1. Daily percentage survival of freshwater-spawned *O. niloticus* eggs artificially incubated at various salinities.

Incubation salinity (ppt)	Age: (days post-hatching)	−3 (spawn)	−2 (remove and incubate)	−1	Age: (days post-hatching) 0 (hatch)	1	2	3	4	5	6 (yolk sac absorbed)
0			100	94.0 ± 4.7[a] (80.0 − 99.4)[b]	90.3 ± 6.5 (70.8 − 98.8)	89.4 ± 6.3 (70.8 − 98.2)	89.2 ± 6.3 (70.8 − 98.2)	89.0 ± 6.2 (70.8 − 97.6)	88.6 ± 6.3 (70.0 − 97.6)	88.6 ± 6.3 (70 − 97.6)	88.5 ± 6.3 (70 − 97.6)
5			100	92.0 ± 5.8 (74.6) − 99.4)	83.3 ± 7.5 (62.3 − 96.3)	83.1 ± 6.9 (63.9 − 94.5)	83.0 ± 6.9 (63.9 − 94.5)	82.6 ± 7.1 (63.1 − 94.5)	82.5 ± 7.0 (63.1 − 94.5)	82.5 ± 7.0 (63.1 − 94.5)	82.5 ± 7.0 (63.1 − 94.5)
10			100	91.0 ± 7.5 (68.5 − 99.4)	87.4 ± 8.9 (60.8 − 98.8)	85.9 ± 9.2 (58.5 − 98.2)	85.5 ± 9.6 (56.9 − 98.2)	85.5 ± 9.6 (56.9 − 98.2)	84.4 ± 9.3 (56.9 − 98.2)	84.4 ± 9.3 (56.9 − 98.2)	84.4 ± 9.3 (56.9 − 98.2)
15			100	90.9 ± 5.8 (74.6 − 98.8)	84.7 ± 6.4 (67.7 − 95.1)	80.8 ± 7.9 (62.3 − 95.1)	80.6 ± 8.0 (62.3 − 95.1)	72.2 ± 7.3 (61.6 − 92.9)	64.2 ± 12.9 (30.8 − 92.9)	56.3 ± 19.9 (0 − 92.9)	56.3 ± 19.9 (0 − 92.9)
20			100	92.2 ± 4.9 (78.5 − 98.8)	82.4 ± 8.7 (57.7 − 96.3)	45.2 ± 22.2 (0 − 91.6)	41.1 ± 22.4 (0 − 90.7)	39.2 ± 23.1 (0 − 89.7)	38.9 ± 23.0 (0 − 89.7)	38.9 ± 23.0 (0 − 89.7)	37.9 ± 22.6 (0 − 89.7)
25			100	85.4 ± 11.8 (50.0 − 99.4)	63.5 ± 16.4 (20.8 − 90.3)	21.5 ± 20.2 (0 − 82.1)	20.5 ± 19.8 (0 − 79.9)	20.0 ± 20.0 (0 − 79.9)	20.0 ± 20.0 (0 − 79.9)	20.0 ± 20.0 (0 − 79.9)	20.0 ± 20.0 (0 − 79.9)
32			100	25.5 ± 14.5 (0 − 51.2)	7.9 ± 4.0 (0 − 31.7)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0

[a]Mean ± S.E.M. (Standard Error of the Mean) for 4 incubation trials.
[b]Range.

in survival values between salinities were observed by one day post-hatching. Following this period of early mortality, survival generally stabilized through six days post-hatching, although some mortality continued at 15 ppt. Survivorship patterns for eggs incubated at salinities of 5 and 10 ppt were closely similar to the pattern observed for eggs incubated in freshwater. At six days post-hatching, mean survival values of 82.5, 84.4 and 88.5%, respectively, were recorded in these salinities. Progressively greater mortality occurred with increasing incubation salinity. At six days post-hatching, mean survival values of 56.3, 37.9 and 20.0% were recorded for incubation salinities of 15, 20 and 25 ppt, respectively. However, as the standard errors and ranges of Table 1 indicate, survival varied considerably between broods incubated in salinities of 15 ppt and above. For example, at incubation salinities of 15 and 20 ppt, survival values at six days post-hatching ranged from 0 to 92.9% and from 0 to 89.7%, respectively.

No consistent relationship was observed between incubation salinity and time to hatching. Poor survival and hatching of eggs incubated in the higher salinities was associated with various structural abnormalities generally characterized by an underdevelopment of organs.

SALINITY TOLERANCE OF FRY HATCHED FROM FRESHWATER-SPAWNED EGGS ARTIFICIALLY INCUBATED AT VARIOUS SALINITIES (FRESHWATER-SPAWNED, SALINE WATER-HATCHED FRY)

Mean body weights, lengths, and condition factors of seven-day old freshwater-spawned, saline water-hatched fry are presented in Table 2. The single brood successfully hatched at a salinity of 25 ppt had a mean body length and weight which was conspicuously greater than those of broods incubated and hatched in lower salinities. However, there were no significant ($P > 0.05$, t-test) differences between fry hatched in any salinity and those hatched in freshwater with respect to these parameters.

Corresponding ST_{50}, MST, and MLS-96 values of seven-day old fry hatched at various salinities are also presented in Table 2. Since the maximum salinity employed during MLS-96 indexing was 32 ppt, a relative tolerance value was not provided when survival exceeded 50% in all salinities 96 hours following transfer from hatching salinity (MLS-96 > 32 ppt). Therefore, in order to obtain a representative MLS-96 value for fry hatched in a given salinity, mean survival over all trials was computed for each transfer salinity and MLS-96 determined from the resultant generalized survivorship pattern. Fig. 3 illustrates these generalized survivorship patterns for seven-day old freshwater-spawned, saline water-hatched fry, 96 hours following direct transfer to various salinities. As Fig. 3 shows, MLS-96 progressively increased from 19.2 ppt for fry hatched in freshwater to greater than 32 ppt for fry hatched at 20 ppt and above. The survivorship patterns of Fig. 3 reveal that increasing MLS-96 with increasing hatching salinity was related to an elevation of the salinity of incipient mortality. With each 5 ppt increase in hatching salinity, salinity of incipient mortality was elevated by 2.5 to 5 ppt. Incipient mortality for fry hatched at 0, 5, 10, 15, 20 and 25 ppt occurred at approximately 17.5, 20, 22.5, 27.5, 30 and 32 ppt, respectively. Increasing hatching salinity also expanded the range between incipient and final mortality. For example, incipient and final mortalities for the freshwater-hatched broods occurred within a relatively narrow salinity range of 17.5 to 22.5 ppt. In contrast, for broods hatched at 10 ppt, incipient mortality occurred at 22.5 ppt and mortality was still not complete at 32 ppt. Hence, whereas survival declined rapidly as salinity exceeded the level of incipient mortality for fry hatched in freshwater, a progressively more gradual decline in survival was observed as salinity exceeded the level of incipient mortality for fry hatched at elevated salinities.

Since the time period employed for salinity tolerance testing was 96 hours, a relative ST_{50} value was not provided whenever survival did not fall to 50% by 96 hours following direct transfer from hatching salinity to full seawater ($ST_{50} > 5{,}760$ min). Therefore, in order to obtain a representative ST_{50} value for fry hatched in a given salinity, mean survival over all trials was computed at successive time periods following transfer, and ST_{50} derived from the resultant generalized

Table 2. Median survival time (ST_{50}), mean survival time (MST) and median lethal salinity (MLS-96) of seven-day old *O. niloticus* fry hatched from freshwater-spawned eggs artificially incubated at various salinities.

Incubation salinity (ppt)	Body weight (mg)[a]	Body length (mm)[a]	Condition factor[a]	ST_{50} (min)[b]	MST (min)[a]	MLS-96 (ppt)[b]	Assay temperature range (°C)
0	7.8 ± 0.4 (6)	8.9 ± 0.3 (6)	1.14 ± 0.06 (6)	51.0 (6) 42.0 – 71.0	51.0 ± 4.7 (6) 4.20 – 73.4	19.2 (4) 18.5 – 22.0	27.2 – 29.8
5	8.1 ± 0.8 (5)	9.1 ± 0.2 (5)	1.07 ± 0.05 (5)	59.0 (5) 46 – 150	86.2 ± 27.5 (5) 45.1 – 193.3	21.2 (4)	27.4 – 30.5
10	8.2 ± 0.5 (6)	9.0 ± 0.2 (6)	1.14 ± 0.07 (6)	90.0 (6) 64 – >5,760	1,097.0 ± 934.5 (6) 65.3 – 5,760	25.0 (4) 23.8 – >32	27.4 – 29.8
15	8.0 ± 0.9 (5)	9.1 ± 0.2 (5)	1.05 ± 0.06 (5)	4,320 (5) 147 – >5,760	3,411.2 ±1,073.8 (5) 154.6 – 5,760	30.2 (4) 26.5 – >32	27.3 – 30.5
20	7.7 ± 1.4 (3)	9.0 ± 0.3 (3)	1.03 ± 0.09 (3)	>5,760 (3) 1,402 – >5,760	4,089.5 ± 847.6 (3) 3,005 – 5,760	>32 (2) >32	27.3 – 29.8
25	9.8 (1)	9.8 (1)	1.04 (1)	>5,760 (1)	5,760 (1)	>32 (1)	28.4

[a]Mean ± S.E.M. (no. of determinations). Ranges of values are presented for MST.
[b]Derived from generalized survivorship patterns as described in text. Range is given below median point; no. of determinations in parentheses.

survivorship pattern. Fig. 4 illustrates these generalized survivorship patterns as a function of time for seven-day old freshwater-spawned, saline water-hatched fry following direct transfer from hatching salinity to full seawater (32 ppt). As Fig. 4 shows, ST_{50} increased from 51.0 min for fry hatched in freshwater, to greater than 5,760 min for fry hatched at 20 ppt or above. Mortality occurred primarily during the initial eight hours following transfer from hatching salinity to full seawater (32 ppt), then stabilized thereafter through 96 hours. Increasing hatching salinity resulted in a progressive increase in the percentage of individuals surviving 96 hours following direct transfer from hatching salinity to full seawater (32 ppt). Fry hatched in freshwater or 5 ppt exhibited complete mortality within the initial two or four hours, respectively, following transfer. In contrast, fry hatched in 10, 15, 20 and 25 ppt exhibited mean survival values of 28.7, 51.3, 69.3 and 100%, respectively, 96 hours following transfer.

REPRODUCTIVE PERFORMANCE OF YEARLING *O. NILOTICUS* IN LABORATORY AQUARIA AT VARIOUS SALINITIES

Results of studies on the reproductive performance of yearling *O. niloticus* broodstock in laboratory aquaria at various salinities are summarized in Table 3. The data represent spawnings recorded from 30 May to 18 October 1983. For comparative purposes, Table 3 also presents results of a separate study on reproductive performance of *O. niloticus* in freshwater laboratory aquaria, which employed an older (two to three years) and much larger (mean seasonal body length, weight: 21.5 cm, 203.9 g) broodstock consisting of 16 females. For the older broodstock, data represent spawnings recorded from 26 March to 18 October 1983.

