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EL CAJON PROJECT



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A potentially major secondary benefit of large impoundment projects is the development of a reservoir fishery. The value of such a fishery, in both economic and social terms, depends on a suite of factors, including levels of fish production, species composition of the fish community, ease of harvest, access to the reservoir, population densities and settlement patterns within the reservoir basin, agricultural production in the surrounding area and the hydraulic management regime of the impoundment. Low levels of riverine fish production in the area of a future impoundment project, as is the case for the Humuya and Sulaco rivers, serve to increase the potential contribution of a reservoir fishery.

Pre-impoundment fisheries studies may include two major orientations. The first of these is directed towards predicting the effects of a dam on riverine fish communities, both upstream and downstream of the impoundment. A good example of these impacts, which are often of considerable economic importance, is the obstruction of migration routes of salmonid fish stocks in many North American rivers. The second major orientation of pre-impoundment studies concerns the reservoir fishery itself, and consists of not only predicting which species are likely to succeed in the new lake, but also establishing an adequate base of biological information to assist in the development of effective management strategies for the fishery. This aspect of pre-impoundment studies is of special importance where little is known of the biology and ecology of native fish species, as was the case for those of the El Cajón area.

The El Cajón pre-impoundment fisheries studies were designed with both of these orientations in mind. Their major objectives were to 1) document the

composition and distribution of the fish fauna in the El Cajón area, and 2) study the biology and ecology of the major fish species. These objectives and the scope of the investigations are discussed in greater detail in the introductions to later sections of this report.

Although there has been a traditional separation between much limnological and fisheries work (Rigler 1982), the dual emphasis placed on limnology and fish ecology in the present pre-impoundment studies has provided the base for an integrated approach to the El Cajón reservoir ecosystem and to future impoundment projects in Honduras. There have been relatively few in-depth pre-impoundment studies carried out in the tropics (one notable exception being the investigations on the Purarí system in Papua New Guinea; Petr 1983) and comprehensive post-impoundment studies (e.g. Balon and Coche 1974; Imevbore and Adegoke 1975) are not common. Post-impoundment work on both the fisheries and limnology of L. El Cajón will add considerably to the extensive data base already established for the region and has the potential not only for promoting an optimal reservoir management strategy, but also for developing one of the most complete documentations of any reservoir project in the tropics.

This second volume of the El Cajón Limnology and Fisheries Program Report discusses results from the fisheries studies which are based on the analyses of over 3000 fish from the El Cajón watershed. After a summary of these investigations (Section 11.2), Section 11.3 discusses the likely characteristics of the new reservoir fishery and represents an integration of the pre-impoundment studies which are analyzed in Sections 11.4 to 11.7.

The fisheries program was designed with two principal objectives: 1) describe the distribution and relative abundance of riverine fish species in the El Cajón area and, 2) obtain a base of information on the biology and ecology of the major species. This data base is used to a) assess the impact of the El Cajón project on the native fish fauna and, b) serve as a foundation for fisheries management strategies in the new reservoir.

Sampling was carried out between 1980 and 1982 at a series of 22 river stations in the Humuya, Sulaco and Yure watersheds. The developing reservoir fishery of L. Yure was also monitored in order to assess the effects of impoundment on a native fish assemblage. Gill netting and electroshocking were the principal methods employed for fish capture. Samples were analyzed for diet, reproductive condition, fecundity and, in some species, growth rates. The latter were determined either using scaled analyses or with the cohort (Peterson) method. Various aspects of the methodologies used in river and lake fishery studies are discussed as part of this report. Regular series of samples from some stations permitted an analysis of seasonal changes in the trophic and reproductive ecology of common fish species.

11.2.1 RIVER FISH COMMUNITIES

A total of 31 species of fish were collected from the El Cajón area, representing 45% of the number recorded from the whole of Honduras during a major survey in 1972. The number of species at any one site is approximately proportional to the size of the river. Smaller streams, like the tributaries flowing into L. Yure, contain about 7 species, whereas the Humuya and Sulaco rivers contain upwards of 20. Thirteen species were recorded from mid-way along the R. Yure. In small and medium sized streams and rivers, over 75% of

total biomass is represented by 3 families: Cichlidae, Pimelodidae and Characidae. The two most abundant cichlids are Cichlasoma spilurum ("congo") and C. motaguense ("guapote"). The first of these is a small species and does not live for more than two years. Its diet consists mainly of the algae growing on rocks. Guapote attain a larger size and feed on aquatic insect larvae and, as adults, on fish. Congos reproduce mainly between December and March whereas most guapote spawn during the wet season. Both produce one to several hundred eggs. Other cichlids present in the lower gradient rivers include two medium sized species, the predaceous C. managuense ("guapote tigre") and the herbivorous C. maculicauda ("boca colorada"). Two smaller cichlids, C. nigrofasciatum and C. robertsoni show an interesting non-overlapping distribution, with the former being found in the R. Sulaco and the latter in the R. Humuya.

Of the two pimelodid catfish species ("bagres"), Rhamdia cabreræ is more common than R. guatemalensis in upland rivers, whereas in lower gradient areas, the dominance pattern is reversed. Both species exhibit similar diets which are based on aquatic insect larvae. R. cabreræ breeds in the dry season and produces fewer but larger eggs than R. guatemalensis which reproduces in the wet season. Both species are nocturnal and are found under boulders and stream banks during the day.

The most common fish in river pools are often the characins Astyanax fasciatus ("sardina") and Brycon guatemalensis ("machaca"). Although very similar in appearance, machacas grow to a considerably larger size than sardinas. Both are omnivorous, but seeds and leaves are especially important food items for adult machacas. Younger stages are insectivorous. Machacas apparently spawn during the dry season and peak reproduction by sardinas occurs in April-June. They both produce several thousand eggs, those of

machaca being larger than sardina eggs.

11.2.2 LAGO YURE FISHERY

Five species of fish were commonly captured in L. Yure and two others were recorded infrequently. Gill net catch per unit effort was low throughout 1980 and 1981 but increased significantly in 1982. This was in part a result of the appearance of Daphnia in the zooplankton community, which resulted in fish feeding to a greater extent in mid-water and at the surface thereby increasing in their susceptibility to gill netting. However, it is also likely that fish populations were increasing in abundance at this time. Gill-netting and electroshocker sampling caught fish almost exclusively in the littoral zone, especially at the mouths of inflowing streams.

The only cichlid species in the lake, Cichlasoma motaguense (guapote), was usually a major component of total gill net catches. As in the riverine populations guapote are omnivorous, but the younger stages feed primarily on insect larvae and zooplankton, and adults are more piscivorous. Guapote reproduce throughout the year in this lake, but peak spawning occurs in the wet season. Growth rates of guapote were estimated by tagging fish and by scale analyses. Both methods produced similar results, indicating that this species grows about 60mm per year. Reproduction first occurs in the second year and males attain a larger size and greater age than females.

The primary zooplankton feeder in L. Yure is the sardina (Astyanax fasciatus), which is the major prey species for adult largemouth bass. Bass were introduced into the reservoir from L. de Yojoa in 1980 and by 1982 were forming an important part of both the experimental and the subsistence fishery catches. Spawning occurs mainly in the first part of the wet season, but mature individuals were taken during most of the year. Bass predation may be causing a reduction in the guapote population of the reservoir.

A reversal in the relative abundance of the two catfish species in L. Yure was documented during the study. Rhamdia cabreræ was dominant in 1980, but by 1982 the dominant catfish was R. guatemalensis, a species more characteristic of larger rivers rather than the upland streams which are the typical riverine habitat for R. cabreræ. Most bagres caught by gill-netting were mature individuals. Reproductive seasonality apparently paralleled that observed in riverine populations of these species. Both catfish feed on benthic invertebrates in L. Yure.

Tepemechin (Agonostomus monticola) were occasionally caught in gill nets. All specimens were taken near stream mouths and most were mature. This species is characteristic of fast-flowing rivers and is probably not a regular inhabitant of L. Yure.

The food base available to the reservoir fish community increased significantly between 1980 and 1982, presumably stimulating fish production. Not only did the large cladoceran, Daphnia, dominate the zooplankton community in 1982 and form the major food item for a significant proportion of the fish community, but also increasing benthic invertebrate populations, associated with the developing plant community, led to substantially higher food abundance.

11.2.3 EL CAJON RESERVOIR FISHERY

The steeply sloping shore-line which will characterize much of the El Cajón reservoir, together with the lake's drawdown regime, will not favor the development of benthic aquatic plant populations and the associated invertebrate communities that serve as an important food resource for many littoral fish species. Cichlids, especially Cichlasoma motaguense, C. nigrofasciatum and C. robertsoni, will be major consumers of the littoral

benthic invertebrate populations, as will the catfish Rhamdia spp. It is anticipated that R. guatemalensis will be much more abundant in L. El Cajón than R. cabreræ.

Detritus will represent an important food resource for a time after impoundment and may be exploited by the cichlid C. maculicauda. No true detritivore exists among the native fish assemblage, however. Brycon guatemalensis will be one of the larger herbivorous species in the reservoir but is expected to be associated primarily with the headwater regions and the inflowing rivers.

A major predator in the new reservoir will be C. managuense and this species could well become an important component in the lake fishery. Adult largemouth bass will likely be an additional important predator in L. El Cajón since it is probable that this species will be introduced into the system either from L. Yure or from L. de Yojoa. Bass juveniles are already present in the upper reaches of the R. Yure.

The development of planktivorous fish populations will be an important factor influencing the overall productivity of the reservoir. Astyanax fasciatus and Melaniris guatemalensis will be the major zooplanktivorous species, but it is uncertain whether they will be abundant in the open water zone of the lake. Cichlid and bass juveniles will also be consumers of zooplankton but will occur primarily in littoral areas. Sampling the pelagic zone of the reservoir in order to monitor planktivorous fish populations will be an important part of the post-impoundment fisheries program and will enable the assessment to be made of the proportion of planktonic primary production that is being converted into fish biomass.

Potential fish yield is difficult to determine with any precision. Nevertheless, a series of estimates are provided and some of the assumptions

inherent in their derivation are discussed. A monitoring program however, is essential to follow the developing fishery and to investigate the species shifts which are predicted in this report. Every effort should be made to integrate the fisheries studies with the post-impoundment limnology program. It may also be beneficial to combine a fisheries management study on L. El Cajón with one for L. de Yojoa, probably in cooperation with other governmental agencies.

Although the El Cajón dam will block the Humuya migration route of Centropomus pectinatus and Pomadasys crocro, it is not anticipated that the impoundment project will have a severe effect on downstream fish communities, especially in the area below the confluence with the R. Ulúa.

El programa de pesca fue diseñado basado en dos objetivos principales:

1) describir la distribución y abundancia relativa de las especies de peces riverinos de la zona El Cajón, y 2) obtener información básica sobre la biología y ecología de las especies principales. Estos datos son utilizados para a) estimar el impacto del proyecto de El Cajón en la fauna nativa piscívora y b) servir como base para las estrategias de manejo de pesca en el nuevo embalse.

El muestreo fue realizado entre los años 1980 y 1982 en 22 estaciones distribuidas en las cuencas del Humuya, Sulaco y Yure. La pesca del embalse de Yure fue también monitoreado para estimar los efectos de éste en la comunidad de peces nativos. Redes agalleras y "electroshock" fueron los métodos principales empleados para la captura de peces. Las muestras fueron analizadas para estudiar la dieta, condición reproductiva, fecundidad y, en ciertas especies, la tasa de crecimiento. Este último fue determinado utilizando los métodos de cohortes de Peterson y análisis de escamas. Parte de este reporte ilustrará varios aspectos de las metodologías empleadas en los estudios de peces dulceacuícolas. Series de muestras regulares de algunas estaciones permitieron un análisis de los cambios estacionales en la ecología trófica y reproductiva de las especies más comunes.

11.2.1 COMUNIDADES DE PECES RIVERINOS

Treinta y un especies de peces se colectaron en el área de El Cajón, el cual representa un 45% del total colectado en todo Honduras durante un muestreo extensivo realizado en 1969 y 1970 (Martín 1972). El número de especies en cada zona de colección es aproximadamente proporcional al tamaño

del río. Las quebradas como los afluentes del Lago Yure contienen cerca de 7 especies, en comparación con los ríos Humuya y Sulaco que contienen más de 20 especies. Trece especies fueron encontradas en la parte media del río Yure. En quebradas y ríos de tamaño pequeño o medio, el 75% de la biomasa total está representada por 3 familias: Cichlidae, Pimelodidae y Characidae. Los cíclidos más abundantes son: Cichlasoma spilurum (congo) y C. motaguense (guapote). El primero de ellos es una especie pequeña y su longevidad es de aproximadamente dos años. Su dieta consiste principalmente de algas que crecen sobre las rocas. El guapote alcanza un mayor tamaño, alimentándose los jóvenes de larvas de insectos acuáticos y los adultos de peces. Los congos se reproducen principalmente entre diciembre y marzo; en cambio la mayoría de los guapotes se reproducen durante la estación lluviosa. Ambos peces producen de uno a varios cientos de huevos. Otros cíclidos encontrados en los ríos con menor pendiente incluyen dos especies medianas, el depredador C. managuense (guapote tigre) y el herbívoro C. maculicauda (boca colorada). Dos cíclidos pequeños, C. nigrofasciatum y C. robertsoni demuestran una distribución segregada, con el primero localizado en el río Sulaco y el segundo en el río Humuya.

Dentro de las especies de la familia Pimelodidae (bagres), Rhamdia cabrerae es más común que R. guatemalensis en las quebradas de altas elevaciones mientras que en los ríos de menor pendiente se observa lo inverso en el patrón de dominancia. Ambas especies exhiben una dieta similar la cual está basada en larvas de insectos acuáticos. R. cabrerae se reproduce en la época seca y produce una menor cantidad de huevos, pero de mayor tamaño, que R. guatemalensis, el cual se reproduce en la estación lluviosa. Ambas especies son nocturnas, encontrándose durante el día debajo de rocas y cerca

de las orillas del río.

Los peces más comunes en las pozas de los ríos son los carácidos Astyanax fasciatus (sardina) y Brycon guatemalensis (machaca). A pesar de su similitud en apariencia, las machacas crecen hasta un tamaño considerablemente mayor que las sardinas. Ambos peces son omnívoros aunque para las machacas las semillas y las hojas son alimentos especialmente importantes. En ambos, los estadios juveniles son insectívoros. Las machacas aparentemente deshovan durante la estación seca ocurriendo la cima de la reproducción de las sardinas entre abril y junio. Ambos producen varios miles de huevos, siendo los huevos de las machacas más grandes que los huevos de las sardinas.

Seis especies de poecílidos (olominas) fueron colectadas en el área de El Cajón, incluyendo una especie aún no descrita capturada en el río Cacaguapa. Todas estas especies son vivíparas y se reproducen durante todo el año. Tres de las cuales comen perifiton y las otras son principalmente insectívoras.

Otras especies de peces presentes en los ríos de El Cajón incluyen Awaous tajasica (guavina), la cual tiene las aletas pélvicas modificadas para succión, probablemente para ayudarse a mantener su posición en corrientes rápidas, Synbranchus marmoratus (anguilla) y Gymnotus cylindricus (señorita). Un pequeño "silverside", Melaniris guatemalensis, fue capturado ocasionalmente. Este es un pez insectívoro en los ríos aunque probablemente será un comedor importante de zooplancton en el nuevo embalse.

Dos especies migratorias fueron encontradas: Centropomus pectinatus (robalo) y Pomadasys crocro. Una tercera especie, Arius melanopus, puede ser migratoria en el sistema Humuya-Ulúa. Este bagre tiene un comportamiento reproductivo muy característico en el cual los machos encuban los grandes huevos y larvas en la boca.

11.2.2 PESCA EN LAGO YURE

Cinco especies de peces fueron capturadas con frecuencia en el lago Yure y otras dos fueron encontradas infrecuentemente. La captura por redes agalleras por unidad de esfuerzo fue baja a través de 1980 y 1981 pero incrementó significativamente en 1982. Esto fue en parte resultado de la aparición de Daphnia en la comunidad del zooplancton, lo cual influyó en que los peces se alimentaran más a menudo en la zona media y superficie incrementando así su susceptibilidad a las redes agalleras. Sin embargo, es probable también que las poblaciones de peces estuviesen aumentando en abundancia en este período. Las muestras con redes agalleras y "electroshock" capturaron peces casi exclusivamente en la zona litoral, especialmente cerca de las bocas de las quebradas afluyentes.

El único cíclido en el lago, Cichlasoma motaguense (guapote), fue generalmente un componente sustancial en las capturas de las redes agalleras así como en las poblaciones riverinas. Los guapotes del lago Yure son omnívoros, los estadíos jóvenes se alimentan primariamente de larvas de insectos y zooplancton y los adultos de peces. El guapote se reproduce a través de todo el año, pero el pico de desove ocurre en la estación lluviosa. Las tasas de crecimiento del guapote fueron estimadas marcando los peces y por análisis de escamas. Ambos métodos produjeron resultados similares, indicando un crecimiento aproximado de 60mm por año y que los machos alcanzan un tamaño más grande y una mayor longevidad que las hembras.

El comedor principal de zooplancton en el lago Yure es la sardina (Astyanax fasciatus), la cual es presa común del los bass adultos. El bass fue introducido al embalse desde el lago de Yojoa en 1980, y para 1982 empezó a formar una parte importante en las capturas experimentales así como en las

capturas de subsistencia. El deshove ocurre principalmente en la primera parte de la estación lluviosa aunque individuos sexualmente maduros se capturaron durante la mayoría del año. La depredación por bass puede haber causado una reducción en la población del guapote en el embalse.

Un cambio en la abundancia relativa de las dos especies de bagre en el lago Yure fue documentado durante el estudio. Rhamdia cabreræ, especie típica de altas elevaciones, fue dominante en 1980, pero para 1982 el bagre dominante era R. guatemalensis, una especie más común en grades ríos.

La mayoría de los bagres capturados en el lago por las redes agalleras fueron individuos maduros. La estacionalidad reproductiva aparentemente se parece a la de las poblaciones riverinas de estas especies. Ambos bagres se alimentan de invertebrados bénticos en el lago Yure.

Los tepemechines (Agonostomus monticola) fueron ocasionalmente capturados en las redes agalleras. Todos los especímenes fueron tomados cerca de la boca de las quebradas estando en su mayoría maduros. Esta especie es característica de ríos de flujo rápido y probablemente no es un habitante regular del lago Yure.

La cantidad de alimento en el embalse disponible para la comunidad piscívora incrementó significativamente entre 1980 y 1982, supuestamente estimulando la producción de peces. El gran cladóceros, Daphnia, dominó la comunidad de zooplancton en 1982 y llegó a constituir el alimento principal para una gran parte de la comunidad. También incrementaron las poblaciones de invertebrados bénticos asociados con el desarrollo de la comunidad de plantas, resultando en un incremento sustancial en la abundancia de alimento.

11.2.3 LA PESCA EN EL EMBALSE DE EL CAJON

Las orillas de pendientes escarpadas las cuales caracterizarán gran parte del embalse de El Cajón, junto con el régimen de "drawdown" en el lago no favorecerán el desarrollo de poblaciones de plantas acuáticas bénticas ni a la comunidad de invertebrados asociados a ellas que sirven como un recurso alimenticio importante para muchas especies litorales. Los cíclidos, especialmente Cichlasoma motaguense, C. nigrofasciatum y C. robertsoni, serán los consumidores importantes de las poblaciones de invertebrados bénticos, así como los bagres Rhamdia spp. Se anticipa que R. guatemalensis será mucho más abundante en el lago El Cajón que R. cabreræ.

El detritus representará un recurso alimenticio importante para el período posterior al embalsamiento y podrá ser utilizado por el cíclido C. maculicauda. Sin embargo ningún detritívoro real existe entre las especies nativas. Brycon guatemalensis será una de las grandes especies herbívoras en el embalse pero se espera que esté asociada inicialmente con las zonas cercanas a los ríos afluyentes.

El depredador principal en el nuevo embalse será C. managuense, especie que podría bien ser un componente importante en la pesca del lago. Los bass adultos serán posiblemente un depredador adicional importante en el lago El Cajón por cuanto es posible que eventualmente sea introducido al sistema, ya sea desde el lago Yure ó lago de Yojoa. Los bass juveniles están ahora presentes en la zona arriba del río Yure.

El desarrollo de una población planctívora será un importante factor que influirá en la productividad integral del embalse. Astyanax fasciatus y Melaniris guatemalensis serán las principales especies zooplanctívoras, aunque es incierto si serán abundantes en las zonas de aguas abiertas en el lago.

Los cíclidos y bass juveniles serán también consumidores del zooplancton pero esto ocurrirá mayormente en las áreas litorales. El muestreo de la zona pelágica del embalse para monitorear las poblaciones de peces planctívoros será una parte importante en el programa de pesca posterior al embalsamiento permitiendo estimar la proporción de la producción primaria planctónica que será convertida a biomasa de peces.

Aunque la captura potencial de peces es difícil de determinar a cualquier precisión, una serie de estimaciones son discutidas. Sin embargo, un programa de monitoreo será seguido esencial para el desarrollo de la pesca y para las investigaciones de los cambios en especies los cuales son predecidos en este reporte. Todo esfuerzo debe dirigirse hacia la integración de los estudios de pesca con el programa limnológico posterior al embalsamiento. Será beneficioso combinar un estudio de manejo de pesca en El Cajón con uno en el lago de Yojoa, probablemente en colaboración con otras agencias gubernamentales.

Aunque la presa de El Cajón bloquee la ruta de migración en el Humuya del Centropomus pectinatus (robalo) y Pomadasys crocro, no se anticipa que el proyecto del embalsamiento tendrá un efecto serio en la comunidad de peces río abajo, especialmente en el área debajo de la confluencia con el río Ulúa. Es posible que especies de peces depredadores serán favorecidas en la zona inmediatamente debajo de la represa debido a la mayor claridad del agua.

FISHERY OF
LAGO EL CAJON

The fishery of the El Cajon reservoir deserves special attention during the post-impoundment program because it should contribute significantly to the well-being of people living in the surrounding area and represents one of the major benefits of the project. Developing a fishery monitoring program and integrating the resulting information with the pre-impoundment data base presented in this report will represent one of the more challenging aspects of the post-impoundment limnology and fisheries program, but one which will certainly pay off in socio-economic benefits. A series of suggested directions for the fishery program to follow is included in the main recommendations section (Section 3) in Vol. 1 of this report. Additional recommendations appear in the present section, which discusses some of the likely characteristics of the El Cajón fishery and, more importantly, attempts to provide a basis for developing the best future management strategies.

11.3.1 COMMUNITY STRUCTURE IN L. EL CAJON

Production in the El Cajón reservoir will in part be influenced by the success of native riverine fish species in adapting to lacustrine conditions. Furthermore, species' relative abundance will be a factor influencing the type of gear most suitable to the reservoir fishery and the extent of management that will be necessary. A number of abiotic and biotic factors will in turn influence species composition but, as with most ecosystems, detailed predictions of likely inter-specific interactions and outcomes are difficult to make and do not represent a substitute for a close monitoring of temporal changes occurring within the community.

The suite of factors potentially influencing a reservoir fish community

Table 11.1: Summary of factors influencing reservoir fisheries.

Tabla 11.1: Resumen de factores influyendo la pesca de embalses.

Change from lotic to lentic conditions:	<ul style="list-style-type: none">-- Habitat preferences/tolerances → influence on reservoir species composition.-- Silt deposition → possible effects on nest sites, eggs, etc.-- Environmental constancy -- fluctuations of physical and chemical environmental parameters, differences between lacustrine and riverine environments → influence on reproductive seasonality and growth rates.
Thermal regime / stratification:	<ul style="list-style-type: none">-- Water temperature → influence on growth rates.-- Oxygen regime → proportion of lake volume that is inhabitable by fish; possibility of fish kills.-- Mixing regime, pelagic primary production → influence on concentrations (densities) of planktonic food organisms → influence on fish production.-- Nutrient status (--see below).
Littoral zone:	<ul style="list-style-type: none">-- Lake morphology → influence on length of shore-line.-- Littoral gradient → influence on development of macrophyte and invertebrate populations; relative importance of littoral vs. pelagic environment; fish species composition; fishery production and technology (eg. ease of beach seining).
Reservoir management regime:	<ul style="list-style-type: none">-- Drawdown → drying-up of invertebrate, periphyton and macrophyte populations → reduced availability of food and shelter; influence on nest sites/spawned eggs.-- Degree of synchrony between seasonal water quality fluctuations and changes in water level -- differences between riverine and reservoir environments → influence on reproductive seasonality, migration patterns, etc.-- Dam discharge regime → influence on reservoir water quality/mixing → influence on primary and secondary(?) pelagic production.
Flooded vegetation:	<ul style="list-style-type: none">-- Detritus → food resource in new impoundment.-- Trees → substrate for periphyton and associated invertebrates → food resource for fish.-- Impacts on methods of fish harvest (eg. feasibility of using gill nets, beach seines and bottom trawls).

Changes in nutrient
status and productivity:

- Influence of flooded vegetation and nutrient leaching from flooded soils.
- Temporal patterns in fish production → management implications.

Zooplankton community:

- Behavior (migration) and size composition of plankton → influence on fish food resource (and vice versa).

Socio-economic factors:

- Movement of fishermen to new reservoir → increase in fishing pressure → management implications.
- Need to adapt fishing methods to lake system.
- Relative importance of fish in local economy.
- Marketing development.
- Involvement/consultation of fishermen in management strategies.

Downstream fishery:

- Barrier effect of dam; availability of other rivers for fish migrations.
 - Influence of water quality (O_2 and H_2S concentrations, temperature) on immediate downstream fish populations.
 - Species tolerances, species shifts, community composition; disease factors.
 - Impact of reduced nutrient/sediment loading on downstream/coastal primary and secondary production.
 - Impact of reduced flooding on fish reproduction, feeding and production.
-

are summarized in Table 11.1. These processes have been the subject of a number of general reviews (e.g. Lowe-McConnell 1975, Goldman 1976, Petr 1978, SCOPE 1972) and, except for the several specific examples which follow, will not be treated here.

As previously discussed in Vol. 1 of this report, the steeply-sloping shoreline of the El Cajón reservoir, together with the drawdown regime, will not favor the development of a well vegetated littoral zone and its associated benthic invertebrate populations (e.g. Hunt and Jones 1972). The importance of benthic invertebrates in the diets of many native fish species is clearly shown in the riverine and L. Yure studies presented in Sections 11.6 and 11.7. Cichlids, especially, are primarily littoral species and most of them rely to some extent on benthic invertebrates. Guapote (Cichlasoma motaguense) were apparently food limited in L. Yure during the first few years after that reservoir's formation. Development of littoral macrophyte and invertebrate populations in L. El Cajón will vary spatially depending on the slope of the shoreline. Abundance of littoral fish species, such as cichlids, will probably also vary in a related way as was seen in L. Yure and has been shown for other tropical reservoirs (e.g. L. Kariba; Mitchell 1976). Flooded trees will be an additional factor influencing fish distribution since they can act as a substrate for the development of periphyton and associated invertebrates (e.g. Petr 1970) as well as potentially acting as an "anchor" for populations of floating aquatic macrophytes.

A predicted trophic network for the El Cajón reservoir is presented in Fig. 11.1. It is based on information presented in Sections 11.6 and 11.7 of this report and is intended to summarize likely trophic interactions in a general way, but does not provide a detailed account of the food chain in the

new reservoir. Most fish species in the El Cajón area are fairly "plastic" in terms of their feeding habits (i.e. they can take a broad range of food items) and thus are well suited to the changing food environment of a new impoundment.

A major food resource in new reservoirs is detritus which derives from flooded vegetation. Detritus often plays an important role in supporting the characteristic peak fish populations of new reservoirs (e.g. Ita 1976). True detritivores are not represented in the fish communities of the El Cajón area, but the cichlid Cichlasoma maculicauda (boca colorada) feeds on macrophytes (seeds and other parts of terrestrial plant species). C. robertsoni also appears to use detritus and C. spilurum (congo) feeds primarily on periphyton (attached algae). These species, especially C. maculicauda, are likely to benefit from the newly flooded vegetation in the El Cajón reservoir. In addition, allochthonous organic material entering the reservoir via rivers will continue to represent an important food source for species like C. maculicauda and Brycon guatemalensis in the upper reaches of the reservoir. The success of this latter species in the new lake, however, is uncertain since Brycon (machaca) tend to be found in faster flowing water where they feed on insect and plant material drift, as juveniles and adults respectively. Adults will probably also utilize the reservoir's detritus food base.

Several cichlid species, especially C. nigrofasciatum, C. motaguense and the younger age classes of C. managuense will, as noted above, depend primarily on benthic invertebrates, as will the catfish Rhamdia. If a largemouth bass population becomes established in the reservoir, juveniles of this species will also utilize benthic invertebrate production to some extent. Based on the present distribution of Rhamdia spp. in the El Cajón area and on

the species shift observed in L. Yure, it is probable that R. guatemalensis will be considerably more abundant in the El Cajón reservoir than R. cabreræ. Both will likely be more abundant near the mouths of inflowing streams. The mouth-brooding catfish, Arius melanopus, may also become a significant consumer of benthic invertebrates if a population is able to maintain itself in the reservoir. As discussed in Section 11.6.2.8, however, Arius appears to be migratory in the Humuya/Ulúa system and thus its future in L. El Cajón is uncertain. Nevertheless, a population of a related species, A. taylori, does exist in at least one other Central American reservoir, Lago 5 de Noviembre in El Salvador (Serruya and Pollinger 1983). Even if Arius is able to establish a breeding population in L. El Cajón, it is unlikely that it will represent an important component in reservoir fish harvests because of its low fecundity. Females of this species typically contain only about 20 mature eggs (see Fig. 11.39).

Poeciliids in the El Cajón area include both herbivorous and insectivorous species. It is likely that the former group (especially Poecilia mexicana) will predominate in the new reservoir, but the populations may be kept at very low levels by predation, as has been observed in the L. Yure system (Sections 11.6.2.5 and 11.7).