For yearling females, total number of spawnings was greater in the brackish salinities of 5 through 15 ppt than in either full seawater (32 ppt) or freshwater. Low spawning frequency in full seawater can in part be explained by a tendency for the mean interval between spawnings to lengthen in the higher salinities from approximately 18 days at 5 and 10 ppt, to 22.9 days at 15 ppt, and to 31.0 days at 32 ppt. However, as the intervals between successive spawnings varied over a considerable range in any given salinity, these differences were not statistically significant ($P > 0.05$, t-test). The total number of spawnings in each salinity was also influenced by the number of times each female in a salinity group spawned during the period of observation. For example, more spawnings were recorded in 15 ppt than in either 10 ppt or 5 ppt, despite the fact that the mean interval between spawnings was longer in 15 ppt. This was because during the period of observation, each female in the 15 ppt group spawned an average of 6.7 times, whereas each female in the 10 ppt and 5 ppt groups spawned an average of only five times. Only single spawnings from each female were observed in the freshwater control group. In comparison, each female in the older broodstock in freshwater spawned an average of 3.8 times, and the mean interval between spawnings when eggs were removed was 19.7 days: very similar to that observed for yearling females spawning in salinities of 5 to 15 ppt.

For yearling females, the mean number of eggs released per spawning was roughly equivalent at all salinities, although somewhat lower at 15 ppt. When the data are expressed as mean number of eggs released per g body weight (seasonal average), results at 15 ppt were closely similar to those observed in the other salinities, indicating that lower mean number of eggs released per spawning at 15 ppt was related to the smaller sizes of females in this salinity. Mean number of eggs spawned per g body weight under saline conditions did not differ significantly ($P > 0.05$, t-test) from the mean value for yearling females spawning in freshwater. In comparison, females of the older broodstock in freshwater released a mean of 961.3 eggs per spawn, which greatly exceeded the values obtained for yearling females. However, when these results are expressed as number of eggs released per g body weight (seasonal average), older and larger females released a mean of only 5.2 eggs per g body weight, a value considerably lower than those observed for yearling females, regardless of salinity. The mean number of eggs released per g body weight by the older females was significantly

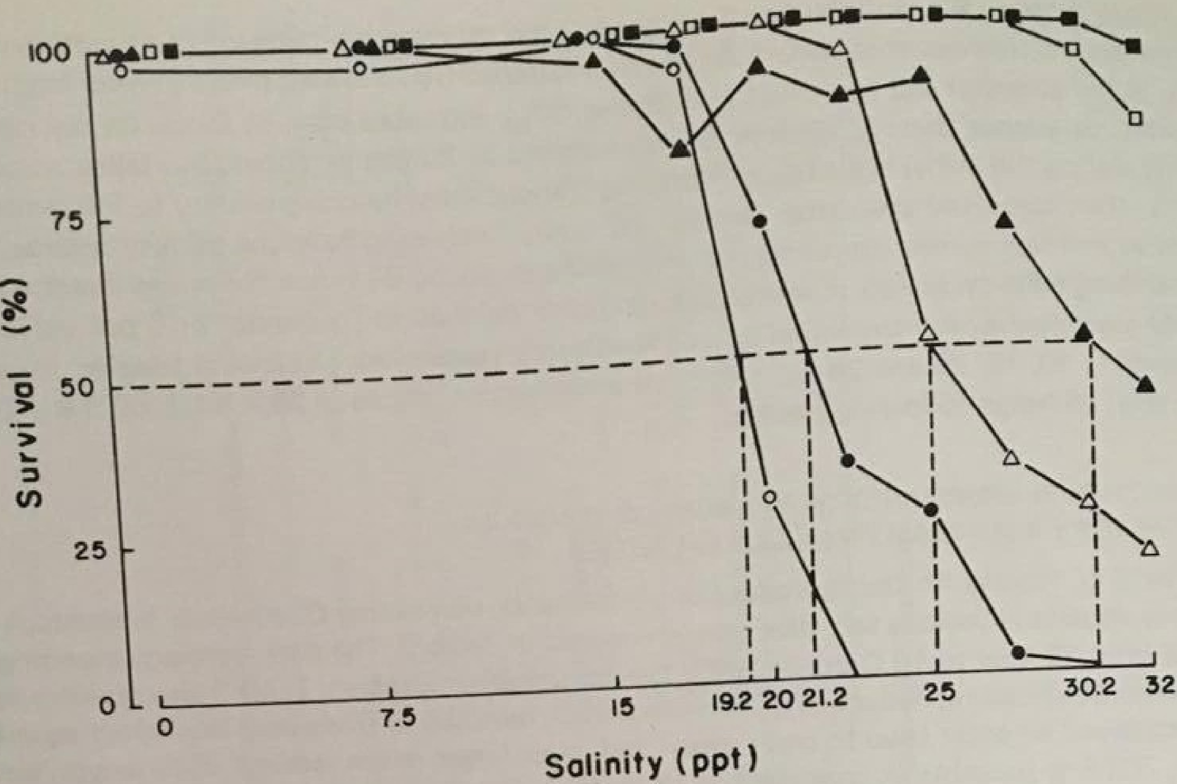


Fig. 3. Survivorship of seven-day old freshwater-spawned, saline water-hatched *O. niloticus* fry, 96 hours following direct transfer from hatching salinity to various salinities. Hatching salinities were: freshwater (○), 5 ppt (●), 10 ppt (△), 15 ppt (▲), 20 ppt (□) and 25 ppt (■). Each plotted point represents the mean survival value for replicate determinations. Number of determinations for each hatching salinity is shown in Table 2. MLS-96 values of Table 2 were derived from these generalized patterns.

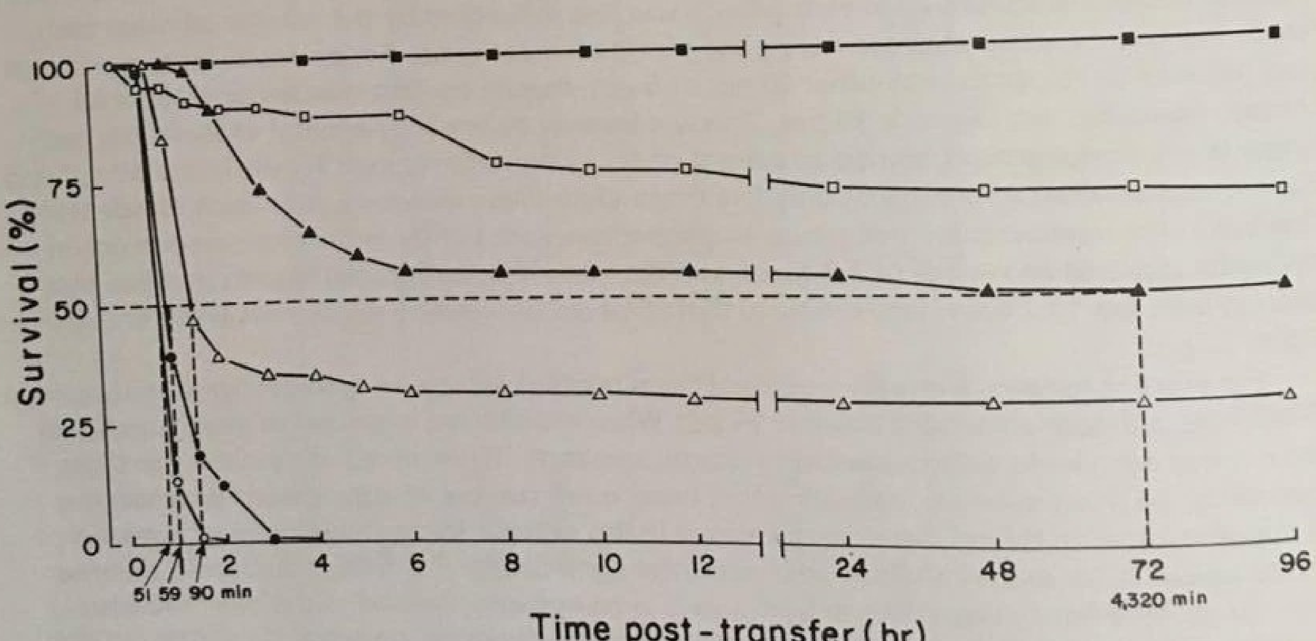


Fig. 4. Survivorship as a function of time for seven-day old freshwater-spawned, saline water-hatched *O. niloticus* fry, following direct transfer from hatching salinity to full seawater (32 ppt). Hatching salinities were: freshwater (○), 5 ppt (●), 10 ppt (△), 15 ppt (▲), 20 ppt (□) and 25 ppt (■). Each plotted point represents the mean survival value for replicate determinations. Number of determinations for each hatching salinity is shown in Table 2. ST_{50} values of Table 2 were derived from these generalized patterns.

Table 3. Reproductive performance of yearling Nile tilapia *(Oreochromis niloticus)* broodstock in laboratory aquaria at various salinities, 30 May-18 October 1983[a], and comparison with older broodstock.

Salinity at spawning (ppt)	No. of spawnings[b]	Mean interval between spawnings (days)[c]	Mean no. of eggs per spawning[c]	Seasonal mean Female body length (cm), body weight (g)[c]	Mean no. of eggs per g body weight[c]	Mean hatching success (%)[d]	Total egg production (per female; per g body wt.)	Total fry production (per female; per g body wt.)
32	7	31.0 ± 8.5 (16 – 49)	260.1 ± 39.2 (136 – 400)	11.9 ± 0.4 34.3 ± 4.1	9.16 ± 1.4 (6.0 – 12.8)	0.7 ± 0.7 (7) (0 – 5)	1,821 (607; 17.7)	13 (abnormal) (0; 0)
15	20	22.9 ± 2.4 (7 – 40)	180.8 ± 21.8 (11 – 367)	10.3 ± 0.6 18.1 ± 3.3	11.3 ± 1.3 (3.8 – 30.1)	36.9 ± 9.5 (14) (0 – 99)	3,616 (1,205; 66.6)	1,334 (444.7; 24.6)
10	15	17.6 ± 2.2 (10 – 26)	295.9 ± 22.5 (189 – 446)	11.4 ± 0.7 25.4 ± 3.7	11.8 ± 0.5 (9.1 – 13.3)	32.7 ± 10.2 (11) (0 – 99)	4,439 (1,479.7; 58.3)	1,452 (484.0; 19.1)
5	15	18.3 ± 1.9 (11 – 30)	226.9 ± 22.9 (90 – 365)	11.5 ± 0.2 26.7 ± 1.4	8.3 ± 0.9 (4.7 – 14.2)	51.6 ± 8.6 (12) (0 – 93.1)	3,404 (1,134.7; 42.5)	1,757 (585.7; 21.9)
0 (yearling)	3	–	273.3 ± 70.4 (150 – 394)	11.4 ± 0.8 24.3 ± 1.5	9.6 ± 2.9 (6.6 – 15.3)	30.9 ± 30.9 (3) (0 – 92.8)	820 (273.3; 11.2)	253 (84.3; 3.5)
0 (2-3 yr)	60	19.7 ± 1.3 (13 – 37)	961.3 ± 61.8 (72 – 1490)	21.5 ± 1.3 203.9 ± 19.7	5.2 ± 0.3 (0.6 – 9.2)	54.2 ± 7.3 (35) (0 – 99.9)	57,678 (3,604.9; 17.7)	31,261 (1,953.8; 9.6)

[a]For yearling broodstock, a group of 3 females and 3 males was maintained in each salinity. For 2-3 yr old broodstock, a group of 16 females was maintained in freshwater aquaria at a ratio of 1-3 females:1 male.