Of the native piscivorous species, Cichlasoma managuense will probably become a major predator in the new reservoir. Based on experience in other lakes, a comparison of the diets of riverine populations and the relative distribution of the two species, C. motaguense is likely to be rather less important in L. El Cajón. A related guapote, C. dovii, forms a major component of the commercial fishery in L. Arenal, a large hydroelectric impoundment in Costa Rica (W. Bussing, personal communication). A second

predator species which could be important in L. El Cajón is the dormilón (Gobiomorus dormitor). This eleotrid species was not recorded in river samples collected from the El Cajón watershed during the present study, but is present in L. de Yojoa and was taken from the R. Varsovia, just downstream from the Varsovia diversion dam. Dormilón were introduced into L. Yure from L. de Yojoa in May 1980 (according to local fishermen). This introduction does not appear to have been successful, however, since only one dormilón was caught in L. Yure during the entire fishery monitoring program and local fishermen were unaware that this species still existed in the reservoir. The one specimen taken was a male measuring 256mm S.L. and its stomach contained guapote remains. Dormilón usually do not represent a major proportion of the L. de Yojoa commercial harvest but are probably an important component structuring the lake's fish community.

In addition to native predator species, the largemouth black bass is very likely to become one of the major predators in the El Cajón reservoir. Its intentional introduction into this lake is not recommended, at least for a period of 5-6 years. However, the presence of juvenile bass in the upper reaches of the R. Yure (presumably having "escaped" from L. Yure via spillway discharge) and the relative proximity of source populations in L. Yure and L. de Yojoa mean that introductions of bass into the El Cajón reservoir will be almost inevitable. Based on experience from L. Yure, bass will probably be very successful in L. El Cajón, although the reservoir population will likely decline from a peak occurring after the bass become established. This is a pattern frequently observed in other reservoirs (Moyle 1976). Juvenile bass will probably depend primarily on zooplankton in L. El Cajón (see below), but intermediate and perhaps adult size classes will compete with cichlids and

other native species for the benthic invertebrate food resource. The largemouth bass is economically very important in many N. American reservoir fisheries and in L. de Yojoa it forms the base of the commercial fishery. Since the larger size classes are piscivorous, however, bass represent a relatively inefficient way of producing protein, a factor which should be considered in planning management strategy for the El Cajón fishery. Furthermore, the impact of bass on the native fish assemblage is often severe, as suggested by species shifts in L. de Yojoa (Cruz 1979a) and L. Atitlán (Carlander 1975; Serruya and Pollinger 1983) following bass introductions.

Zooplankton represent a potentially major food resource in the El Cajón reservoir, and its efficient utilization by fish will be important in determining overall fish production levels in this system. Of the native fish species present in the rivers of the El Cajón watershed, two are likely to be zooplanktivorous in the new reservoir, Astyanax fasciatus (sardina) and Melaniris guatemalensis. Juveniles of other species, for example guapote and bass, will also feed on zooplankton. Astyanax is an important zooplanktivore in L. Yure and in other Central and South American lakes (Bussing 1976; Deevey, Deevey and Brenner 1980; Barbosa and Matsumura-Tundisi 1984). Melaniris spp. are also important consumers of zooplankton, for example in lakes of the Petén region of Guatemala (Deevey, Deevey and Brenner, 1980) and in Gatún Lake, Panama (Zaret 1971, 1972). In Gatún Lake, adult Melaniris are found only in littoral areas, but juveniles inhabit the pelagic zone. In the post-impoundment fisheries program special effort should be devoted to the investigation of the ecology of Melaniris, in view of its potentially significant role in the lake's food chain. Mid-water trawling, or at least horizontal and vertical tows with a coarse mesh, large diameter plankton net,

should be used to sample the open water population of Melaniris.

Although they will be important planktivores in the El Cajón reservoir, Astyanax and Melaniris are not truly pelagic species since they are littoral spawners and are often associated with the littoral zone even when not spawning. Members of the shad family (Clupeidae), however, are primarily open water species, although they often spawn in shallow water (Eddy and Underhill 1974). They possess a very fine gill raker structure adapted for plankton feeding and are important prey fish in many lakes and reservoirs of N. America. Although no clupeid species has been recorded from the El Cajón region, the genus Dorosoma is present in L. Managua and in some Guatemalan lakes (Deevey, Deevey and Brenner 1980; Miller 1966). In L. Managua, D. chavesi is the most abundant fish in gill net samples (Serruya and Pollinger 1983). If none of the species native to the El Cajón area efficiently exploit the pelagic niche of the new reservoir, the introduction of Dorosoma sp. might be advisable. It should be emphasized, however, that no introductions of exotic species should be considered until 1) the reservoir fishery has reached a "stable" phase, approximately 4-8 years after dam closure and, 2) detailed ecological analyses of the native reservoir species have been undertaken. One exception would be the "seeding" of L. El Cajón with Daphnia. Although this cladoceran will possibly colonize the new reservoir within a few years in any case, the early development of an abundant population of this large cladoceran would promote the production of planktivorous fish, as has been seen in L. Yure.

A further species which might be considered for introduction is Cichlasoma urophthalmus. This is the "carpa" of L. de Yojoa and, although it was not recorded from any of the rivers sampled during the present program, it

is present in the Ulúa and Chamelecón systems (Martín, 1972). It is an omnivorous species and grows to a good size (over 1 kg) in L. de Yojoa. If it appears that the food base in the El Cajón reservoir is adequate, C. urophthalmus might represent a valuable future addition to the fishery.

Apart from the largemouth bass, there are at least two other exotic species present in the El Cajón watershed which may develop significant populations in the new reservoir. The channel catfish (Ictalurus punctatus) was occasionally caught in gill net sampling in the R. Humuya. Although primarily an inhabitant of larger rivers, it is an important component in many N. American reservoir fisheries and has high food value. It is among the most important species for aquaculture. Channel catfish exhibit relatively high growth rates (Moyle 1976), are typically omnivorous, and can be maintained at high density. The specimens taken from the R. Humuya were feeding on aquatic insects, and some plant material, as well as Brycon, Cichlasoma and Rhamdia. The individuals caught in the R. Humuya presumably represented fish which had escaped from culture ponds in Honduras.

Tilapia (Sarotherodon mossambicus) juveniles were also taken from the R. Humuya. This species was introduced into L. de Yojoa several years ago and now forms a major component of the commercial harvest there. In addition to the S. mossambicus juveniles just mentioned, one adult individual of S. niloticus was also captured in the R. Humuya. This species is a tilapia which feeds on phytoplankton and can digest blue-green algae (Moriarty 1973) which most fish are unable to assimilate (Moriarty 1973). Because it is apparently already present in the Humuya system, even though in low abundance, it may become a significant component of the reservoir community. Since it is herbivorous, it would of course represent a relatively efficient link between

Plate 1: Channel catfish (Ictalurus punctatus)

-- an exotic species present in the R. Humuya.

Foto 1: El bagre "channel catfish" (Ictalurus punctatus)
una especie introducida que se encuentra en el
río Humuya.

reservoir pelagic primary production (phytoplankton) and fish biomass.

11.3.2 FISH PRODUCTION

A good prediction of the productivity of a reservoir fishery is almost impossible, especially where a series of production values for other similar lakes is unavailable. A number of production and biomass estimates, however, are presented in Table 11.2. These are all very approximate and three of them are based on regressions which have been derived from either N. American, Indian or African data sets. The estimates should therefore be taken only as indicators of likely fish standing crops and potential yields.

The morpho-edaphic index (Ryder 1965; Ryder et al. 1974; Henderson et al. 1973) is calculated from total dissolved solids and mean depth and has been widely used to predict fish yields from lakes in various parts of the world. The assumptions inherent in the use of the MEI are thoroughly discussed in the references just cited and will not be reviewed here. It should be noted, however, that the MEI-fish yield relationships are valid only for homogeneous sets of lakes and thus the use of N. American reservoir regressions is at best an approximation. Probably the more satisfactory estimate in Table 11.2 is the one based simply on trophic transfer efficiencies. Annual primary production estimates for L. Yure and L. de Yojoa are very similar (see Tables 7.10 and 8.5, Vol. 1), and an average of the two has been used here as a prediction of primary production in the El Cajón reservoir. Third trophic level fish production (ie. assuming all fish to be zooplanktivorous, for example) is estimated at 3680 tonnes/year. Assuming a 10% transfer efficiency between third and fourth trophic levels (the true efficiency of piscivorous species is often higher), the production of third trophic level fish is about 370 tonnes/year, very similar to the commercial fish harvest prediction based

Table 11.2 : Fish production and biomass estimates for L. El Cajón, L. Yure and L. de Yojoa.

Tabla 11.2 : Estimaciones de productividad y biomasa de peces para los lagos El Cajón, Yure y Yojoa.

	L. El Cajon	L. Yure	L. de Yojoa
MEI (a)	2.6	2.3	10.4
Total Fish Biomass (tonnes) (b)	1003	6	2147
---Reservoir MEI estimate			
Bass harvest (potential) (tonnes/year) (c)	47.5	0.3	61.0
---Reservoir MEI estimate			
Commercial fish harvest (potential) (tonnes/year) (d)	358	2	346
---Melack primary production regression			
Total fish production (tonnes/year) (e)	3680	22	3520
---Trophic level estimation			

Notes

- (a) Morpho-edaphic index = Total dissolved solids (mg/l) / Mean depth (m)
(TDS estimated from conductivity data using a conversion factor of 0.65; Schlesinger and Regier, 1982).
- (b) Estimate of total biomass (standing crop) based on relationship with MEI in N. American mainstream reservoirs (Jenkins 1982): $\log_{10} B = 1.759 + 0.713 \log_{10} \text{MEI} - 0.093 \log_{10}^2 \text{MEI}$. (Storage reservoir relationship used for L.de Yojoa).
- (c) Estimate based on relationship between MEI and largemouth bass harvest in N. American reservoirs (Jenkins 1982): $\log_{10} H = 0.516 + 0.582 \log_{10} \text{MEI} - 0.259 \log_{10}^2 \text{MEI}$.
- (d) Relationship between average daily gross primary production (PG) and commercial fish yield (H), derived by Melack (1976): $\log_{10} H = 0.122 \text{PG} + 0.95$. Average daily net primary production assumed to be $400/365 = 1.1 \text{ g C m}^{-2} \text{ d}^{-1}$ for all 3 lakes (see vol. 1). Photosynthetic quotient of 1.2 used to convert production data to $\text{mg O}_2 \text{ m}^{-2} \text{ d}^{-1}$. Gross photosynthesis assumed to be 4X net photosynthesis (Melack 1976).
- (e) Total fish production (not harvest) at primary carnivore level from annual primary production estimates and assuming a 10% transfer efficiency between trophic levels. Carbon contents of fish assumed to be 10% of net weight (Gulland, 1970).

on Melack's (1976) regression of yield and primary production. It should be noted that commercial fish harvest will usually be somewhat less than 50% of the total fish production within a system.

The actual amount of fish produced within a lake depends in part on how much of the pelagic primary production is utilized. In reservoirs with short retention times, a significant amount of synthesized organic matter can be lost from the system via discharge from the dam. Further, drawdown may strand a significant part of the periphyton and invertebrate production along the steep sides of the reservoir. In both man-made and natural lakes, the abundance and perhaps the feeding efficiency of planktivorous fish species are important factors influencing the proportion of pelagic primary production that is transferred to fish (Hecky et al. 1981). The role of pelagic planktivores in the El Cajón reservoir has been discussed above and an investigation of their biology and ecology in the new system should form an essential part of the post-impoundment fisheries program.

Although prediction of absolute fish production in L. El Cajón using the MEI is difficult, the index can often be used on a monitoring basis to predict changes in yield. In the Volta Reservoir in Ghana, for example, MEI changes provided a good estimate of the change in fish yield one year in advance of the actual harvest (Ryder et al. 1974). Such predictions can represent a valuable tool in reservoir fishery management.

Regardless of absolute levels, the initial pattern of fish production in L. El Cajón will probably resemble that seen in many other reservoirs, i.e. an increase during the first few (2-4) years following impoundment, followed by a decrease and final "stabilization" at some intermediate level. There will of course be fluctuations, to a greater or lesser degree, around this

"stable" level. A well designed fisheries management strategy will follow these changes in fish production and fish harvest and decide upon any regulations and stocking strategies necessary to maintain yield at a maximum (see below).

11.3.3 DOWNSTREAM FISHERY

Impoundment projects can have a major impact on fish communities downstream from the dam wall. While the role of the Aswan high dam in reducing nutrient concentrations in the R. Nile, in turn leading to a drastic reduction in the sardine fishery of the eastern Mediterranean, is one of the classic examples of the impacts of large dams (Ben-Turfa 1973; George 1972), downstream effects are not always so extreme. Still, they have been well documented for many impoundment projects and include various impacts on production levels (eg. Shaheen and Yosef 1979; Lawson 1963), reproduction (Khoroshko, 1972), species diversity (Edwards 1978), migration patterns (Raymond 1979), and fish health (Grizzle 1981).

It is unlikely that impacts of the El Cajón reservoir on downstream fish communities will be severe. The R. Ulúa does not have an extensive flood plain (which is inundated annually) and so there are presumably no marked lateral fish migrations to be disrupted by a reduction in maximum river discharge rates resulting from the El Cajón project. The R. Ulúa, which joins the R. Humuya (Comayagua) downstream from the dam site, will help to buffer the impact of El Cajón on the lower Ulúa, both in terms of nutrient/sediment transport (see Section 6, Vol. 1) and by providing a continued route for migratory fish species.

Subtle changes in the downstream fish community, especially along the

stretch of river between the dam wall and the Ulúa confluence, are expected but they are difficult to predict in detail. Water transparency will be increased below the dam during part of the year and accumulations of fish will probably occur there as individuals moving upriver find their passage blocked. Predatory species are likely to be especially important in this region as the water clarity increases. Sampling effort directed to this area will provide very useful information on riverine fish stocks and invertebrate populations. The principal migratory species in the El Cajón area are Centropomus pectinatus (robalo), Pomadasys crocro and, perhaps, Arius melanopus (note, however, that migratory behavior was not conclusively demonstrated in the pre-impoundment studies). If, as is suggested by the present data base, these species move upstream in the dry season, then it is unlikely that many will remain in the reservoir area after dam closure (June). Thus the future existence of these species upstream from the dam site would appear to be extremely unlikely.

11.3.4 RESERVOIR MANAGEMENT STRATEGIES

The fish production of L. El Cajón will be of most use to those people living in reasonably close proximity to the lake, although a sports fishery may eventually develop. Exploitation of the fishery may not be very intensive, at least in the initial stages, and a basic monitoring program combined with a series of investigations into the biology and ecology of important species, will help to ensure that the maximum long term benefits are derived from the new food resource represented by the reservoir fishery. A series of recommendations for the fisheries program has been provided in Vol. 1 of this report and should be reviewed in the light of this volume. Fig. 11.2 describes a monitoring/research framework which should provide the

SAMPLING

11-33

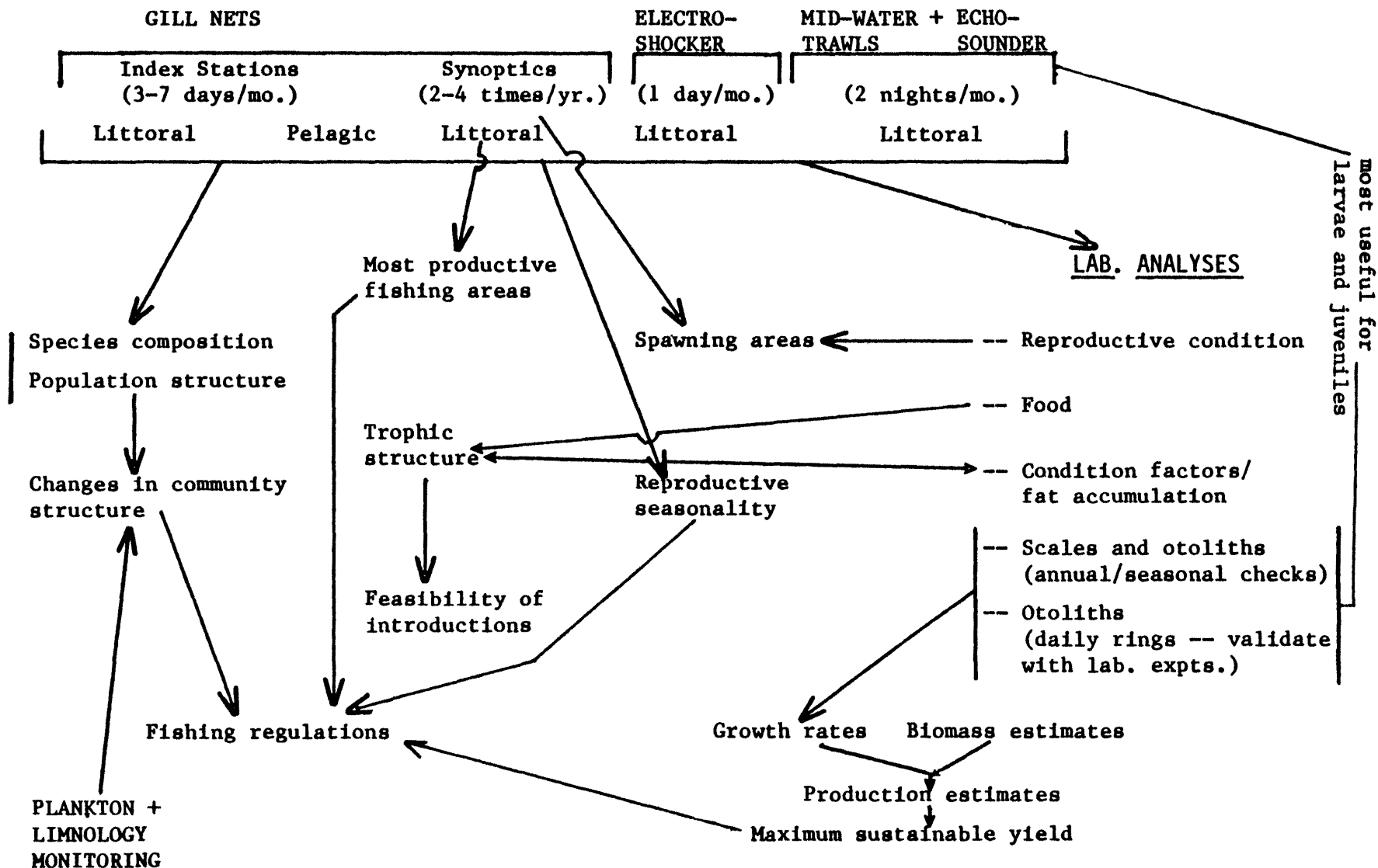


Figure 11.2: Summary of a program for research and management in the El Cajón reservoir.

Figura 11.2: Resumen de un programa de investigación y manejo en el embalse de El Cajón.

necessary information base to enable informed advice to be given and decisions to be made on how best to manage the new lake fishery. Publications such as Bagenal (1978) and Gerking (1978) provide considerably more detail on aspects of fishery management than can be discussed here.

Much of the fishery monitoring program can be carried out in conjunction with the post-impoundment limnology program. An integration of the two will be highly beneficial, not only in terms of the El Cajón system, but also within the context of future impoundment projects in Honduras. An alternative approach to the fishery program would be to combine it with one designed to study fish production and yield patterns in L. de Yojoa. The fishery of this lake is a very valuable one and it is possible that maximum sustainable yield could be higher than the present harvest rates. Integration of Yojoa and El Cajón fisheries development programs, presumably in collaboration with the Dirección de Recursos Naturales, would allow the most constructive use of equipment, financial resources, manpower and expertise. The fisheries of both lakes could benefit from a coordinated effort based on the data already available from this investigation. The long term value in terms of protein production and commerce in sport and fish products can provide one of the more important benefits to the people of Honduras from the construction of El Cajón high dam.

PRE-IMPOUNDMENT

STUDIES

Fish sampling was carried out at a total of 22 river stations on the Humuya, Sulaco and Yure rivers. These stations are shown in Fig. 11.3 and Table 11.2. As previously discussed in Section 4.3.3 (Volume I), the fish sampling program was designed to provide 1) a distributional analysis of the fish fauna of the El Cajón and 2) a detailed documentation of the feeding and reproductive ecology of important species. In order to achieve these objectives, a few stations (R. Yure at Yure, the Yure and Humuya rivers at their confluence, L. Yure) were sampled repeatedly, whereas other stations were visited once or twice. With the extensive demands of the Limnology and Fisheries Program, it was obviously not possible to obtain complete temporal series of samples from the entire range of sampling sites.

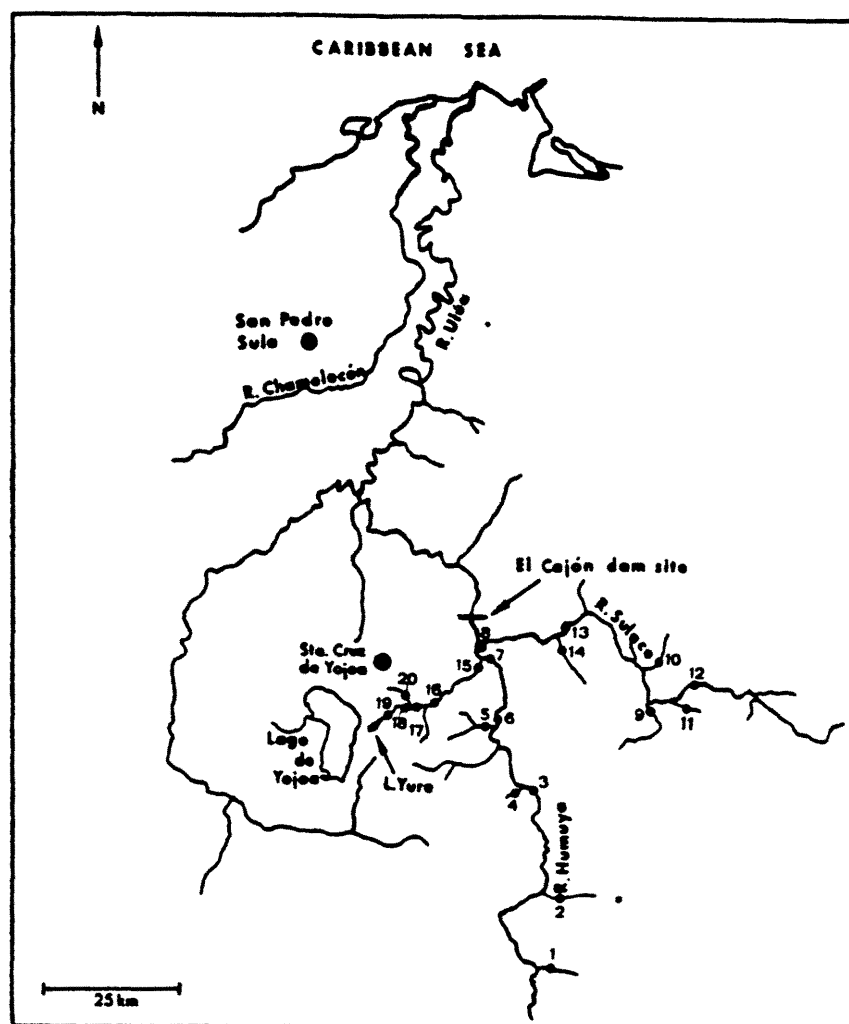
The substrate at most of the river sampling stations reflected high current velocity and was composed primarily of cobbles and boulders (see Hynes [1970] for the terminology employed in substrate description), although larger areas of the main Humuya and Sulaco channels had a sand/gravel substrate. The rocky nature of river channels often made sampling relatively difficult (see Methods Section 5.2.4.1, Vol. 1).

The seasonal variation in river discharge, turbidity and other water quality parameters was less for the R. Yure than for the Humuya and Sulaco rivers. Environmental fluctuations, especially of water velocity and turbidity, are often important structuring forces for riverine fish communities, in terms of both direct effects such as washouts and indirect effects like food resource availability. Reference is made to Section 6 and Appendix 2 in Vol. I of this report, where seasonal variation in water quality is discussed in detail.

Table 11.3 : River stations sampled for the fisheries program.

Tabla 11.3 : Las estaciones de los ríos muestreadas en el programa de la pesca.

	<u>River</u>	<u>Station</u>	<u>Station #</u> (Fig. 11.3)
<u>Humuya watershed</u>	Chiquito	Comayagua	1
	Cacaguapa	Comayagua-La Libertad road crossing	2
	Humuya	Ojos de Agua	3
	Q. Agua Caliente	nr. Ojos de Agua	4
	Q. de Chamo	Confluence with R. Humuya	5
	Humuya	Confluence with Q. de Chamo	6
	" "	Confluence with R. Yure	7
	" "	Confluence with R. Sulaco	8
<u>Sulaco watershed</u>	Canquigue	Confluence with R. Sulaco	9
	Jacagua	Victoria-Las Vegas road crossing	10
	Colorado	Minas de Oro-Victoria road crossing	11
	Sulaco	nr. Victoria	12
	" "	nr. Salitrón Viejo	13
	Yunque	Confluence with R. Sulaco	14
<u>Yure watershed</u>	Yure	Confluence with R. Humuya	15
	" "	Yure	16
	" "	Las Delicias	17
	" "	San Bartolo	18
	" "	L. Yure dam	19
	Q. Agua Amarilla	San Isidro-Yure road crossing	20
	Q. Sin Nombre	L. Yure	21
	Q. del Cerro	L. Yure	22



KEY:

- | | |
|--|------------------------------|
| 1: R. Chiquito at Comayagua | 15: R. Yure at Humuya confl. |
| 2: R. Cacaguapa | 16: R. Yure at Yure |
| 3: R. Humuya at Ojos de Agua | 17: R. Yure at Las Delicias |
| 4: Q. Agua Caliente | 18: R. Yure at San Bartolo |
| 5: Q. de Chamo | 19: R. Yure at Yure dam |
| 6: R. Humuya at Q. de Chamo confluence | 20: Q. Agua Amarilla |
| 7: R. Humuya at Yure confluence | |
| 8: R. Humuya at Sulaco confluence | |
| 9: R. Canquigue | |
| 10: R. Jacagua | |
| 11: R. Colorado | |
| 12: R. Sulaco at Victoria | |
| 13: R. Sulaco at Salitrón Viejo | |
| 14: R. Yunque | |

Figure 11.3: Map of the El Cajón area showing stations sampled during the fisheries program.

Figura 11.3: Mapa del área de El Cajón mostrando las estaciones muestreadas durante el programa de pesca.

In order to gain insight into the developing fishery of a dendritic reservoir in the El Cajón area, L. Yure was routinely sampled between 1980 and 1982. Catch per unit effort was generally low in this lake. In order to obtain adequate sample sizes, sampling was concentrated on those areas likely to produce the best catches. Without exception, these areas were along the shore-line, especially near the mouths of the inflowing streams. Open water and deep water gill net sets usually caught nothing. Most of the reservoir's perimeter was sampled during the course of the study. The stations (Fig. 11.4). were between 2 and 15 m from the shore and generally were less than 4 m deep.

The littoral region of L. Yure is for the most part steeply sloping (see Fig. 7.2, Vol. 1) and the substrate is composed primarily of a silty clay. Benthic plant populations, mainly composed of the macroalga Chara sp., developed during 1982, occurring at depths less than 1 m (Fig. 7.4). The depth of the euphotic zone, taken as the depth at which 1% of surface light was present, varied between about 2 and 6 m in L. Yure (Fig. 9.1). The water column of this reservoir was anoxic below about 8 m for approximately 9 months of each year (February - November, Fig. 7.14). Thermocline depression, leading in December to eventual turnover of the water column, was a relatively gradual process in L. Yure. Because of this, significant reduction in surface dissolved oxygen concentrations was never observed as it occasionally was in L. de Yojoa. These and other aspects of the limnology of L. Yure are extensively discussed in Section 7, Vol. 1 of this report.

LAGO YURE

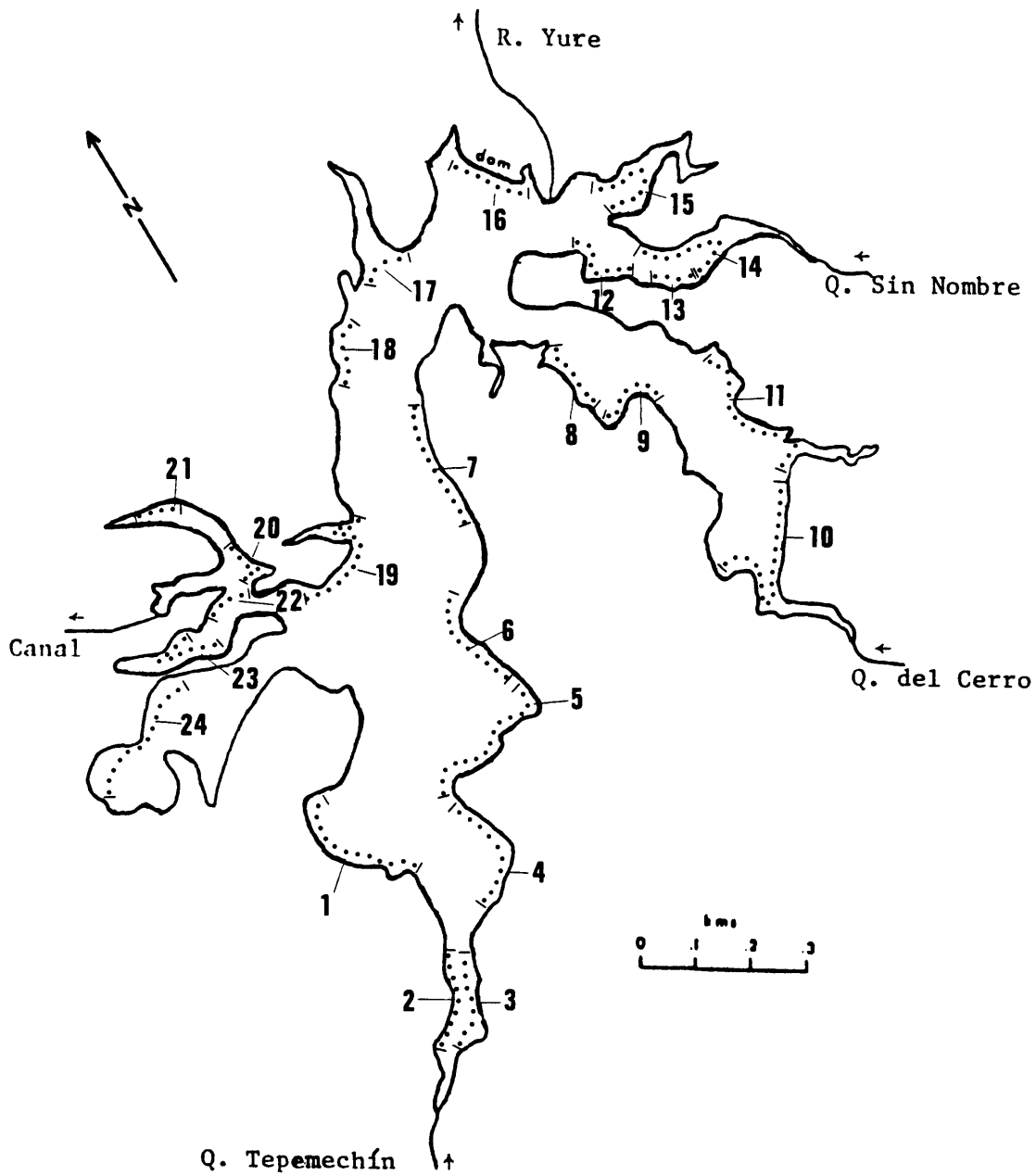


Figure 11.4: Map of L. Yure showing gill-netting stations.