[b]Total spawnings observed per group, not necessarily from the same individual.

[c]Mean ±S.E.M. Values in parentheses denote range.

[d]Data represent hatching success (non-fertile spawns included) during artificial incubation and are expressed as mean values ± S.E.M. Range is given below and no. of determinations in parentheses on the right.

($P < 0.001$, t-test) less than those of yearling females spawning in salinities from 5 to 32 ppt.

During artificial incubation of tilapia eggs, non-fertile spawns, characterized by lack of embryo formation, were occasionally observed. For eggs spawned under saline conditions, it was difficult to differentiate between non-fertile spawns resulting from male inactivity and those caused by salinity effects on egg or sperm quality. Hence, when determining mean hatching success during artificial incubation of eggs spawned in various salinities, non-fertile spawns were included (as 0% hatch) in all calculations. Extremely poor hatching success resulted with eggs spawned in full seawater (32 ppt). In one incubation trial, a few abnormal larvae were hatched, all of which died soon after hatching. Mean hatching successes were similar for eggs spawned by yearling females in freshwater (30.9%), 10 ppt (32.7%) and 15 ppt (36.9%). Mean hatching success was considerably higher for eggs spawned at 5 ppt (51.6%) and compared with that obtained with eggs spawned by the older broodstock in freshwater (54.2%). As hatching success varied from 0% to greater than 90% in any given spawning salinity up to 15 ppt, differences in mean hatching successes between these salinities were not statistically significant ($P > 0.05$, t-test).

Although total egg production was greater at 10 ppt, total fry production was greatest at 5 ppt, due to the improved hatching success at 5 ppt. Seasonal egg production per female was much greater for larger, older breeders in freshwater than for yearling breeders in any salinity. However, seasonal egg production per g body weight was greater for yearling breeders in brackish salinities than for older breeders in freshwater. Seasonal fry production per g body weight was also greater for yearling females in brackish salinities than for older females in freshwater. These results suggest that for a given total weight of fish, smaller, yearling females in brackish salinities of up to 15 ppt will produce a greater number of eggs and fry than larger females in freshwater.

SALINITY TOLERANCE OF FRY SPAWNED AT VARIOUS SALINITIES (SALINE WATER-SPAWNED FRY)

Mean body weights, lengths, and condition factors of six to nine-day old fry spawned at various salinities are presented in Table 4. Since only one successful hatching was recorded for yearling females in freshwater, it was necessary to employ fry produced in freshwater by older females as controls in Table 4. As these results show, mean body weight and length of the freshwater-spawned broods were generally higher than those of broods spawned in brackish salinities. Mean weight and length of the freshwater-spawned broods was significantly ($P < 0.05$, t-test) greater than those of broods spawned at 5 and 10 ppt. In tilapias, egg weight increases with body weight of spawner (Peters 1983). Differences in egg weight are due mainly to differences in yolk content, which should have a corresponding effect on size of fry which develop from these eggs. The relatively large size of broods spawned in freshwater may therefore be related to the much larger sizes of spawners from which they originated. Size differences between broods spawned by yearling females in brackish salinities are difficult to interpret since the ages of these broods varied from six to nine days post-hatching. Condition factors of broods spawned in brackish salinities did not differ significantly ($P > 0.05$, t-test) from those of broods spawned in freshwater.

Corresponding ST_{50}, MST and MLS-96 values for these six to nine-day old fry spawned at various salinities are also presented in Table 4. ST_{50} and MLS-96 values were derived from generalized survivorship patterns as described earlier. Fig. 5 illustrates generalized survivorship patterns for six to nine-day old saline water-spawned fry 96 hours following direct transfer from the spawning salinity to various salinities. MLS-96 increased from 19.2 ppt for broods spawned in freshwater to greater than 32 ppt for broods spawned in 15 ppt. The patterns of these changes are very similar to those described earlier for freshwater-spawned, saline water-hatched fry (Fig. 3). As Fig. 5 shows, increasing MLS-96 with increasing spawning salinity is also related to an elevation of the salinity of incipient mortality and an increase in the salinity range between incipient and final mortality. In general, an increase in spawning salinity of 5 ppt elevated salinity of incipient mortality by 2.5 to 7.5 ppt.

Table 4. Median survival time (ST_{50}), mean survival time (MST) and median lethal salinity (MLS-96) of 6-9 day old *O. niloticus* fry spawned at various salinities.

Spawning salinity (ppt)	Body weight (mg)[a]	Body length (mm)[a]	Condition factor[a]	ST_{50} (min)[b]	MST (min)[a]	MLS-96 (ppt)[b]	Assay temperature range (°C)
0	7.8 ± 0.4 (8)	8.8 ± 0.2 (8)	1.13 ± 0.05 (8)	51.0 (8) 29.0 – 72.0	51.1 ± 5.3 (8) 29.9 – 73.4	19.2 (6) 18.5 – 22.0	25.5 – 29.8
5	5.2 ± 0.3 (6)	8.1 ± 0.1 (6)	0.99 ± 0.05 (6)	600.0 (6) 131 – 780	970.2 ± 270.4 (6) 145.6 – 1,768.4	28.1 (4) 27 – 30.4	27.4 – 30.2
10	5.6 ± 0.3 (7)	8.1 ± 0.1 (7)	1.07 ± 0.08 (7)	360.0 (7) 59.0 – >5,760	2,218.2 ± 639.4 (7) 85.0 – 5,048.5	⩾32 (4)	27.0 – 29.5
15	6.9 ± 1.3 (6)	8.8 ± 0.3 (6)	0.93 ± 0.08 (6)	>5,760 (6)	5,326.4 ± 199.6 (6) 4,702.6 – 5,760	>32 (1)	27.0 – 30.1

[a]Mean ± S.E.M. (no. of determinations). Ranges of values are presented for MST.
[b]Derived from generalized survivorship patterns as described in text. Range of values is given below median values; no. of determinations in parentheses.

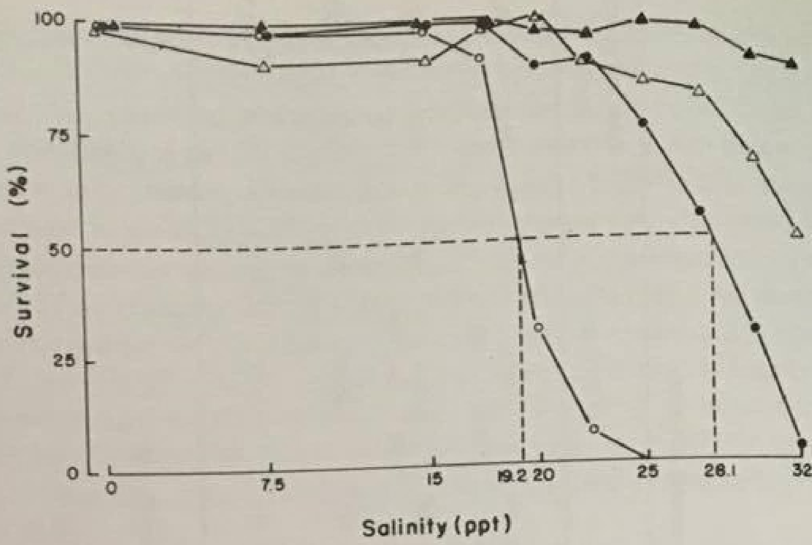


Fig. 5. Survivorship of six to nine-day old saline water-spawned *O. niloticus* fry, 96 hours following direct transfer from spawning salinity to various salinities. Spawning salinities were: freshwater (○), 5 ppt (●), 10 ppt (△), 15 ppt (▲). Each plotted point represents the mean survival value for replicate determinations. Number of determinations for each spawning salinity is shown in Table 4. MLS-96 values of Table 4 were derived from these generalized patterns.

Generalized survivorship patterns for broods spawned or hatched at identical salinities are compared in Figs. 6a, 6b and 6c for salinities of 5, 10 and 15 ppt, respectively. As these results show, at identical salinity of spawning or hatching, saline water-spawned fry exhibited higher MLS-96 values than freshwater-spawned, saline water-hatched fry. These patterns also suggest that the range between incipient and final mortality may be expanded to a relatively greater degree by increasing spawning salinity than by increasing hatching salinity. From the statistical variability of data illustrated in Figs. 6a, 6b and 6c, it is evident that saline water-spawned progeny generally exhibited more consistent survival values between broods than did freshwater-spawned, saline water-hatched progeny.

Fig. 7 illustrates generalized survivorship patterns as a function of time for six to nine-day old saline water-spawned fry following direct transfer from spawning salinity to full seawater (32 ppt). As Fig. 7 shows, ST_{50} increased from 50.9 min for broods spawned in freshwater to greater than 5,760 min for broods spawned at 15 ppt. Unexpectedly, broods spawned at 5 ppt had a higher ST_{50} than those spawned at 10 ppt. However, mean survival at 96 hours was higher in broods spawned at 10 ppt.

SALINITY TOLERANCE OF FRESHWATER-SPAWNED AND HATCHED FRY ACCLIMATIZED TO VARIOUS SALINITIES (FRESHWATER-SPAWNED, FRESHWATER-HATCHED, SALINE WATER-ACCLIMATIZED FRY)

Mean body weights, lengths and condition factors of 11 to 18-day old *O. niloticus* fry spawned and hatched in freshwater, but acclimatized for seven to eight days to various salinities, are presented in Table 5. Broods maintained in freshwater were all 15 days old while those acclimatized to salinities of 5 through 15 ppt ranged from 11 to 18 days old. Since these fry were older, they were larger than the freshwater-spawned, saline water-hatched fry (seven days old) or saline water-spawned fry (six to nine days old) whose salinity tolerances were described earlier. Corresponding ST_{50} and MST values for these 11 to 18-day old fry, spawned and hatched in freshwater, but acclimatized to

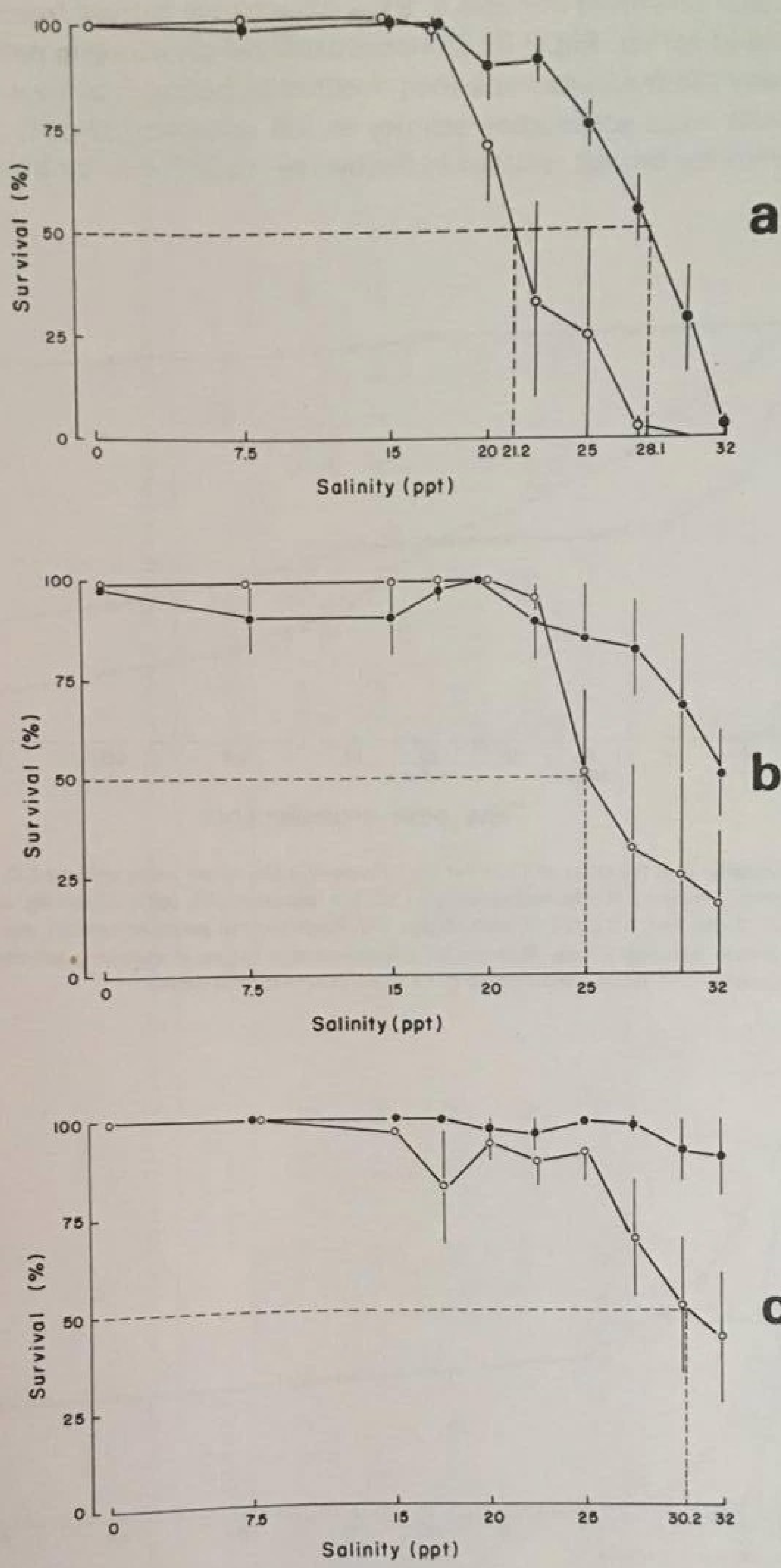


Fig. 6. Comparison of survivorship between freshwater-spawned, saline water-hatched (○) and saline water-spawned (●) *O. niloticus* fry, 96 hours following direct transfer from identical hatching or spawning salinity, respectively, to various salinities. Survivorship patterns are compared for hatching and spawning salinities of 5 ppt in Fig. 6a, 10 ppt in Fig. 6b and 15 ppt in Fig. 6c. Each plotted point represents the mean survival value for three to four determinations. Vertical bars represent ± S.E.M. Absence of vertical bars indicates that the S.E.M. lies within the area of the plotted point.

various salinities, are also presented in Table 5. ST_{50} values were derived from generalized survivorship patterns as described earlier. Fig. 8 illustrates generalized survivorship patterns as a function of time for 11 to 18-day old freshwater-spawned, freshwater-hatched, saline water-acclimatized fry following direct transfer from acclimation salinity to full seawater (32 ppt). ST_{50} progressively increased from 29.0 min for broods retained in freshwater, to 270 min for broods acclimatized to 15 ppt.

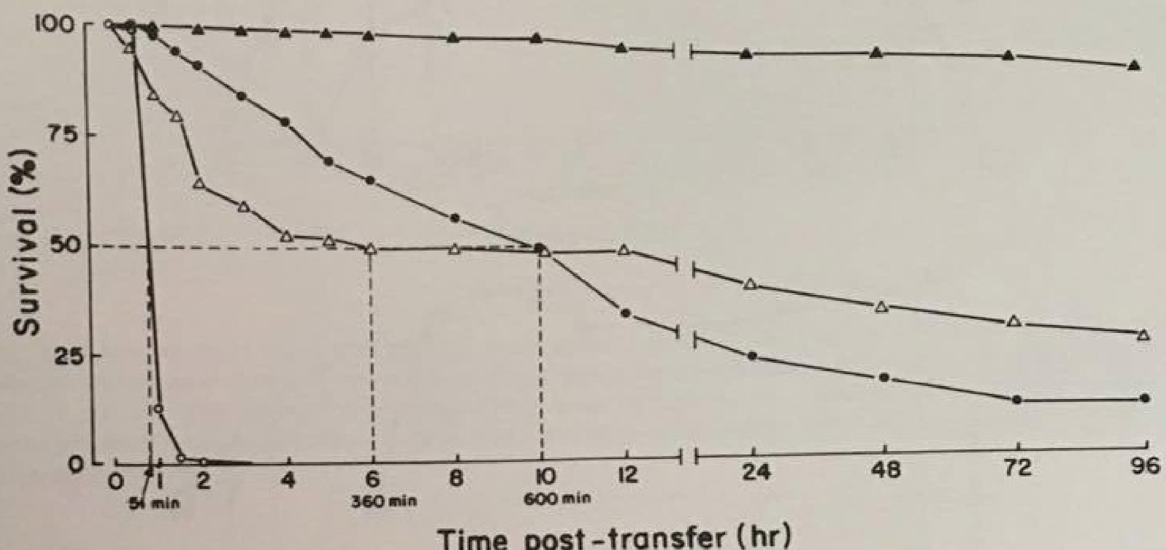


Fig. 7. Survivorship as a function of time for six to nine-day old saline water-spawned *O. niloticus* fry, following direct transfer from spawning salinity to full seawater (32 ppt). Spawning salinities were: freshwater (○), 5 ppt (●), 10 ppt (△), and 15 ppt (▲). Each plotted point represents the mean survival value for replicate determinations. Number of determinations for each spawning salinity is shown in Table 4. ST_{50} values of Table 4 were derived from these generalized patterns.

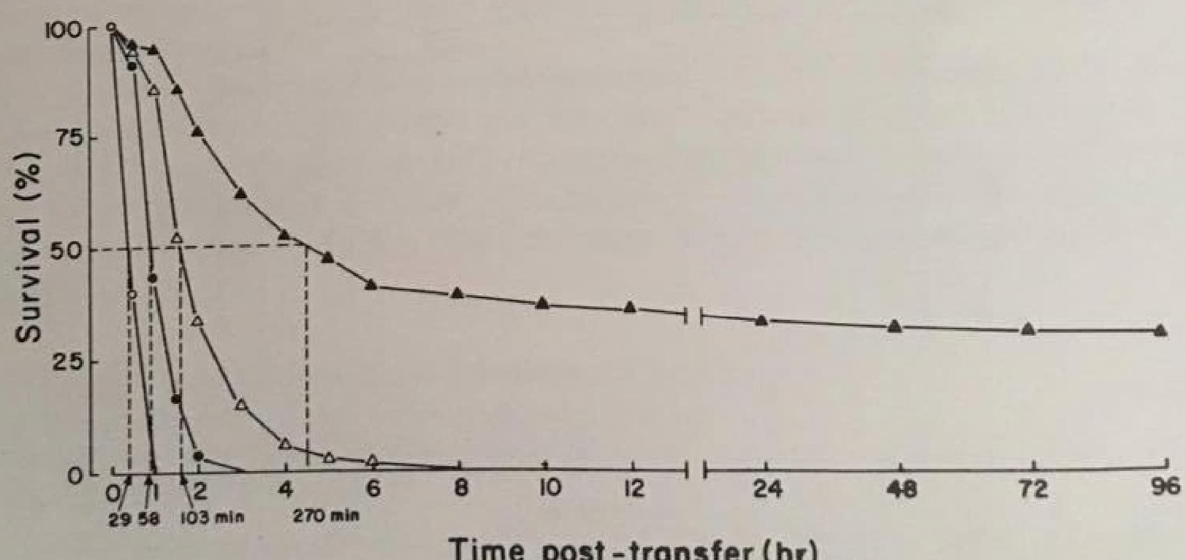


Fig. 8. Survivorship as a function of time for 11 to 18-day old freshwater-spawned, freshwater-hatched, saline water-acclimatized *O. niloticus* fry, following direct transfer from acclimatization salinity to full seawater (32 ppt). Acclimatization salinities were: freshwater (○), 5 ppt (●), 10 ppt (△), and 15 ppt (▲). Each plotted point represents the mean survival value for replicate determinations. Number of determinations for each acclimatization salinity is shown in Table 5. ST_{50} values of Table 5 were derived from these generalized patterns.

Table 5. Median survival time (ST_{50}) and mean survival time (MST) of 11-18 day old freshwater-spawned and freshwater-hatched *O. niloticus* fry following acclimatization to various salinities.

Acclimatization salinity (ppt)	Body weight (mg)[a]	Body length (mm)[a]	Condition factor[a]	ST_{50} (min)[b]	MST (min)[a]	Assay temperature range (°C)
0	12.2 ± 1.2 (4)	10.5 ± 0.2 (4)	1.03 ± 0.04 (4)	29.0 (4) 24.0 – 32.0	29.8 ± 1.9 (4) 26.2 – 34.0	25.8 – 30.2
5	11.5 ± 1.3 (6)	9.1 ± 0.3 (6)	1.51 ± 0.06 (6)	58.0 (6) 41.0 – 81.0	62.1 ± 15.3 (6) 41.6 – 83.6	27.0 – 28.0
10	11.4 ± 0.8 (6)	9.3 ± 0.1 (6)	1.42 ± 0.05 (6)	103.0 (6) 64.0 – 165.0	116.0 ± 47.6 (6) 72.2 – 185.4	27.5 – 28.0
15	12.0 ± 0.7 (6)	9.7 ± 0.2 (6)	1.32 ± 0.02 (6)	270.0 (6) 155.0 – >5,760	1,966.4 ± 1,608.0 (6) 430.2 – 4,319.3	27.2 – 28.0

[a]Mean ± S.E.M. (no. of determinations). Ranges of MST values are presented.
[b]Derived from generalized survivorship patterns. Range of values is given below median values; no. of determinations in parentheses.