Figura 11.4: Mapa del lago Yure ilustrando las estaciones muestradas con redes agalleras.

Sampling and analytical methodology used in the fisheries studies has already been discussed in the comprehensive methods section of this report (Section 5, Vol. 1). In the present section, a more detailed discussion is provided of certain aspects of the methodology in order to emphasize those problems and restrictions inherent in this type of fisheries work.

11.5.1 SELECTIVITY OF SAMPLING GEAR

Most types of fishing gear are selective, ie. they catch more of some size classes than of others (see, for example, the reviews of Ricker [1975] and Lagler [1978] and references cited therein).

The majority of the sampling at river stations had to be carried out with an electroshocker because the rocky nature of the substate prohibited the use of seines. Electroshocking was limited to areas less than about 1.5 m deep and probably did not provide a representative sampling either of larger fish (>~250 mm standard length) or of those species which are fast swimmers (for example, the characins Astyanax and Brycon). In addition, larval stages are assumed to be under-represented in the samples. For the purposes of the present study, however, especially the repeated sampling of R. Yure at Yure and the L. Yure perimeter, electroshocking provided an adequate sample series. The occasional use of small explosive charges in pools of the R. Yure allowed some "calibration" of the electroshocking technique, the results of which will be discussed in Section 11.6. Although not used in the present study, perhaps the most effective method for electroshocker calibration involves the closing off with nets of a section of river. The enclosed area is then sampled repeatedly with an electroshocker (eg. Mahon et al., 1979), with all captured

fish being removed from this area. Finally, a fish toxin such as rotenone is applied to the sampled area to enable the capture of all remaining individuals. The rotenone catch composition is then compared to the electroshocker catch composition and the relative selectivity of the latter method is calculated for that stretch of stream. It may be possible to divert the treated water by pumping it off at the lower end in order to reduce the killed zone. In any future study of the riverine fish communities of the El Cajón area, especially any investigation into levels of fish production, it would be advisable to carry out this calibration procedure.

Sampling bias is especially significant with gill-netting. Graded fleets of gill nets were used in the studies on L. Yure in order to reduce the problem of gear selectivity. Net specifications appear in Table 5.3 (Vol. 1, p. 5-108). The true selection curve of a gill net can only be calculated when the actual size frequency distribution of the sampled fish community is known. One method to obtain a quantitative estimate of gear selectivity is to release marked fish into the population and record their subsequent re-captures in gill nets of various mesh sizes (Lagler 1978). This was outside the scope of the present L. Yure fisheries study. However, a record was kept of the size of fish caught in specific mesh sizes. Data are presented in Appendix 1. Since these data were only collected during the second half of the study there are insufficient points to allow selection curves to be fitted for several species/mesh size combinations. The information in Appendix 1 is therefore given in terms of raw numbers. The data suggest that the graded fleet of gill nets used in L. Yure was capable of sampling the entire size range, above a certain minimum size, of Rhamdia, Cichlasoma and Micropterus. Selectivity was greatest for Astyanax, which was to be expected from the shape of this species

and its lack of spines. Since the main objective of the reservoir fishery study was to document temporal changes in reproductive and feeding ecology, net selectivity was not evaluated as a critical factor. Larval and fingerling stages were insufficiently sampled in the present study and it would certainly be advisable to invest additional effort during future studies of the El Cajón fishery in order to better understand the ecology of these important life history stages. Similarly, in any future, detailed, investigations of the population structure, dynamics and production of the El Cajón reservoir fishery, it will be important to more fully document gill net selectivity.

11.5.2 AGE AND GROWTH

Scales: Scales, otoliths, vertebrae and spine sections are the hard parts of fish most commonly used for age and growth determinations. In the present study, the scales of a number of species were examined for growth checks. Scales were removed from an area just above the tip of the pectoral fin and below the lateral line, in fish possessing ctenoid scales. In species with cycloid scales, they were removed from above the lateral line, just anterior to the dorsal fin. Otoliths were also examined, but no annular markings were evident. Vertebrae and spine sections were examined occasionally but no clear markings were observed.

Growth checks on scales derive from the pattern with which circuli, or ridges, are laid down as the scales grow and may take a variety of forms. For example, a check may be represented by the zone where a series of closely-spaced circuli is followed by a zone of widely-spaced circuli. Widely-spaced circuli correspond to periods of more rapid growth. Alternatively, a growth check may be indicated by circuli either becoming very discontinuous or

"crossing over". This is especially common with ctenoid scales. Examples of growth checks are presented and discussed in Section 11.7. Good reviews of the scale method for age determination are given by Bagenal and Tesch (1978), Lagler (1956), Everhart and Youngs (1981) and Bagenal (1974). Before using this methodology, the following conditions must be satisfied (Everhart and Youngs 1981).

- a) The number of scales on the fish must remain constant throughout its life.
- b) Scales used for age determination must not be regenerated.
- c) Scale growth must be proportional to body growth.
- d) The time of annulus (or growth check) formation must be known.

This is especially important for tropical species where reduced environmental seasonality decreases the chances of observing distinct annular (yearly) growth checks. In the present study, series of scale samples were taken throughout the year in order to demonstrate the timing of check formation. Growth checks which occur at non-yearly or irregular intervals (so-called "false" growth checks) may be an added complication in age determination, depending on whether or not these checks can be distinguished from the regular annular (or some other periodicity) checks.

If scales (or other hard parts) can be reliably used for age determination, then growth rates may be estimated by back-calculation of fish length at previous ages (i.e. lengths when previous growth checks were laid down). Distances along a diagonal of the scale are measured from the scale center, or focus, to each annulus. If the relationship between scale radius and fish length is linear with the intercept at the origin, the following

formula is used to calculate fish lengths corresponding to any scale radius (Bagenal and Tesch 1978).:

$$L_n = \frac{S_n}{S} L$$

where L_n = length of fish when growth check "n" was formed

L = length of fish at time scale sample was taken

S_n = radius of growth check "n"

S = total scale radius

In cases where the intercept of the body:scale relationship is not at the origin, the above equation is modified as follows:

$$L_n - a = \frac{S_n}{S} (L - a)$$

where a = intercept value on the length axis.

These formulae can be further modified for cases where the body:scale relationship is not linear. Back-calculation of length and growth rate estimation will be illustrated in Section 11.7 for cichlids of the Yure system.

Cohort Analysis: The basis for cohort analysis (Peterson method) has been summarized in Section 5.2.4.3b, Vol. 1, p. 5-114). Briefly, it depends on a sequential series of samples documenting the increase in length through time of a cohort, i.e. a group of individuals of similar age and size. Cohorts are most easily distinguished in species which have a relatively short spawning season.

A major problem with the Petersen method is that older cohorts tend to become less distinct as mortality decreases the numbers of the older size-classes and as growth rates decline with age. The method also assumes that 1) there is no immigration or emigration from the population being sampled and 2) there is no differential mortality within a cohort (for example, smaller

individuals of a year class experiencing higher death rates).

Cohort analysis has been infrequently used for tropical fish species because spawning is often less restricted relative to the situation for temperate species. However, the method was applicable to two species in the El Cajón area (Cichlasoma spilurum and Rhamdia cabreræ) which are not year-round spawners. Data from these species further illustrate the Petersen method and are discussed in Section 11.6.

"Daily" Growth Rates: Two methods are available which potentially enable a much finer temporal discrimination of growth rates. These methods were not used in the El Cajón study, but reference is made to them here since they may be valuable techniques for any future fisheries work on the El Cajón reservoir or other freshwater systems in Honduras.

The first of these methods involves the study of otolith micro-structure (Pannella 1971, 1980; Volk et al., 1983; Taubert and Coble 1977). When otoliths are ground to thin sections and observed with light or scanning electron microscopy a pattern of fine concentric rings is often observed (rings are often about 2 μ m wide). In a number of species, these rings have been shown to correspond to daily growth increments in the otolith. In these cases, individual fish (especially larvae and young of the year, since rings in older fish tend to become less distinct) can be assigned an age in days. Thus a much finer resolution of growth rates at various life history stages is possible. However, it must be emphasized that the timing of these fine growth increments must be ascertained before the method is used, as they cannot simply be assumed to represent daily increments.

The second method for obtaining a finer resolution of growth rates involves the uptake of radioactively labelled glycine (Ottaway and Simkiss

1977; Dentler 1980; Smagula and Adelman 1982). The technique is based on the following observations:

- 1) As scales grow, they take up glycine for the formation of collagen, which is a major structural component of scales.
- 2) Scales continue to take up glycine for a period after they are removed from the fish.
- 3) The amount of glycine taken up by a scale has been shown for some species to be proportional to the growth of the scale and, in turn, the growth of the fish.

This ^{14}C -glycine uptake methodology therefore potentially enables an index of instantaneous growth rates to be determined. Complications are introduced from the effects of temperature and scale size on the glycine uptake rate and its associated variance (Smagula and Adleman 1982). The technique is thus potentially a useful tool in fisheries research, but much care must be exercised in its use.

11.5.3 GONOSOMATIC INDICES

Gonosomatic indices (GSI) are widely used in fisheries research to describe gonadal development. GSI's are calculated with the following formula:

$$\text{GSI} = \frac{G}{W} \times 100$$

where G = weight of gonads (g); and W = weight of fish (g)

An alternative index is one based on the cube of body length instead of weight. This may be termed gonadal-length index (G.L.I.) and is calculated as

follows:

$$GLI = \frac{G}{L^3} \times 10^7$$

where G = gonad weight (g); and L = standard length of fish (mm)

For an individual fish, the values of the GSI and the GLI will be different and not directly comparable. However, a series of index values taken from a population of fish (to demonstrate seasonal changes in reproductive condition, for example) should show a very similar pattern whether the index is calculated as GSI or GLI. In the present study, GLI's were employed for some species because body weights were not measured for samples provided by fishermen from L. Yure and the use of the GLI was considered more accurate than estimating weights from length-weight regressions.

Although the GSI is widely used, its validity as an index of gonadal activity depends on a number of assumptions. Some of these are as follows (de Vlaming, Grossman and Chapman 1982):

- 1) The regression of gonadal weight on body weight is a) linear, b) has a zero Y-intercept, and c) has a slope which is constant for different stages of gonad development.
- 2) The coefficient of variation of gonadal weight is constant for the entire range of body weight.

If these conditions are not met then it is not strictly valid to compare indices from different sized fish or from fish in different stages of gonadal development.

For a number of temperate species, it has been shown that these assumptions are not in fact valid and that therefore the GSI is not an accurate indicator of reproductive condition (de Vlaming, Grossman and Chapman

1982). Similar analyses carried out for some species of the El Cajón area also indicate that some of the above assumptions are not always valid. As one example, data for the guapote (Cichlasoma motaguense) from L. Yure are presented in Fig. 11.5. Gonad weight has been regressed on body weight for each of gonadal development stages II - V (see Section 5.2.4.2(b), Vol. 1, p. 5-111). Of these four regression lines, only one (Stage II) has a slope significantly different from zero ($P < 0.01$). For the more mature ovarian stages, there is apparently no relationship between gonad and body weights. Thus fish of different sizes which are in the same reproductive stage, will have different GSI values. (Note that the high variance associated with these regressions is partially a result of the broad classification of ovarian stages).

With the sardina (Astyanax fasciatus), a similar analysis indicated that, while the slopes of the regressions significantly differed from zero, the values of these slopes depended on the stage of ovarian development, thus invalidating assumption 1c) above. This discussion demonstrates that care must be taken in comparing specific GSI values. While the GSI and GLI remain useful indices for demonstrating broad seasonal changes in reproductive condition, it is evident that they do not represent a way of accurately comparing developmental state across a wide range of individuals.

11.5.4 DIET ANALYSIS

A number of methods are available for describing fish diets based on analyses of stomach contents (reviewed by Windell and Bowen, 1978). The principal method chosen for the present study involved the measurement of food volumes and has been described in Section 5.2.4.2a (Vol. 1, p. 5-109). The volume of each diet component was expressed as a percentage of the total

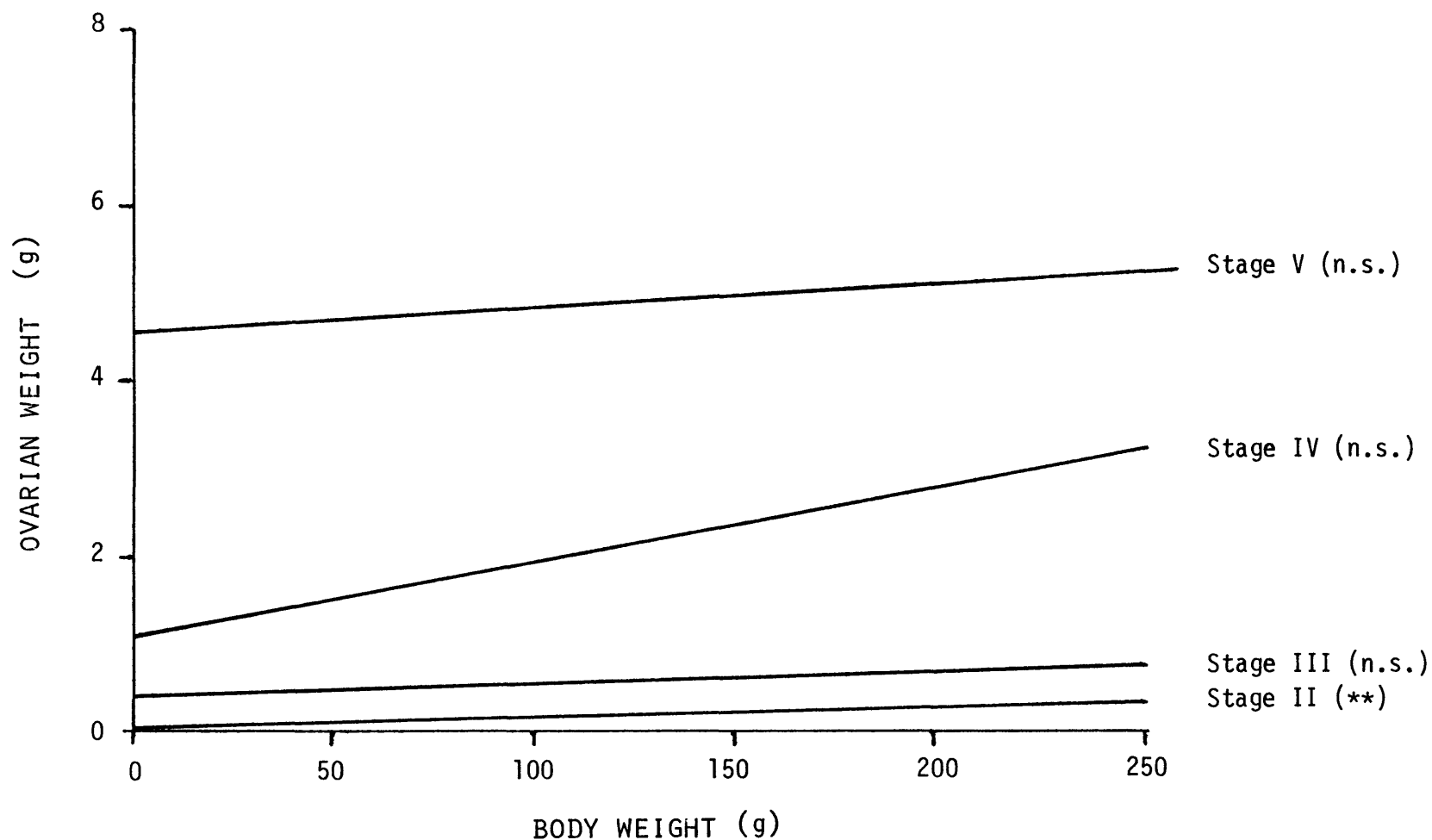


Figure 11.5: Relationship between ovarian weight and female standard length of Cichlasoma motaguense at four maturity stages. (See text for further explanation.)