Generalized survivorship patterns for broods spawned, hatched or acclimatized at identical salinities are compared in Figs. 9a, 9b and 9c, for salinities of 5, 10 and 15 ppt, respectively. As Fig. 9a shows, survivorship was similar for broods acclimatized or hatched at 5 ppt. In both groups, direct seawater transfer resulted in complete mortality within four hours. The survivorship for broods spawned at 5 ppt was distinctly different with more gradual mortality and a mean survival of 12.3% at 96 hours following transfer. At a salinity of 10 ppt, differences in survivorship between groups became more distinct (Fig. 9b). Whereas direct transfer of saline water-acclimatized broods to full seawater resulted in complete mortality within eight hours, a mean survival of approximately 28% was recorded in both the saline water-hatched and saline water-spawned broods 96 hours following transfer. At a salinity of 15 ppt, survival was considerably enhanced in all groups (Fig. 9c). Mean survival values of 30.5, 51.3 and 89.9% were recorded for saline water-acclimatized, saline water-hatched and saline water-spawned broods, respectively, 96 hours following direct transfer to full seawater.

Fig. 10 compares the relationships between salinity tolerance (MST) and spawning salinity, hatching salinity and acclimatization salinity for saline water-spawned, freshwater-spawned, saline water-hatched, and freshwater-spawned, freshwater-hatched, saline water-acclimatized fry, respectively. MST rose non-linearly with increasing spawning, hatching or acclimatization salinity. The relationship between MST and spawning salinity is very similar to that between MST and hatching salinity. Rate of increase in MST with acclimatization salinity was comparatively lower. It is evident from these relationships that at equivalent salinity, early exposure (spawning) produced progeny of comparatively higher salinity tolerance than those spawned in freshwater and hatched at elevated salinity. Similarly, at equivalent salinity, progeny spawned in freshwater but hatched at elevated salinity exhibited higher salinity tolerance than those spawned and hatched in freshwater, then acclimatized to an elevated salinity. Saline water-spawned progeny generally exhibited more consistent MST values between broods than did the saline water-hatched progeny. Mean MST values for the saline water-spawned broods were significantly ($P < 0.05$, t-test) higher than those of the saline water-hatched broods at 5 ppt, and than those of the saline water-acclimatized broods at 5, 10 and 15 ppt. Mean MST values for saline water-hatched and saline water-acclimatized broods were not significantly different at any salinity.

General Discussion and Conclusions

The ontogeny of salinity tolerance in freshwater-spawned and reared *O. niloticus* from 7 to 395 days post-hatching, was described in an earlier report (Watanabe et al. 1984). The salinity tolerance of this species during the early embryonic period of development was determined in the present study. From the generalized survivorship pattern of freshwater-spawned eggs artificially incubated at various salinities, an MLS-96 value of 18.9 ppt was derived, a value equivalent to that found earlier to characterize broods from 7 to 120 days post-hatching. Therefore, characteristic salt tolerance in *O. niloticus* is evident during the initial stages of its ontogeny.

The ability of fertilized eggs of certain teleosts to develop over a wide range of salinities has been described previously. In the plaice, *Pleuronectes platessa,* this ability was attributed to the osmoregulatory activity of the vitelline membrane which is capable of regulating the osmotic concentration of the yolk from the time of fertilization (Holliday and Jones 1967). In the herring, *Clupea harengus,* this ability was present only after completion of gastrulation, and was attributed to osmoregulatory activity of embryonic ectodermal cells rather than the vitelline membrane (Holliday and Jones 1965).

From the generalized survivorship pattern as a function of time for freshwater-spawned *O. niloticus* eggs transferred directly to full seawater (32 ppt), a median survival time (ST_{50}) of 978 min was derived, a value far greater than those found to characterize 7 to 395-day old *O. niloticus* fry and fingerlings, which ranged from 28.8 to 179 min. The relatively high ST_{50} value exhibited by

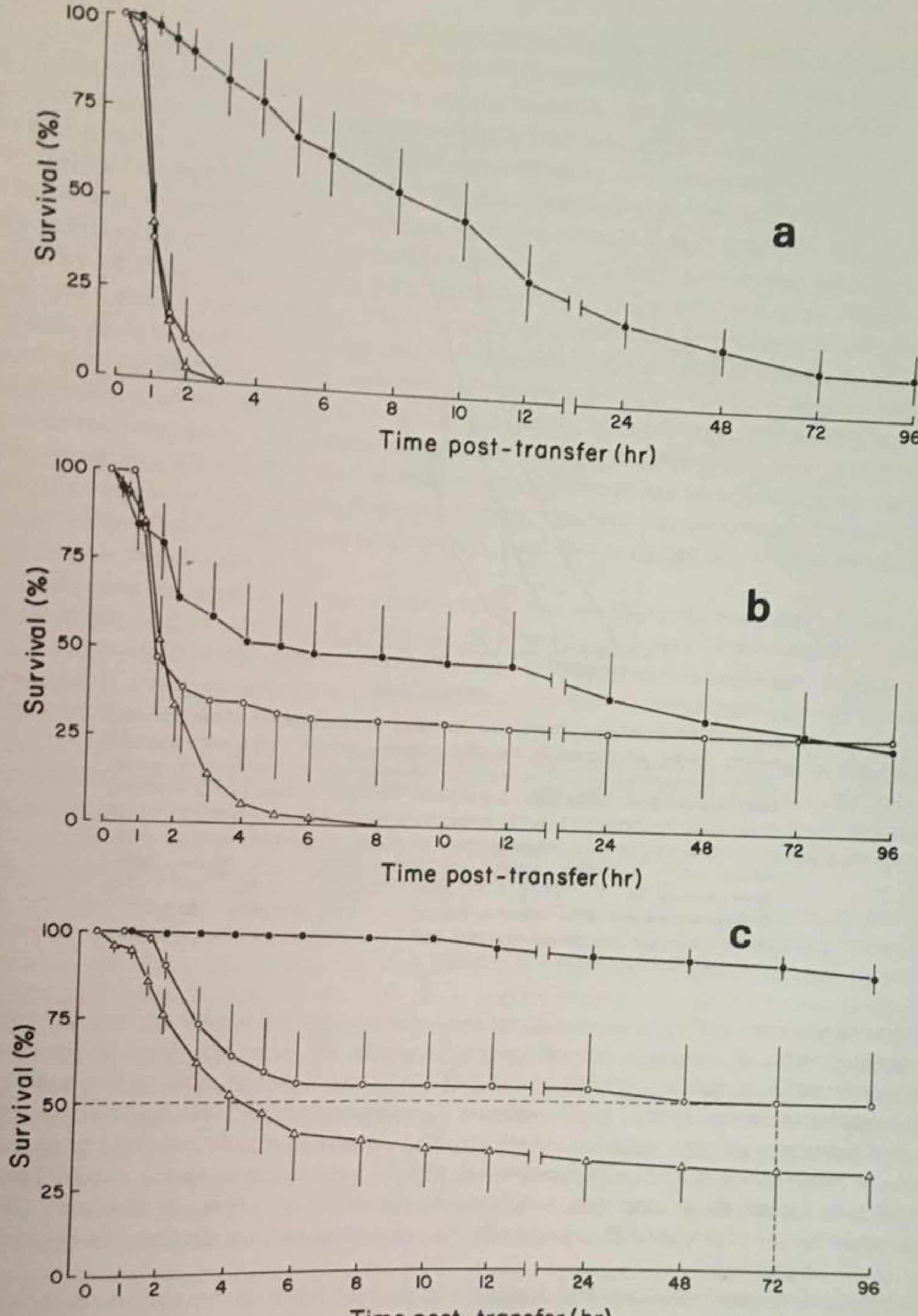


Fig. 9. Comparison of survivorship as a function of time between saline water-spawned (●), freshwater-spawned, saline water-hatched (○), and freshwater-spawned, freshwater-hatched, saline water-acclimatized (△) *O. niloticus* fry, following direct transfer from identical spawning, hatching or acclimatization salinity, respectively, to full seawater (32 ppt). Survivorship patterns are compared for hatching, spawning, or acclimatization salinities of 5 ppt in Fig. 9a, 10 ppt in Fig. 9b, and 15 ppt in Fig. 9c. Each plotted point represents the mean value for five to seven determinations. Vertical bars represent ± S.E.M. Absence of vertical bars indicates that the S.E.M. lies within the area of the plotted point.

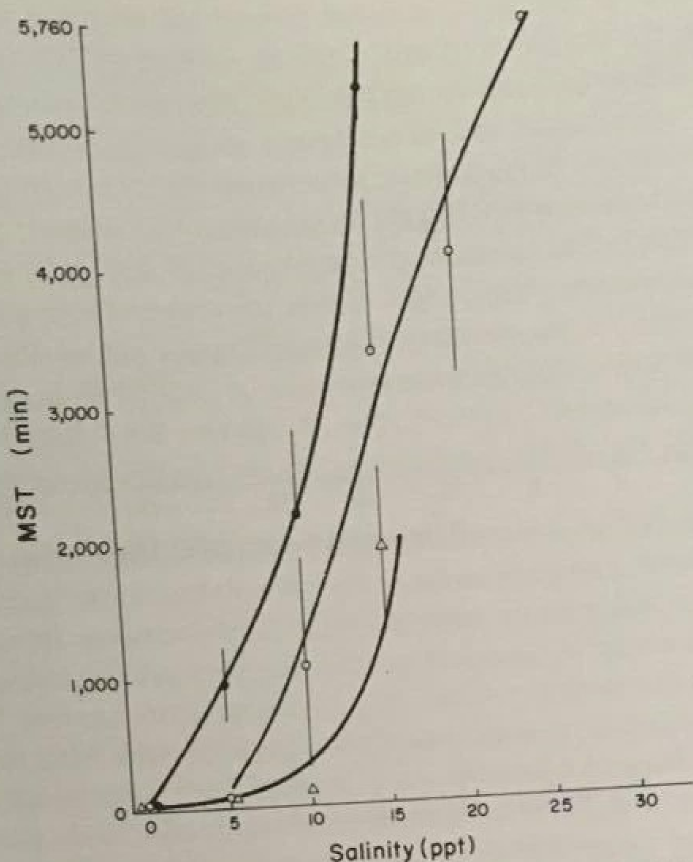


Fig. 10. Salinity tolerance (MST) of *O. niloticus* fry as a function of the spawning salinity (saline water-spawned fry) (●), hatching salinity (freshwater-spawned, saline water-hatched fry) (○), or the acclimatization salinity (freshwater-spawned, freshwater-hatched, saline water-acclimatized fry) (△). Plotted points represent mean values of Table 4, 2 and 5, respectively. Vertical bars represent ± S.E.M. Absence of vertical bars indicates that the S.E.M. lies within the area of the plotted point. Regression analysis produced relationships as follows: saline water-spawned fry, $Y = 51.10 + 253.02X - 24.05X^2 + 2.04X^3$; $R^2 = 1.00$; freshwater-spawned, saline water-hatched fry; $Y = 3.90 - 98.90X + 29.15X^2 - 0.65X^3$; $R^2 = 0.98$; freshwater-spawned, freshwater-hatched, saline water-acclimatized fry, $\ln Y = 2.68 + 0.31X$; $R^2 = 0.86$.

embryos reflects their ability to survive direct seawater transfer for longer periods of time than fry or fingerlings, although complete mortality was observed by 96 hours post-transfer for both embryos and fry or fingerlings. Weisbart (1968) found that the presence of the chorion imparted increased salinity resistance on embryos of Pacific salmon (*Oncorhynchus* spp.). He could not attribute this increased resistance to impermeability of the chorion since the perivitelline fluid of eggs immersed for four or more hours in 31.8 ppt seawater was slightly hyperosmotic to the external medium. Dechorionated embryos, nevertheless, exhibited decreased survival times in seawater. The high ST_{50} values exhibited by embryos of *O. niloticus* in the present study may similarly be related to the presence of the chorion.

The vitelline membrane can also function to protect the embryo against osmotic changes through either impermeability or osmoregulatory activity (Hempel 1979). Differential mortality during incubation in various salinities prior to hatching, however, discounts the possibility of vitelline membrane impermeability. The results are more consistent with the possibility that the vitelline membrane provides protection to the embryo through osmoregulatory activity, which becomes ineffective at high salinities. That ST_{50} values are substantially lowered following hatching further suggests that high salinity tolerance exhibited by embryos is related to the presence of the egg membranes rather than to osmoregulatory activity by embryonic ectodermal cells as postulated for herring (Holliday and Jones 1965).

The large difference in ST_{50} values exhibited by embryos and fry or fingerlings should be interpreted with some reservation, however, as embryos surviving extended periods in full seawater exhibited structural abnormalities, generally characterized by an under-development of organs. Descriptions of developmental abnormalities resulting from the effects of salinity during egg incubation have been summarized by Holliday (1969). Nevertheless, it is remarkable that eggs spawned in freshwater may be incubated and successfully hatched at salinities as high as 25 ppt, whereas 7 to 395-day old fry and fingerlings are unable to survive direct transfer to this salinity. These results may reflect a relatively greater degree of adaptability of early embryos to high environmental salinity than fry or fingerlings. Kinne (1962) proposed that in the desert pupfish *(Cyprinodon macularius)*, the capacity and intensity of non-genetic adaptations to environmental salinity may be maximal during early ontogenic development. In his review of the effects of salinity on the eggs and larvae of teleosts, Holliday (1969) similarly expressed surprise at reports (Oliphan 1940, 1941) of successful hatching of several freshwater spawning species in salinities as high as 20 ppt.

No consistent relationship was observed between incubation salinity and time to hatching. It is well known, however, that the effects of salinity on development rate of teleost eggs can be profoundly modified by many factors including temperature, dissolved oxygen and genotype of parental fish (Holliday 1969). The interaction of such factors may have obscured any salinity-related effects on hatching time in the present study.

Mean body weights, lengths and condition factors of seven-day old freshwater-spawned fry hatched at various salinities were not significantly different from those of fry hatched in freshwater. Forrester and Alderice (1966) suggested that in Pacific cod *(Gadus macrocephalus)*, maximum larval size was associated with those salinity and temperature conditions producing maximum survival to hatching. At 5 to 7°C, maximum survival and larval size were achieved at salinities associated with least osmotic stress. It was inferred that environmental conditions allowing maximum distribution of energy to growth, while satisfying requirements for maintenance and physical activity, should maximize survival and size of larvae in a minimum period of incubation (Alderice and Forrester 1968). Lack of significant size differences of larvae hatched in various salinities despite differential mortality in these salinities is difficult to explain on this basis.

In the present study, the salinity tolerance of fry subjected to various kinds of early salinity exposure was determined. A progressive increase in salinity tolerance with increasing exposure salinity was observed. Rao (1975) reported that the salinity tolerance of newly-hatched larvae of California killifish *(Fundulus parvipinnis)* was influenced by incubation salinity; larvae hatched in lower incubation salinities exhibited greater freshwater tolerance than those hatched at higher salinities. Conversely, tolerance of newly-hatched larvae to 70 ppt increased with salinity of incubation. Pfeiler (1981) similarly observed in bonefish (*Albula* sp.) juveniles that increasing adaptation salinity increased the upper incipient lethal salinity (defined as the salinity at which theoretically 50% of the population can survive indefinitely). That exposure to low salinities may not necessarily result in greater salinity tolerance is suggested by the observation that in Pacific salmon (*Oncorhynchus* spp.) alevins, exposure to 10 ppt for two days followed by 20 ppt for a subsequent two days, produced median survival times following seawater transfer that were the same as those for alevins transferred directly from freshwater to 31.8 ppt seawater (Weisbart 1968).

Exposure to dilute seawater may minimize the osmotic variations associated with direct transfer to full seawater. For example, Iwata et al. (1982) found that pre-acclimatization of chum salmon *(O. keta)* fry to a salinity of 12 ppt for 12 hours resulted in a gradual increase in plasma sodium to the seawater acclimatized levels. Subsequent exposure to full seawater (36 ppt) did not cause a significant change in plasma sodium level. Boeuf and Harache (1982) similarly observed that preadaptation of coho salmon *(Oncorhynchus kisutch)* to 25 ppt for three weeks suppressed the large fluctuation in internal body fluids observed during direct transfer to full seawater (36 ppt).

According to Bashamohideen and Parvatheswararao (1972), prior acclimatization of *O. mossambicus* to 75% seawater facilitated acclimatization to 100% seawater so that there was less osmotic work and therefore less energy expended in 100% seawater. This was evidenced by a lower rate of glucose utilization.

Information on reproduction in tilapias in relation to environmental salinity is scanty. General ranges of salinities over which various species are known to reproduce have been summarized by Wohlfarth and Hulata (1983). The Nile tilapia *(O. niloticus)* was reported to reproduce, along with *T. zillii* and *S. galilaeus* at salinities of 13.5 to 29 ppt in the Great Bitter Lakes of Egypt (El Saby 1951, in Kirk 1972). However, in Lake Qarun, a former freshwater lake which became progressively more saline, only *T. zillii* continued to persist at 29 ppt after other species including *O. niloticus* and *S. galilaeus* had disappeared (El Zarka 1956, in Kirk 1972).

Chervinski (1961) observed spawning of *O. niloticus* in 50% seawater (19 ppt) during growth experiments in concrete tanks. From the small number of young produced, he inferred that relatively fewer young are produced in brackishwater than in freshwater. Similar results had been previously reported for *O. mossambicus* which produced considerably less spawns at 36.2 ppt than in freshwater (Zaneveld 1958, in Chervinski 1961). Chervinski and Yashouv (1971) noted that during growth experiments of *O. aureus* in seawater ponds, there was no reproduction, no nest building and a drop in gonadosomatic index, which they suggested to be due to a resorption of eggs.

Experimental evidence on reproductive performance of tilapias at various salinities has been lacking. In the present study, reproductive performance of yearling *O. niloticus* was monitored under laboratory conditions at various salinities. An inhibitory effect of high salinity on reproduction was also observed. In general, there was a tendency for the intervals between spawns to lengthen in higher salinities, resulting in considerably fewer spawns in full seawater than in brackishwater. These results should be interpreted with some caution, however, as resorption of ripe spawns is a common phenomenon in tilapias and the number of completed spawns may not necessarily indicate the number of spawns actually elaborated by a given fish (Peters 1983). An apparently anomalous result was that total spawns were lowest among yearling females in freshwater. In tilapias, early maturity at small sizes is thought to be a common response to unstable or stressful environmental conditions (Payne 1983). Therefore, greater spawning activity in brackish and seawater may have been related to the salinity exposure history of these individuals. Alternatively, infrequent spawning in freshwater may have resulted from greater resorption of ripe spawns for reasons which are presently unclear. No firm conclusions can be drawn on the basis of available data.

Hatching successes were comparable for yearling females at 5 ppt and older females in freshwater. However, the inhibitory effect of high salinity on reproduction was evidenced by considerably lowered hatching successes at 10 and 15 ppt. Successful hatching was not achieved in full seawater. Therefore, no fry were produced in full seawater despite the fact that eggs continued to be produced and spawned at this salinity. Rearing at high salinities has been suggested as a way to prevent overpopulation in fishponds without the need for sex separation (Chervinski and Yashouv 1971). Present results show that although *O. niloticus* failed to reproduce in full seawater, energy was nevertheless channelled into egg production in females of small sizes. Therefore, all-male rearing through sex separation, sex reversal or hybridization is still an appropriate technique for maximizing growth rates at high salinities.

In a detailed study of egg development in tilapias, Peters (1983) observed the number of eggs released per spawn to increase with body weight in the substrate spawner *T. tholloni*, as well as in the mouthbrooding species *O. mossambicus*, *S. melanotheron* and *S. galilaeus*. His results revealed, however, that the curves relating an increase in number of eggs spawned with increasing body weight tended to become flat when body weights reached high values, indicating that large females released relatively fewer eggs per unit weight at each spawn. Payne and Collinson (1983) similarly reported that in both *O. aureus* and *O. niloticus*, smaller females produce more eggs per unit body weight. Since adverse environmental conditions stimulate early maturity at small sizes in tilapias, relatively higher fecundity in smaller fish further enhances the chances of survival under such conditions (Payne and Collinson 1983). Present results clearly show that small, yearling *O. niloticus* females release fewer eggs at each spawn than do older, larger females. However, in agreement with results of previous studies, larger females released fewer eggs per unit weight than did yearling females, regardless of spawning salinity.

Since smaller individuals are more productive per unit weight than larger individuals, it is important for the culturist attempting to maximize broodstock productivity to determine maximum size above which egg production per unit weight begins to decline. Higher egg productivity per unit weight has little practical value, however, if spawnings are less frequent or hatching successes relatively poorer. Results of the present study indicate that seasonal egg and fry production per unit weight was greater among yearling females spawning in brackish salinities of 5 to 15 ppt than in larger females spawning in freshwater. Therefore, seasonal fry production would be expected to be greater for smaller females for a given total weight of fish, even under brackishwater conditions.

Kinne (1962), in his experiments with the euryhaline teleost, *Cyprinodon macularius*, demonstrated that fish hatched from eggs remaining in the spawning salinity exhibited higher food conversion efficiencies than those transferred between three and six hours after fertilization into another salinity within its ecological tolerance range. For example, at a rearing temperature of 30°C, fish spawned and reared in seawater (35 ppt) showed better conversion efficiencies than those of the same brood hatched and reared in freshwater. Likewise, those spawned and reared in freshwater showed better conversion efficiencies than those of the same brood hatched and reared in seawater. His results suggest, however, that if rearing is to be performed at a salinity outside the optimal growth range for the species, then maximal growth and food conversion efficiencies may be achieved by spawning at the same salinity. Kinne concluded that the osmotic environment to which the eggs are exposed within three to six hours after spawning induces adjustments which persist throughout the lives of the fish hatched from these eggs and that these adjustments are non-genetic adaptations of the organism to environmental salinity which are not transmitted to the next generation. He further proposed that the effects of spawning salinity were based on the passage of the external medium through the egg chorion in forming the perivitelline fluid, thereby modifying the environment in which the embryo develops.