Figura 11.5: Relación entre el peso de los ovarios y la longitud estandar de Cichlasoma motaguense para cuatro estadios de madurez. (Véase el texto para mayor explicación.)

(n.s. = regression not significantly different from zero; ** = regression significantly different from zero ($p < .01$).)

volume of food in the stomach for each individual fish and population averages were calculated as the average of individual percentage values. Averages were based on the total number of individuals whose stomachs contained food and not on the total number of individuals analyzed. No one method for describing diets is entirely adequate. Since the volumetric method tends to be biased in favor of larger food items or those which are digested more slowly, diet data are usually presented in more than one way in the following sections. In addition to the volumetric representation, frequency of occurrence and dominance are also used. Frequency of occurrence is simply the number of fish containing a particular food item, expressed as a percentage of the total number of fish containing food. The dominance method indicates the percentage of individuals in which a particular food item is the dominant component by volume. A comparison of diet data presented in these three ways will usually provide a good understanding of what fish are feeding on.

It should be noted that the fish food studies summarized in this report do not attempt any estimation of the quantity of food eaten per unit time. Such data can be obtained from field and/or laboratory studies of stomach contents and evacuation rates (Windell 1978) or, alternatively, using an energy budget approach (Mann 1978). These approaches, however, were beyond the scope of the present study.

This section is divided into three parts. The first of these provides an overview of fish distribution and community structure within the El Cajón watershed. This is followed (11.6.2) with a species by species account of the biology and ecology of the El Cajón fish fauna. Finally (11.6.3), this material is brought together as a synthesis of community structure and function.

11.6.1 COMMUNITY STRUCTURE -- AN OVERVIEW

A total of 31 species (representing 22 genera and 15 families) were collected from the El Cajón area (Table 11.4). Of these species, 3 are exotic (tilapia, largemouth black bass and the channel catfish), and 2 were not taken from within the El Cajón watershed itself (Cichlasoma urophthalmus, the "carpa" of L. de Yojoa, and Profundulus guatemalensis, a killifish recorded only from the R. Tamalito).

Table 11.4 shows the species composition of the Humuya, Sulaco and Yure drainages. The latter is taken to include only that part of the watershed upstream from the R. Yure at Yure (i.e. samples from the Yure/Humuya confluence are not considered because of probable "contamination" from the Humuya fish assemblage).

Because of unequal sampling effort in terms of both quantity and quality, too much emphasis must not be placed on apparent differences in species composition between the Humuya and Sulaco rivers. This is especially the case with respect to the larger species, for which sample sizes are generally low. There is no reason to believe, for example, that the migratory robalo (Centropomus pectinatus) did not enter both the Humuya and Sulaco rivers,

Table 11.4 : Species collected from the El Cajón region during the Fisheries Program.

Tabla 11.4 : Las especies colectadas en la región de El Cajón durante el Programa de Pesca.

Family	Species	Local Name	H	Y	S †
Characidae (4) *	<u>Astyanax fasciatus</u>	sardina	✓	✓	✓
	<u>Brycon guatemalensis</u>	machaca	✓	✓	✓
Gymnotidae (1)	<u>Gymnotus cylindricus</u>	señorita	✓	✓	
Pimelodidae (3)	<u>Rhamdia cabreræ</u>	bagre	✓	✓	✓
	<u>R. guatemalensis</u>	bagre	✓	✓	✓
Cyprinodontidae (2)	<u>Profundulus guatemalensis</u>	olomina	(R. Tamalito only)		
Poeciliidae (12)	<u>Alfaro huberi</u>	olomina	✓	✓	✓
	<u>Poecilia mexicana</u>	" "	✓	✓	✓
	<u>P. sphenops</u>	" "	✓	✓	✓
	<u>Poecilia new species A</u>	" "	✓		
	<u>Heterandria bimaculata</u>	" "		✓	
	<u>Poeciliopsis gracilis</u>	" "	✓	✓	✓
Synbranchidae (1)	<u>Synbranchus marmoratus</u>	anguilla	✓	✓	
Cichlidae (16)	<u>Cichlasoma maculicauda</u>	boca colorada	✓		✓
	<u>C. spilurum</u>	congo	✓	✓	✓
	<u>C. nigrofasciatum</u>	(congo ?)			✓
	<u>C. robertsoni</u>	(mojarra ?)	✓		
	<u>C. urophthalmus</u>	carpa	(L. de Yojoa only)		
	<u>C. motaguense</u>	guapote	✓	✓	✓
	<u>C. managuense</u>	guapote tigre	✓		
Ariidae (3)	<u>Arius melanopus</u>	bagre negro	✓		
Atherinidae (1)	<u>Melaniris guatemalensis</u>		✓		
Centropomidae (6)	<u>Centropomus pectinatus</u>	robalo	✓		
Pomadasyidae (2)	<u>Pomadasys crocro</u>	corbinata	✓		✓
Mugilidae (4)	<u>Agonostomus monticola</u>	tepemechn		✓	
	<u>Joturus pilchardi</u>	cuyamel			✓
Gobiidae (10)	<u>Gobiomorus dormitor</u>	dormilón	(L. Yure + Yojoa + R. Varsovia only)		
	<u>Awaous talasica</u>	guavina	✓	✓	✓
(Introduced species)					
Cichlidae	<u>Sarotherodon mossambicus</u>	tilapia	✓		
Centrarchidae	<u>Micropterus salmoides</u>	bass		✓	
Ictaluridae	<u>Ictalurus punctatus</u>	bagre vaca (channel catfish)	✓		

* Numbers in parenthesis refer to the number of species recorded from Honduras by Martin (1972)

† Collected from Humuya (H), Yure (Y) and Sulaco (S) watersheds.

Table 11.5: Summary of fish collections from the El Cajón watershed.

Tabla 11.5: Resumen de las colecciones de peces desde la cuenca de El Cajón.

KEY:

ASF:	<u>Astyanax fasciatus</u>
BRG:	<u>Brycon guatemalensis</u>
GYC:	<u>Gymnotus cylindricus</u>
RHC:	<u>Rhamdia cabreræ</u>
RHG:	<u>R. guatemalensis</u>
PRG:	<u>Profundulus guatemalensis</u>
ALH:	<u>Alfaro huberi</u>
POM:	<u>Poecilia mexicana</u>
POS:	<u>P. sphenops</u>
POA:	<u>Poecilia new sp. A</u>
HEB:	<u>Heterandria bimaculata</u>
POG:	<u>Poeciliopsis gracilis</u>
SYM:	<u>Synbranchus marmoratus</u>
CIC:	<u>Cichlasoma maculicauda</u>
CIS:	<u>C. spilurum</u>
CIN:	<u>C. nigrofasciatum</u>
CIR:	<u>C. robertsoni</u>
CIU:	<u>C. urophthalmus</u>
CIM:	<u>C. motaguense</u>
CIG:	<u>C. managuense</u>
ARM:	<u>Arius melanopus</u>
MEG:	<u>Melaniris guatemalensis</u>
CEP:	<u>Centropomus pectinatus</u>
POC:	<u>Pomadasys crocro</u>
AGM:	<u>Agonostomus monticola</u>
JOP:	<u>Joturus pilchardi</u>
AWT:	<u>Awaous taiasica</u>
ICP:	<u>Ictalurus punctatus</u>
TIN:	<u>Sarotherodon niloticus</u>

Table 11.5 (cont.)

R. Yure @ Yure ----->

Date	12/I/81			16/II/81			8/VI/81			18/VIII/81			27/X/81		
	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
Species															
POS	23	*22	15-35	(4)	-		44	*79	22-48	17	*40	26-50	15	28	23-62
ALH	22	*17	19-41	(12)	-		92	*100	16-46	17	*18	17-45	11	12	18-45
HEB	2	?	?				44	*39	14-51				8	6	17-38
POG	9	*8	23-42												
CIS	79	506	22-86	91	968	31-83	123	767	14-86	90	645	16-84	140	1240	27-88
CIM	30	356	33-131	13	120	31-78	24	504	16-125	28	355	32-100	21	668	32-139
CIR							1	?	86						
BRG															
ASF	1	*<1	19							7	18	24-75	9	67	26-91
RHC	9	170	90-131	6	11	20-123	23	421	49-135	14	175	60-120	19	378	82-136
RHG	24	245	51-125	11	226	78-158	8	130	88-116	5	121	67-142	15	367	68-150
AWT				1	111	167	6	672	88-208	1	142	179			
SYM							3	72	120-345				1	16	230
GYC															
I/D #	PV1120101+02			PV1160201			PV1080601			PV1180801			PV1271001		
Gear	E/sh			E/sh			E/sh			E/sh			E/sh		

Table 11.5 (cont.)

R. Yure @ Yure ----->															
Date	16/XII/81			25/I/82			11/III/82			18/V/82a)			18/V/82b)		
	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
<u>Species</u>															
POS	(1)	1	-	(0)			17	*28	25-70	23	58	35-56	None of these species was counted in the second sample of this date.		
ALH	(2)	4	-	(0)			8	*11	16-45	30	26	14-49			
HEB	7	10	29				7	*5	15-44	18	16	18-47			
PDG															
CIS	93	958	34-80	87	*1100	39-85	109	1248	14-80	82	878	23-90			
CIM	22	66	32-132	11	170	39-121	15	178	39-99	12	368	18-135	8	368	84-161
CIR															
BRG							1	17	104	3	13	47-67	5	79	69-116
ASF	2	18	58-75	3	22	56-73	15	*135	43-88	1	5	58	25	282	60-87
RHC	8	138	85-111	14	249	68-130	17	376	99-132	7	155	59-134	11	297	100-133
RHG	10	145	62-150	10	235	62-190	16	207	69-127	4	99	98-127	5	133	86-142
AWT							2	81	122-144	4	459	149-191	3	244	130-162
SYM							1	31	273				4	109	205-365
GYC										1	33	194			
I/D #	ER1161201			ER2250101			ER2110301			PV2180502a)			PV2180502b)		
Gear	E/sh			E/sh			E/sh			E/sh			E/sh		

Table 11.5 (cont.)

R. Yure (San Bartolo)				R. Yure (Las Delicias)			Q. Agua Amarilla			R. Yure @ Humuya Confluence ----->					
Date	#	12/I/81 Wt.	L.R.	#	11/III/82 Wt.	L.R.	#	16/II/81 Wt.	L.R.	#	9/XII/80 Wt.	L.R.	#	22/III/81 Wt.	L.R.
Species:															
POS	25	*30	14-48												
POM															
ALH	42	*41	18-52	1	2	45	9	12	16-49	357	*475	11-73	2	12	44-63
HEB															
POG															
CIS	32	147	26-60	82	934	27-83	5	20	32-55	25	*15	11-54			
CIM	3	99	31-76	10	333	81-131				41	598	20-95	48	408	18-95
CIR										4	44	46-89			
CIN													1	1	38
CIG													1	1	34
CIC															
BRG				17	364	104-154							79	734	27-150
ASF	1	11	74	157	*805	56-90	10	8	29-35	24	70	35-68	132	*647	24-81
RHC	12	186	66-124												
RHG										4	38				
AWT															
SYM															
GYC															
MEG													3	2	34-48
I/D #	PV1120103			ER2110302			PV1160203			PV0091201-03			PV1220301		
Gear	E/sh			Exp.			E/sh			+RG0091201 E/sh			Exp.		

R. Humaya @ Yure Confluence----->

Date	20/III/82			20/III/82			8/IX/82			8/IX/82			8/IX/82		
	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
Species															
POS				7	*15	27-55									
POM	2	19	64-68	43	*122	27-67	(19)	?	-	(0)					
ALH															
HEB															
POG				1	*1	29									
CIS	1	53	105	(6)	87	17-98	3	141	94-98	(41)	*225	26-79			
CIM				2	4	31-42				17	566	29-170			
CIR				8	253	21-139				52	425	43-84			
CIN															
CIG				1	230	194				8	202	60-97			
CIC							4	1456	153-203	8	70	41-63			
BRG	4	1698	158-338				2	88	83-164	17	*22	16-20			
ASF	5	34	57-72	3	20	58-67	5	*45	65-72						
RHC										1	15	96			
RHG	1	164	226	4	76	94-117	1	249	255	3	27	50-103			
AWT							1	76	149						
SYM															
GYC															
MEG													24	40	46-61
ARM	17	1384	149-189	1	76	161									
ICP	2	2492	353-479				1	93	188						
TIN	1	544	254												
POC	2	973	240-300												
CEP							1	2299	493						
I/D #	ER2200301			ER2200302			ER2080901			ER2080902			ER2080903		
Gear	G/N			E/sh			G/N			E/sh			H/N		

R. Chiquito ----->							R. Humuya @ Ojos de Agua			R. Humuya @ Q. de Chamo ----->						Q. de Chamo		
Date	17/XI/80			17/XI/80			5/IV/81			21-22/IV/82			22/IV/82			21/IV/82		
	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
<u>Species:</u>																		
POS																8	?	-
POM	25	*97	10-73	(46)	*165	18-69	99	*204	24-52							233	?	-
ALH							2	1	30-50							13	?	-
HEB																		
POG	38	*79	25-53	(27)	*20	17-42	1	1	28							5	?	-
CIS	2	60	70-96	1	5	50	17	56	19-84							147	*858	20-88
CIM	2	69	83-106	1	7	58	6	32	20-72							18	*171	30-72
CIR							2	3	32-35							1	*11	62
CIN																		
CIG																		
CIC																1	<1	19
BRG							4	18	55-74				4	1075	174-280	13	*694	68-208
ASF																7	*56	62-79
RHC				5	46	68-96	5	268	98-178									
RHG				1	2	50	2	72	128-136							2	187	174-182
AWT													1	390	258			
SYM																2	237	408-447
GYC																		
MEG																		
ARM													6	625	172-194	43	3958	131-193
ICP																		
TIN																		
POC													2	655	230-238	1	500	256
CEP																		
I/D #	PV0171101			PV0171102			PV1050402			ER2210401 + ER2220401			ER2220402			ER2210402		
Gear	E/sh			E/sh			E/sh			G/N			G/N			E/sh		

Table 11.5 (cont.)