It was determined in the present study that at equivalent salinity, early exposure (spawning) produces Nile tilapia progeny of comparatively greater salinity tolerance than those spawned in freshwater but hatched at elevated salinity. These results are consistent with the idea that significant adjustments to environmental salinity are made within a short period of time following spawning. In tilapia eggs, formation of the perivitelline space due to water absorption is completed two to three hours after fertilization (Peters 1983). It may be similarly hypothesized that the osmotic environment to which eggs are exposed within two to three hours after spawning induces adjustments which affect the salinity tolerance of fry hatched from these eggs.

The relatively more consistent results obtained with saline water-spawned progeny compared to saline water-hatched progeny may be related to the fact that whereas fry spawned and hatched at a given salinity were exposed to a constant saline environment throughout development, those removed from freshwater for incubation at elevated salinities were removed at different stages of development. This resulted from the fact that since the exact time of spawning was sometimes unknown, time of removal may have ranged from 12 to 36 hours post-spawning. Hence, each brood was exposed to the freshwater spawning medium for non-identical periods of time. Broods transferred to elevated salinities at an earlier stage of development would be expected to exhibit greater salinity tolerance.

It was also determined in the present study that at equivalent salinity, Nile tilapia progeny spawned in freshwater but hatched at elevated salinity exhibit comparatively higher salinity tolerance than those spawned and hatched in freshwater, then subsequently acclimatized to an elevated salinity. These results suggest that adaptability to a given environmental salinity during early development diminishes as development proceeds. The more closely similar salinity tolerance values exhibited by saline water-hatched and saline water-acclimatized fry compared to saline water-spawned fry also suggest that the most profound adjustments to environmental salinity are indeed made during the period of early development following fertilization.

It was determined in a previous study (Watanabe et al. 1984) that hybrid progeny of *O. mossambicus* (♀) and *O. niloticus* (♂) exhibit higher salinity tolerance than either *O. aureus* or *O. niloticus*. As size-related changes in salinity tolerance were observed in these species, it was suggested that a combination of hybridization (to increase salinity tolerance levels) and maximization of early freshwater growth to size of maximum tolerance (to minimize freshwater requirements) may optimize conditions for economic culture of tilapias in seawater. Results of the present study have demonstrated that early salinity exposure, through spawning and incubation at elevated salinities, can effectively enhance salinity tolerance levels in young tilapia fry. The feasibility for spawning under saline conditions was demonstrated by successful fry production in salinities as high as 15 ppt. Furthermore, seasonal fry production per unit weight by females in brackish salinities of 5 through 15 ppt exceeded that observed for larger females in freshwater. In addition to enhancing salinity tolerance levels of fry, early salinity exposure provides the added benefit of reducing freshwater requirements associated with broodstock holding and early rearing.

Maximization of early freshwater growth to size of maximum salinity tolerance and early salinity exposure through spawning and hatching at elevated salinities appear to be conflicting approaches. However, if increased tolerance with size is related to body surface:volume relationships (Parry 1960), to development of the hypoosmoregulatory system (Wedemeyer et al. 1980) or to ontogenic changes in hemoglobin (Perez and Maclean 1976), then it seems reasonable to assume that progeny spawned and hatched at elevated salinities would similarly exhibit ontogenic changes in salinity tolerance. In salmonids, the rate of development of the hypoosmoregulatory system is influenced by prior acclimatization to low salinities and by growth rate (Wagner et al. 1969). It follows that optimum time for seawater transfer of fry spawned and hatched in elevated salinities is when size of maximum salinity tolerance is attained. Therefore, hybridization, early salinity exposure and maximization of early growth to size of maximum salinity tolerance are all compatible techniques for saltwater tilapia culture. Temperature control, application of growth promoters or all-male rearing are all potentially useful techniques for attaining size of maximum salinity tolerance in the shortest period of time. Further experiments are required to determine the ontogeny of salinity tolerance in progeny spawned and hatched at elevated salinities.

It is not possible to equate high salinity tolerance with high growth rates in seawater on the basis of available data. However, as results to date have demonstrated that salinity tolerance varies considerably with age, size, and salinity exposure history of the individual, it is important that these factors be defined and standardized when designing experiments for evaluating the growth performance of tilapias in relation to environmental salinity.

The genetic approach to developing strains or hybrids which exhibit good growth and survival in seawater remains an important research priority for saltwater tilapia culture. In addition, nongenetic techniques such as early salinity exposure and selection of optimal transfer times may help to maximize the potential of moderately salt-tolerant species, such as *O. niloticus*, for survival and growth during culture at higher than optimal salinities.

Acknowledgements

The authors wish to thank the following for making this work possible: the Institute of Marine Biology, National Sun Yat-Sen University, Kaohsiung for provision of experimental facilities and logistic support; the Rockefeller Foundation for providing one of the authors (W.O.W.) with a postdoctoral research fellowship; Mr. Anne van Dam for assistance in carrying out the experiments and Dr. Roger S.V. Pullin for helpful advice. This work was undertaken during a program of research cooperation between the International Center for Living Aquatic Resources Management, Manila and the Council for Agricultural Planning and Development of the Government of Taiwan.

References

Alderice, D.F. and C.R. Forrester. 1968. Some effects of salinity and temperature on early development and survival of the English sole (*Parophrys vetulus*). J. Fish. Res. Board Can. 25(3): 495-521.

Bashamohideen, M. and V. Parvatheswararao. 1972. Adaptations to osmotic stress in the freshwater euryhaline teleost *Tilapia mossambica*. IV. Changes in blood glucose, liver glycogen and muscle glycogen levels. Mar. Biol. 16: 68-74.

Boeuf, G. and Y. Harache. 1982. Criteria for adaptation of salmonids to high salinity seawater in France. Aquaculture 28: 163-176.

Chervinski, J. 1961. On the spawning of *T. nilotica* in brackishwater during experiments in concrete tanks. Bamidgeh 13(1): 30.

Chervinski, J. and A. Yashouv. 1971. Preliminary experiments on the growth of *Tilapia aurea* (Steindachner) (Pisces, Cichlidae) in sea water ponds. Bamidgeh 23(4): 125-129.

Chervinski, J. 1982. Environmental physiology of tilapias, p. 119-128. *In* R.S.V. Pullin and R.H. Lowe-McConnell (eds.) The biology and culture of tilapias. ICLARM Conference Proceedings 7, 432 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Forrester, C.R. and D.F. Alderice. 1966. Effects of salinity and temperature on embryonic development of the Pacific cod (*Gadus macrocephalus*). J. Fish. Res. Board Can. 23(3): 319-340.

Hempel, G. 1979. Early life history of marine fish. University of Washington Press, Seattle.

Holliday, F.G.T. 1969. The effects of salinity on the eggs and larvae of teleosts, p. 293-311. *In* W.S. Hoar and D.J. Randall (eds.) Fish physiology. Vol. 1, Academic Press, New York.

Holliday, F.G.T. and M.P. Jones. 1965. Osmotic regulation in the embryo of the herring (*Clupea harengus*). J. Mar. Biol. Ass. U.K. 45: 305-311.

Holliday, F.G.T. and M.P. Jones. 1967. Some effects of salinity on the developing eggs and larvae of the plaice (*Pleuronectes platessa*). J. Mar. Biol. Ass. U.K. 47: 39-48.

Iwata, M., T. Hirano and S. Hasegawa. 1982. Behavior and plasma sodium regulation of chum salmon fry during transition into seawater. Aquaculture 28: 133-142.

Kinne, O. 1962. Irreversible non-genetic adaptation. Comp. Biochem. Physiol. 5: 265-282.

Kirk, R.G. 1972. A review of recent developments in *Tilapia* culture, with special reference to fish farming in the heated effluents of power stations. Aquaculture 1: 45-60.

Landless, P.J. and A.J. Jackson. 1976. Acclimatizing young salmon to sea water. Fish Farming Int. 3(2): 15-17.

Lee, J.C. 1979. Reproduction and hybridization of three cichlid fishes, *Tilapia aurea* (Steindachner), *T. hornorum* (Trewavas) and *T. nilotica* (Linnaeus) in aquaria and in plastic pools. Auburn University, Auburn, Alabama. 84 p. Ph.D. dissertation.

Olifan, V.I. 1940. Contributions to the physiological ecology of the eggs and larvae of fishes. I. The effect of salinity on early developmental stages of *Abramis brama* L., *Lucioperca lucioperca* L. and *Caspialosa volgensis* Berg. Zool. Zh. 19: 73-98.

Olifan, V.I. 1941. Effect of salinity on the eggs and larvae of carp, vobla and bream. Vses. Nauchn.-Issled. Inst. Morsk. Rybn. Khoz. i Okeanogr. Tr. 16: 159-172.

Parry, G. 1960. The development of salinity tolerance in the salmon, *Salmo salar* (L.) and some related species. J. Exp. Biol. 37: 425-434.

Payne, A.I. 1983. Estuarine and salt tolerant tilapias, p. 534-543. In L. Fishelson and Z. Yaron (compilers). International Symposium on Tilapia in Aquaculture, Nazareth, Israel, 8-13 May 1983. Tel Aviv University, Israel.

Payne, A.I. and R.I. Collinson. 1983. A comparison of the biological characteristics of *Sarotherodon niloticus* (L.) with those of *S. aureus* (Steindachner) and other tilapia of the delta and lower Nile. Aquaculture 30: 335-351.

Perez, J.E. and N. Maclean. 1976. The haemoglobins of the fish *Sarotherodon mossambicus* (Peters): functional significance and ontogenetic changes. J. Fish Biol. 9(5): 447-455.

Peters, H.M. 1983. Fecundity, egg weight and oocyte development in tilapias (Cichlidae, Teleostei). ICLARM Translations 2. 28 p. International Center for Living Aquatic Resources Management, Manila, Philippines.

Pfeiler, E. 1981. Salinity tolerance of leptocephalous larvae and juveniles of the bonefish (Albulidae : Albula) from the Gulf of California. J. Exp. Mar. Biol. Ecol. 52: 37-45.

Rao, T.R. 1975. Salinity tolerance of laboratory-reared larvae of the California killifish, *Fundulus parvipinnis* Girard. J. Fish Biol. 7(6): 783-790.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon*, *Oreochromis* and *Danakilia*. British Museum (Natural History), London.

Wagner, H.H., F.P. Conte and J.L. Fessler. 1969. Development of osmotic and ionic regulation in two races of chinook salmon *Oncorhynchus tshawytscha*. Comp. Biochem. Physiol. 29: 325-341.

Watanabe, W.O., C.M. Kuo and M-C. Huang. 1984. Salinity tolerance of the tilapias *Oreochromis aureus* (Steindachner), *O. niloticus* (L.), and *O. mossambicus* (Peters) x *O. niloticus* hybrid. ICLARM Technical Reports 16. (In press)

Wedemeyer, G.A., R.L. Saunders and W.C. Clarke. 1980. Environmental factors affecting smoltification and early marine survival of anadromous salmonids. Mar. Fish. Rev. 42(6): 1-14.

Weisbart, M. 1968. Osmotic and ionic regulation in embryos, alevins, and fry of five species of Pacific salmon. Can. J. Zool. 46: 385-397.

Wohlfarth, G.W. and G. Hulata. 1983. Applied genetics of tilapias. ICLARM Studies and Reviews 6, 26 p. Second edition. International Center for Living Aquatic Resources Management, Manila, Philippines.

Universidad Internacional de las Américas

School of Education and Foreign Languages

Graduation Seminar

Thesis Submitted to Obtain the Bachelor in English

Effect of the Procedures and Methods Used to Translate the Documents La Poda del Alcornocal (Querus Super L.). Cuantificación de sus Productos from Spanish into English and Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Saltwater Culture From English Into Spanish for Universidad Nacional de Costa Rica

Student: Vian Nazira Brenes Alemán

December, 2017

Justification

As part of this project, the translation of two texts which belong to UNA were performed. These documents are an important part of the students study program, that means they will benefit students and teachers at the same time.

Research Question

What is the effect of the procedures and methods used to translate the documents *La poda del alcornocal (Quercus Super L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture* from English into Spanish for UNA?

General Objective

To analyze the effect of the procedures and methods used to translate the documents *La poda del alcornocal (Quercus Super L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture* from English into Spanish for UNA

Specific Objectives

1. To translate the documents *La poda del alcornocal (Quercus Super L.) cuantificación de sus productos* from Spanish into English for UNA and *Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture* from English into Spanish for UNA

Specific Objectives

2. To apply various translation techniques to the documents in order to achieve communicative texts

3. To evaluate the effect of the translation techniques applied on the documents

4. To create a glossary with the most relevant terminology found in both texts

Theoretical Framework

Theory	Author	Year of publication
1.	Peter Newmark	1988
2.	Vázquez-Ayora	1977
3.	Di Jin and Nida	2006

Research Subjects

- Universidad Nacional de Costa Rica
Experimental Rearing of Nile Tilapia (Oreochromis niloticus) for Saltwater Culture

- Universidad Nacional de Costa Rica
La Poda del Alcornocal (Querus Super L.). Cuantificación de sus Productos

Type of Study

Qualitative Method

This method was used because of the nature of its information, which is mostly related to "quality" or "kind" rather than quantity or simply numbers.

Procedures

Date	Activity	Instrument
June 8th	Text Analysis of English into Spanish text	Observation
September 6th	Finished translation	Observation
September 15th	Realization of Glossary	Glossary
September 17th	Text Analysis of Spanish into English text	Observation
October 9th	Finished Translation	Observation
October 17th	Realization of Glossary	Glossary
November 19th	Analysis of paragraphs	Color coding

Data Analysis

Text Analysis

Elements to analyze	Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Salt Water Culture	La Poda del Alcornocal (Quercus Suber L.). Cuantificación de sus Productos
Text Style	Descriptive	Informative
Text function or intention	Inform	Inform
Intention of the translator	Inform	Inform
Stylistic scale		
Formality	Formal	Neutral
Generality or difficulty	Technical	Educated
Emotional Tone	Factual	Factual
Translation Method	Communicative	Communicative

Color-Coding

La Poda del Alcornocal (Querus Super L.). Cuantificación de sus Productos

Transposition
Modulation
Omission
Amplification
Explicitation
Literal Translation

Está demostrado que la producción de bellota se ve favorecida por la presencia de nuevos y vigorosos brotes en la zona periférica de la copa (no de brotes chupones o ladrones). El principal efecto que produce la poda consiste, justamente, en estimular la emisión de nuevos y más vigorosos brotes, al concentrar toda la capacidad productora del árbol en unas cuantas ramas seleccionadas. El desequilibrio se restablece en pocos años, pues la biomasa de la copa va aumentando y parece que el sistema radical se reduce en proporción a la reducción que la poda provocó en la copa (Vieira 1937). Cuando el equilibrio se alcanza de nuevo se ralentiza el crecimiento de los brotes y la producción de bellota por unidad de superficie de copa vuelve a estabilizarse en la cuantía original existente antes de la poda; en este estado se hace necesario realizar una segunda poda, que habrá de ser repetida periódicamente.

It is confirmed that the production of the acorn is favored by the presence of new and vigorous sprouts on the peripheral zone of the crown (not sucker or thief sprouts). The main effect of the pruning is precisely to stimulate the growth of new and more vigorous sprouts, by centering all the production capability of the tree to just a few selected branches. The imbalance is reestablished in a few years, because the biomass of the crown increases and it seems that the radical system decreases in proportion to the reduction that the pruning provoked on the crown (Vieira, 1937). When the balance is achieved again, the growth of the sprout is slowed down and the production of acorn per unity of the surface of the crown is established again in the existing original amount before the pruning. In this period of time, it becomes necessary to perform a second pruning, which must be repeated periodically.

Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Saltwater Culture

Transposition
Modulation
Omission
Amplification
Explicitation
Literal Translation

The reproductive performance of yearling O. niloticus broodstock was monitored under laboratory conditions at various salinities and results compared with the performance of an older (two to three-year) broodstock in freshwater. Spawning was observed in salinities ranging from freshwater to full seawater (32 ppt). Mean hatching successes were similar for eggs spawned by yearling females in freshwater (30.9%), 10 ppt (32.7%) and 15 ppt (36.9%). Extremely poor hatching success was obtained with eggs spawned in full seawater. Mean hatching success was considerably higher for eggs spawned at 5 ppt (51.6%) and compared with that obtained with eggs spawned by older females in freshwater (54.2%). Seasonal egg and fry production per female was much greater in the older broodstock in freshwater than in yearling females in any salinity.

El rendimiento de la población reproductora de *O. niloticus* de un año de edad fue monitoreado bajo condiciones de laboratorio en varias salinidades y fue comparado con los resultados del rendimiento de la población reproductora de mayor edad (de dos a tres años) en agua dulce. El desove fue observado en salinidades que oscilan desde agua dulce hasta agua de mar (32 ppm.). El promedio de éxitos en la eclosión fue similar al de los huevos desovados por hembras de un año de edad en agua dulce (30.9%), en 10 ppm (32.7%) y en 15 ppm. (36.9%). Un éxito extremadamente bajo en la eclosión fue obtenido con huevos desovados en agua de mar. El promedio de éxito en la eclosión fue considerablemente más alto para huevos desovados en 5 ppm (51.6%) y fue comparado con el obtenido en huevos desovados por hembras de mayor edad en agua dulce (54.2%). La producción estacional de pececillos y huevos por hembra fue mucho más alta en la población reproductora de mayor edad en agua dulce que la de hembras de un año de edad bajo cualquier salinidad.

Glossaries

La Poda del Alcornocal (Querus Super L.). Cuantificación de sus Productos

Spanish Term	English Term	Grammatical Category	Definition
Acotamiento	Limitation	Noun	Reservar, prohibir o limi tar.
Alcornocal	Cork oak field	Noun	Sitio poblado de alcornoques.
Alcornoque	Cork oak	Noun	Árbol siempre verde, de la familia de las fagáceas, de ocho a diez metros de altura, copa muy extensa, madera durísima, corteza formada por una gruesa capa de corcho, hojas aovadas, enteras o dentadas, flores poco visibles y bellotas por frutos.

Experimental Rearing of Nile Tilapia (Oreochromis Niloticus) for Saltwater Culture

English Term	Spanish Term	Grammatical Category	Definition
Acclimatized	Aclimatado	Adjective	Adapted to a new temperature, altitude, climate, environment, or situation.
Brackish	Salobre	Adjective	Somewhat salty.
Breeder	Criador	Noun	An animal or plant kept for propagation.

Conclusions

Specific Objectives	Conclusion
To translate the documents La poda del alcornocal (Quercus Super L.) cuantificación de sus productos from Spanish into English for UNA and Experimental rearing of Nile tilapia (Oreochromis niloticus) for salt water culture from English into Spanish for UNA	It was carried out a general and a close reading to be familiarized with the documents and terminology. Therefore, thanks to the text analysis, both documents were translated successfully; although, there were some vocabulary difficulties in the texts.
To apply various translation techniques to the documents in order to achieve communicative texts	Translation techniques and procedures were applied to both documents in order to analyze the data for further understanding.

Conclusion

Specific Objectives	Conclusion
To evaluate the effect of the translation techniques applied on the documents	These applied techniques helped the translator to analyze the necessary data to finally deliver a more natural and accurate translation. Literal translation and transpositions were the ones most found, and explicitations and modulations were the least found in these texts
To create a glossary with the most relevant terminology found in both texts	Glossaries were crucial for the translation process as they helped the translator who could create a data base with a vocabulary dictionary to look up certain specific rather difficult terms. In addition, it allowed the translator to give unity and consistency to the documents.

Unexpected Results

The Spanish into English document (La poda del alcornocal) seemed to contain several troublesome terms, which needed to be added to the glossary. However, this expected large number narrowed to just eighteen terms.

Recommendations

- Be organized
- Read the to be translated texts thoughroughly
- Have in hand a notebook with all translation techniques
- Follow the advice of experts

References

Andrews, R. (2003). Research Question. New York. Continuum.

Bassnett, S. (2014). Translation Studies (4th ed.). New York: Methuen & Co. Ltd.

Di, J, & Nida A. E. (2006). On Translation: An expanded edition. Hong Kong. City University of Hong Kong Press.

Essays, UK. (November 2013). Three Scales of Emotional Tone English Language Essay. Retrieved from https://www.uniassignment.com/essay-samples/english-language/three-scales-of-emotional-tone-english-language-essay.php?cref=1

Ferraro, E. F. (2006). Investigations in the Workplace. Florida. Auerbach Publications.

House, J. (2015). Translation Quality Assessment: past and present. New York. Routledge.

Johnson, S. (2011) Dissertation Writing Assignment Help UK. Importance of SPSS in Data Presentation for Dissertation. Retrieved from: dissertation-help-uk.blogspot.com/2011/11/importance-of-spss-in-data-presentation.html.

Lavadeira, S. (2015) A Comparative Linguistic Analysis of English and Spanish Advertising Discourse. Spain. Universidade da Coruña

Lionbridge. (2016). How to Create Translation Style Guide and Terminology Glossary. Retrieved from: http://content.lionbridge.com/how-to-create-a-translation-style-guide-and-terminology-glossary/

Lionbrisge. (2013). What is a Translation Glossary? Retrieved from http://info.lionbridge.com/rs/lionbridge/images/Lionbridge%20FAQ_Glossary_2013.pdf

Newmark, P. (1988). *A textbook of Translation*. Hertfordshire. Prentice Hall International vUIO Ltd.

Osimo, B. (2002). The "Translation Book:" Method Applied for Primary Sources. Milano.

Vázquez-Ayora, G. (1977). Introducción a la Traductología. Washington D.C. Georgetown University Press.