R. Canquique				R. Jacagua			R. Colorado			R. Yunque			Q. Agua Caliente		
Date	1/IV/81			2/IV/81			3/IV/81			7/IV/81			5/IV/81		
#	Wt.	L.R.		#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
Species:															
POS	114	*205	17-56	8	*4	20-35	19	*31	29-53	36	*109	20-68	119	*75	11-54
POM	87	*188	17-53	85	*139	16-56	46	*91	22-44	58	*350	16-77			
PO?	1	*4	50				1	5	58						
ALH				10	*12	26-39	29	*40	25-51						
HEB															
POG	8	*3	15-37	1	<1	13				1	<1	18			
CIS	6	39	34-66	46	409	50-78	28	367	18-93	59	226	15-72			
CIM	6	141	41-137	7	336	68-160	7	266	40-118	4	60	38-96			
CIR															
CIN	18	49	20-49	9	41	15-56	16	90	24-58	11	23	17-49			
CIG															
CIC															
BRG				10	5	16-45	3	8	42-57	5	10	41-62			
ASF	15	32	39-49	29	180	43-70	45	431	49-89	18	*66	35-75			
RHC				17	359	55-130	33	420	44-138	9	166	89-139			
RHG	5	46	67-92	1	130	130	23	869	58-197	2	23	84-97			
AWT										2	104	99-160			
I/D #	ER1010402			ER1020401			ER1030402			ER1070401			PVT050401		
Gear	E/sh			E/sh			E/sh			E/sh			E/sh		

Table 11.5 (cont.)

R. Cacaguapa				R. Sulaco (nr. R. Canquique)			R. Sulaco (nr. Victoria)			R. Sulaco (@ Salitron) ----->					
Date 17/XI/80				1/IV/81			3/IV/81			6-7/IV/81			7-8/IV/81		
#	Wt.	L.R.		#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
<u>Species:</u>															
POS				3	*8	42-49	26	*49	25-50	9	*17	27-47			
POM	30	*84	26-57	20	*44	14-56	155	*257	17-65	105	*272	32-57			
POA	5	*21	47-55												
PO?				2	*12	57-59	3	*14	48-58						
ALH	8	*15	33-52												
HEB															
POG	1	<1	27				5	*2	23-29	26	*34	32-39			
CIS	27	96	35-70	3	15	45-48	23	163	21-82	11	62	35-55			
CIM	2	4	36-39				10	148	15-101						
CIR															
CIN				1	6	50									
CIG															
CIC										5	4	24-28			
BRG				1	9	80	10	10	25-45	22	150	36-110	3	3299	355-363
ASF				5	26	52-60	15	51	31-70	47	*142	20-66			
RHC	3	38	76-118				9	206	64-147	1	46	46			
RHG				7	156	68-148	13	666	98-162						
AWT										1	108	174			
SYM															
GYC	1	32	195												
MEG															
ARM															
ICP															
TIN															
POC													1	81	330
CEP															
JOP										1	6	64			
I/D #	PV0171103			ER1010401			ER1030401			PV1060401 + ER1070402			PV1070401 + DC1080401		
Gear	E/sh			E/sh			E/sh			C/N			G/N + "Tapesca"		

Table 11.5 (cont.)

R. Tamalito ----->												R. Jaitique			
Date	17/XII/81			13/I/82			30/XI/82			31/I/83			17/XII/81		
	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.	#	Wt.	L.R.
Species:															
POS	not collected						not collected			(12)	?	-			
POM	not collected			121	*355	22-52	not collected			(84)	?	-	5	7	18-60
ALH	not collected			91	217	22-61	not collected			(153)	?	-	14	6	16-43
PRG	not collected			5	19	48-53	not collected								
CIS	145	1614	35-95				204	*1058	24-88	258	*1597	22-95	41	400	35-86
CIM															
BRG															
ASF	59	211	30-107	2	21	57-81				8	*71	55-73	1	7	64
RHC	222	3217	22-160	109	*1212	56-138	190	*1586	44-142	154	*1128	54-144	23	220	61-109
RHG	1	14	98							1	*31	122			
MIS										2	*23	25-27			
I/D #	ER1171201			ER2130101			AD2301101			AD3310101			ER1171202		
Gear	E/sh			E/sh			E/sh			E/sh			E/sh		

Table 11.5 (cont.)

QSN		QdC ----->	
Date	26-XI-80	26-XI-80	27-I-81
<u>Species</u>			
POS	#		36
	Wt		*42
	LR		19-46
ALH	#	4	22
	Wt	*4	*16
	LR	19-41	15-43
HEB	#		2
	Wt		3
	LR		35-43
CIM	#	5	12
	Wt	34	60
	LR	52-68	39-72
ASF	#	3	8
	Wt	14	22
	LR	49-65	43-57
RHC	#	3	6
	Wt	34	40
	LR	77-103	57-91
MIS	#		2
	Wt		5
	LR		42-50
Gear	E/sh	E/sh	E/sh + C/N

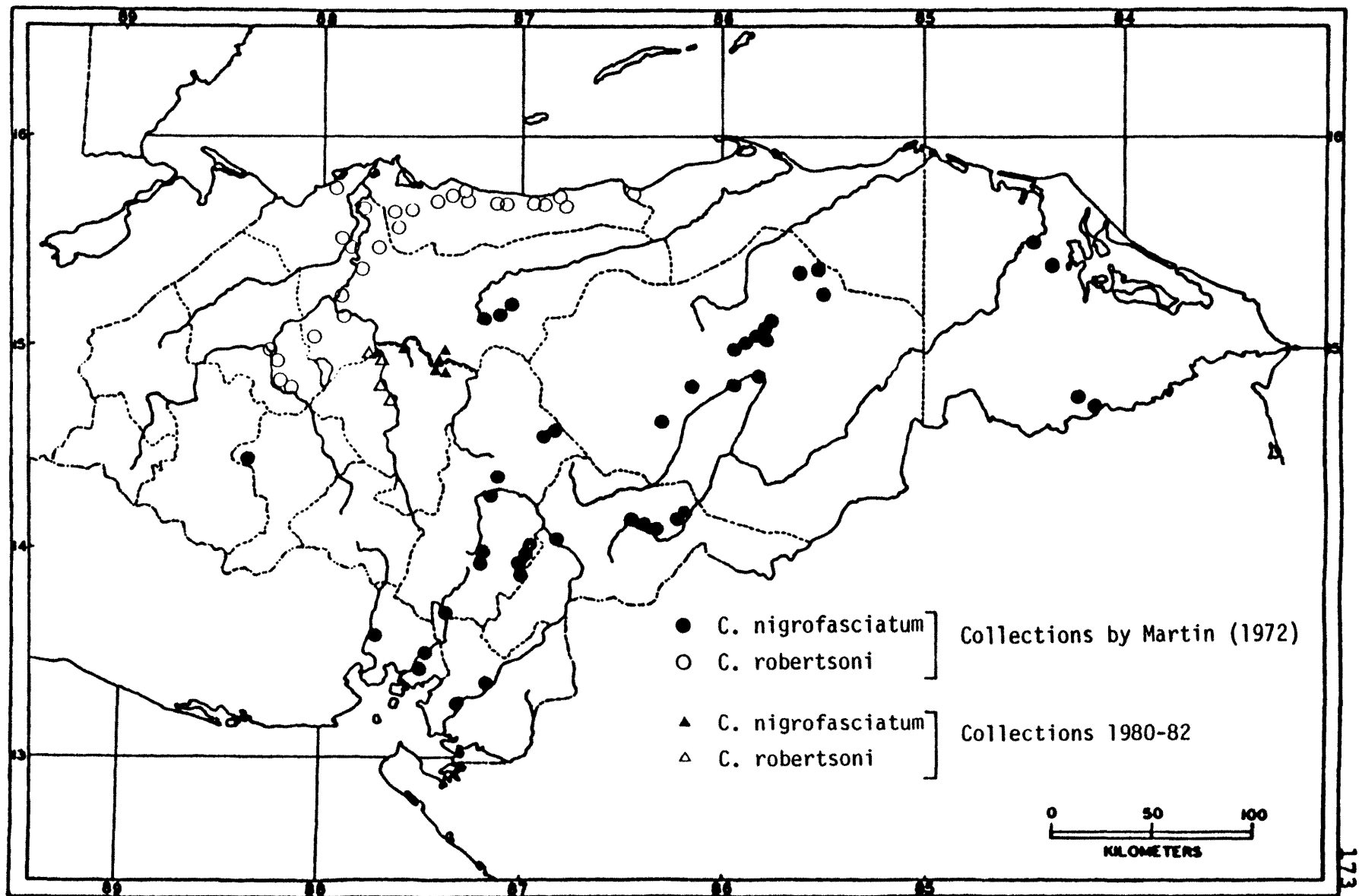
QSN = Q. Sin Nombre)
 QdC = Q. del Cerro) L. Yure tributaries

although it was captured only in the former. Cichlids, however, were more representatively sampled and the striking difference between the Humuya and Sulaco watersheds is the largely non-overlapping distribution of Cichlasoma nigrofasciatum and C. robertsoni (Fig. 11.6). The former species was taken only within the Sulaco watershed (with the exception of one individual taken at the Yure/Humuya confluence), and the latter only from the Humuya watershed. Martin (1972) recorded C. nigrofasciatum primarily from the eastern half of Honduras, whereas C. robertsoni was found only in the north-west sector of the country (Fig. 11.6). Neither species was apparently recorded from the Humuya or Sulaco watersheds. It would appear, therefore, that the areas sampled during the present study represent boundaries of these two species' ranges and that the pattern of non-overlapping distribution referred to above indeed reflects a real situation. These two cichlids may be actively extending their ranges, however, and it is possible that more intensive sampling would show a more widespread existence of both species in the two watersheds.

The lower number of species recorded from the upper part of the Yure watershed reflects a common pattern in the longitudinal zonation of riverine fish communities (e.g. Horwitz 1978). As river gradient decreases and stream order increases, species richness (number of species) typically increases. Usually this increase occurs by the addition of species in a downstream direction, rather than by species replacement. This pattern, which has often been demonstrated in temperate streams, appears also to be characteristic of tropical systems (Lowe-McConnell 1975, Moyle and Cech 1982, Martin 1972, Bishop 1973). Possible factors producing the observed relationship between species diversity and stream order include increasing habitat diversity, a wider food resource base, and, possibly, reduced environmental variation

Figure 11.6: Distribution of Cichlasoma nigrofasciatum and C. robertsoni in Honduras.

Figura 11.6: Distribución de Cichlasoma nigrofasciatum y C. robertsoni en Honduras.



(distribution map modified from Martin, 1972)

(flash flooding, for example) in lower elevation streams.

Data presented in Fig. 11.7 illustrate this trend of increasing species diversity for the Yure system. In Q. del Cerro, a former tributary of the R. Yure now flowing into L. Yure, six species are present. A seventh species, the exotic largemouth bass, Micropterus salmoides, represents a contaminant from L. Yure. The stream community includes one cichlid, one characin, one pimelodid, and three poeciliids (Fig. 11.7a). Within a distance of 8 km downstream from the Q. del Cerro sampling station, an additional species has been added in each of the families Cichlidae (Cichlasoma spilurum), Characidae (Brycon guatemalensis) and Pimelodidae (Rhamdia guatemalensis) (Fig. 11.7c and d). More intensive sampling of the L. Yure tributaries would almost certainly have yielded a further two species, Agonostomus monticola (tepemechin) and Synbranchus marmoratus (anguilla). These species are present in L. Yure and were presumably in the rivers before the reservoir's formation.

By the time the R. Yure reaches its confluence with the R. Humuya, the fish community has been further diversified by the addition of the poeciliids Poecilia mexicana and Poeciliopsis gracilis, the cichlids Cichlasoma robertsoni, C. maculicauda and C. managuense, and the atherinid (silverside) Melaniris guatemalensis (Table 11.5).

In lower order streams which are large enough to have moderately deep pools (Q. del Cerro, for example) fish biomass tends to be dominated by Astyanax fasciatus (sardina), Rhamdia cabreræ (bagre) and Cichlasoma motaguense (guapote). Poeciliids (olominas) are abundant but often less important in terms of biomass (Fig. 11.7a). When few pools are present, Astyanax is less common. In small, steeper gradient streams, apparently the only species present is the poeciliid Alfaro huberi (for example Q. Agua

Figure 11.7: Species composition of riverine fish communities in the El Cajon watershed.

Figura 11.7: Composición de especies de las comunidades riverinas en la cuenca de El Cajón.

KEY:



Characidae

ASF: Astyanax fasciatus

BRG: Brycon guatemalensis



Cichlidae

CIS: Cichlasoma spilurum

CIM: C. motaguense



Pimelodidae

RHC: Rhamdia cabreræ

RHG: R. guatemalensis



Poeciliidae

ALH: Alfaro huberi

POS: Poecilia sphenops

POM: P. mexicana

HEB: Heterobranchus bimaculatus

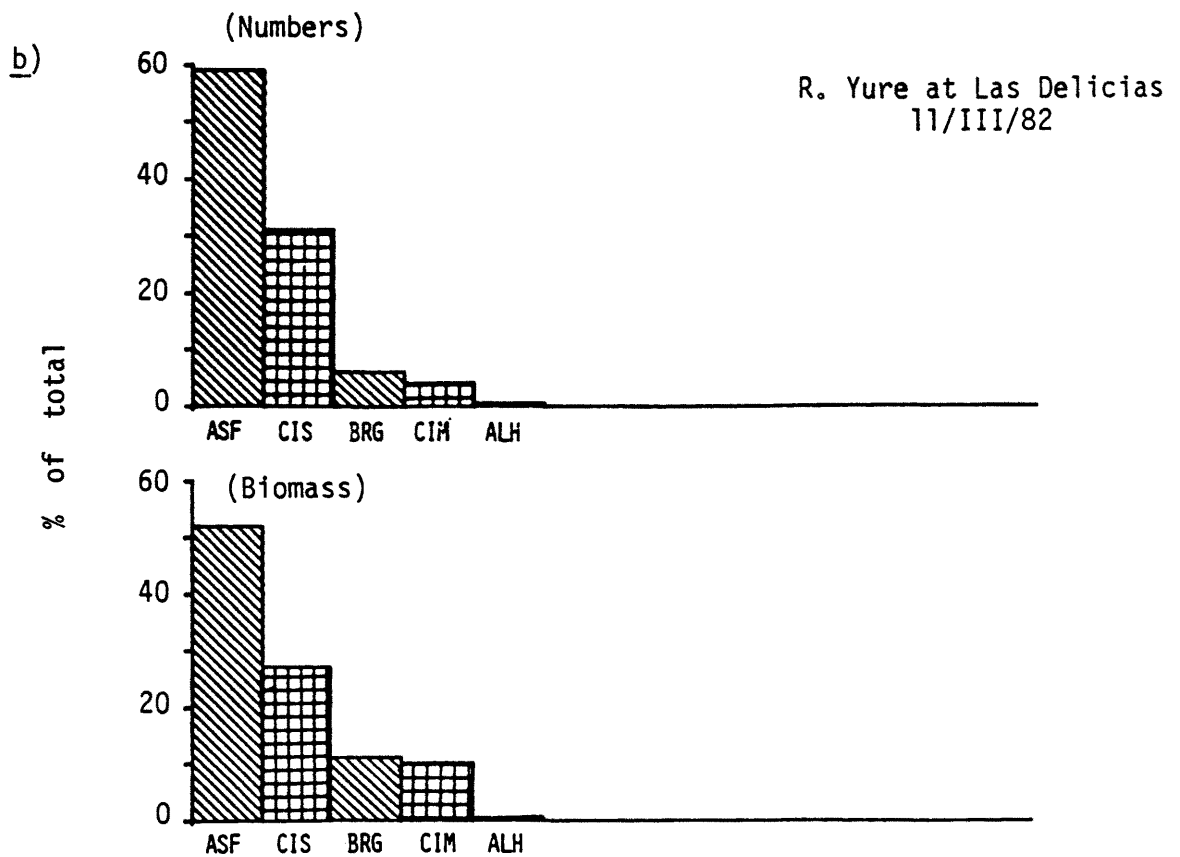
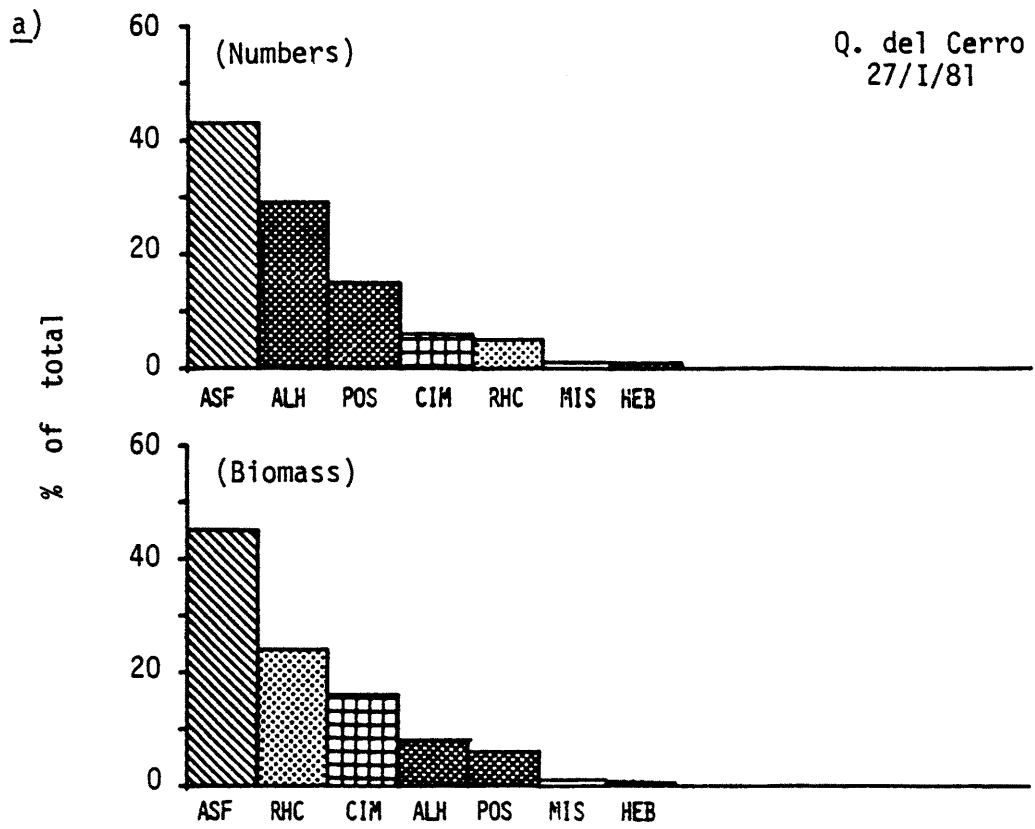
POG: Poeciliopsis gracilis

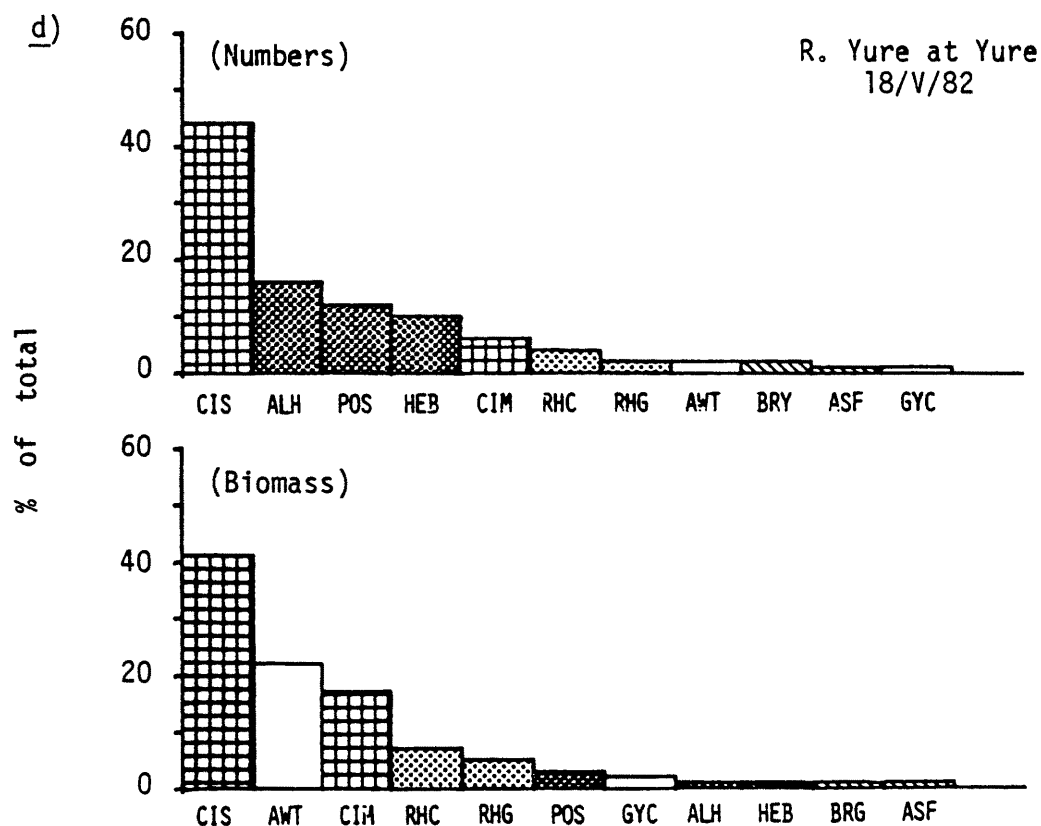
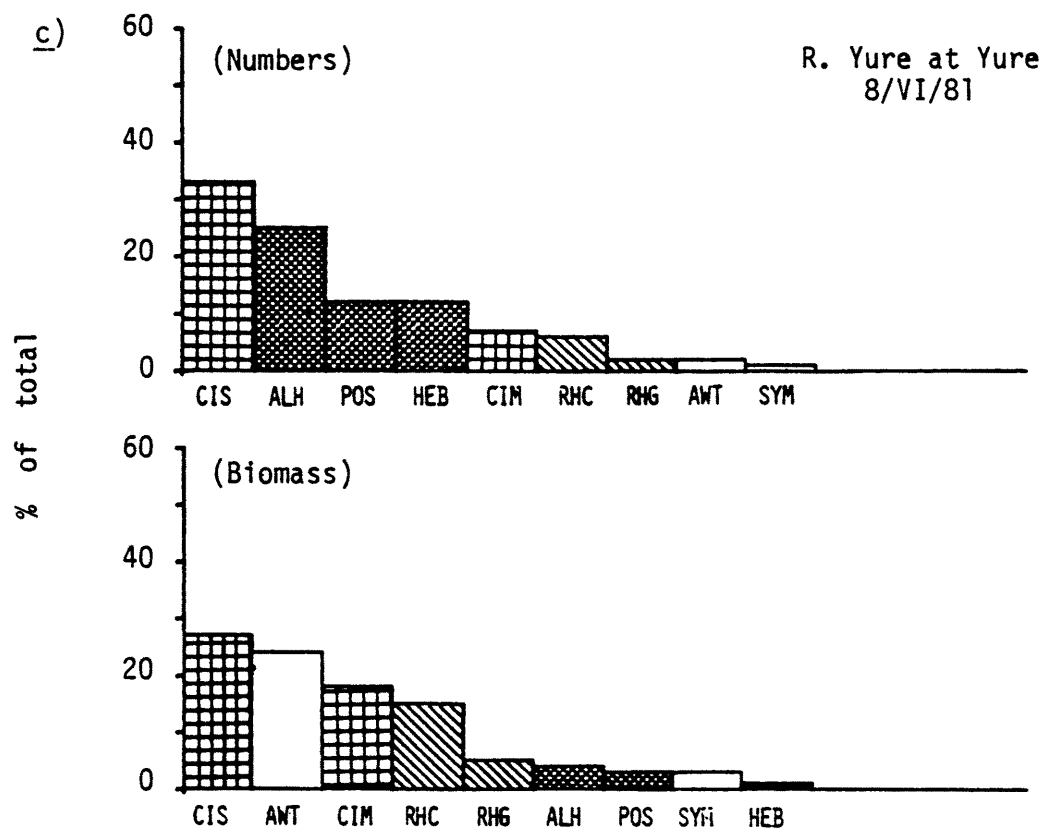


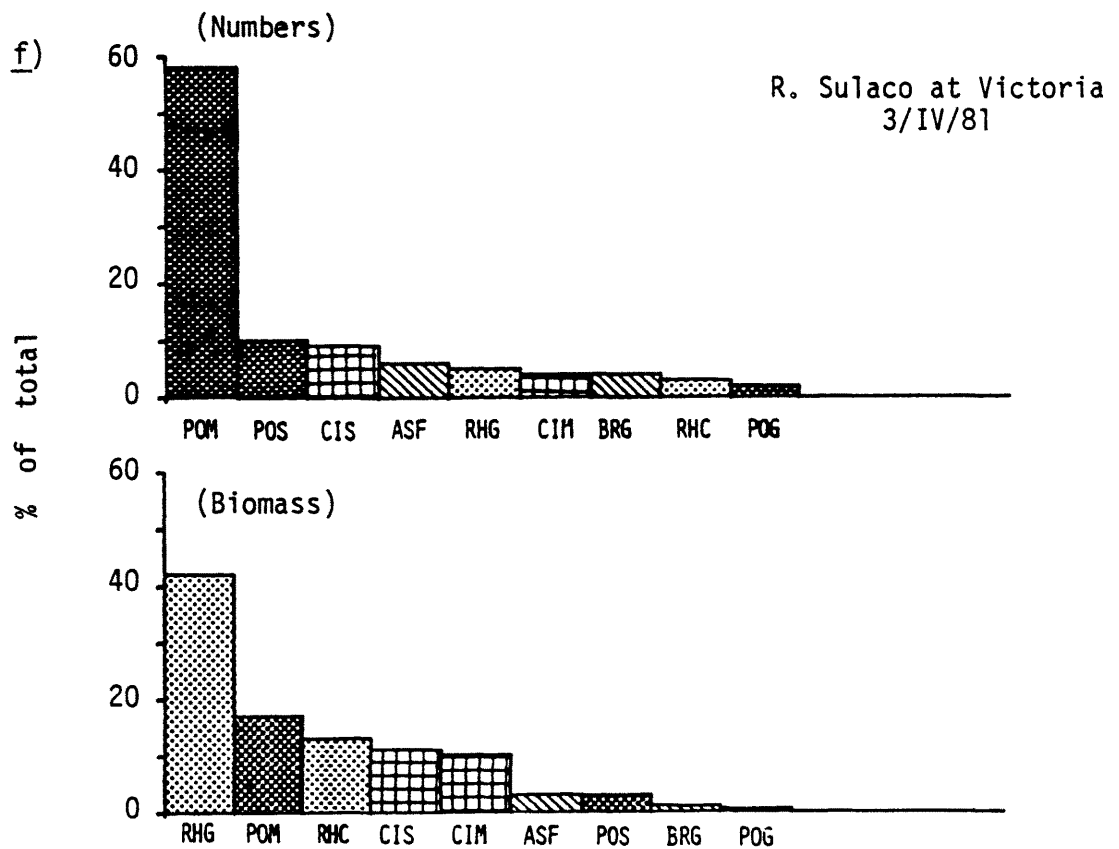
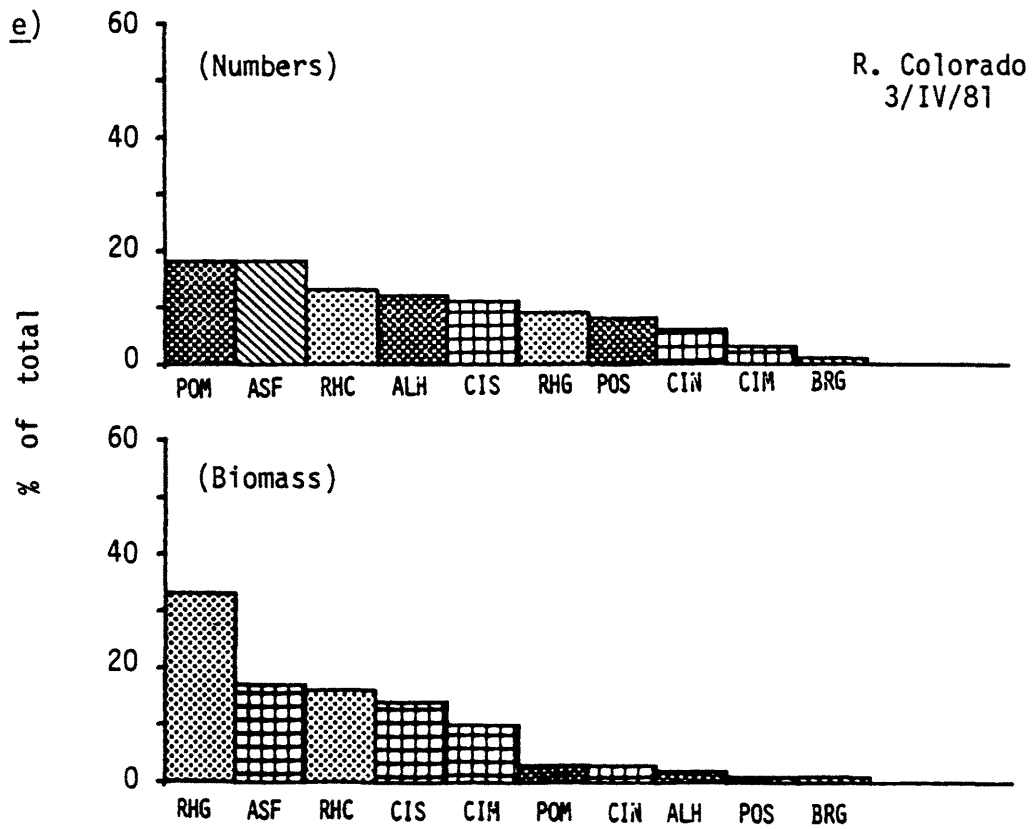
AWT: Awaous taiaşica

SYM: Synbranchus marmoratus

MIS: Micropterus salmoides







Caliente, Table 11.5). Martin (1972, p. 362) states that the only two species occurring in Honduras at elevations above 1100 m are Rhamdia cabreræ and Profundulus guatemalensis. However, it would seem likely that upper elevation streams in the El Cajón area are populated mainly by A. huberi. More extensive sampling is needed to check this.

As stream order increases and species are added to the community, cichlids become major biomass components, especially the herbivorous and insectivorous species Cichlasoma spilurum (congo). The catfish Rhamdia spp. and the gobiid Awaous also are important in terms of biomass, although less so on a numerical basis. The data presented in Fig. 11.7c and d may be biased towards the cichlids, pimelodids and poeciliids, however, because the electroshocker does not efficiently sample the deeper pools. More representative samples from these pools (made with small explosive charges) demonstrate that the characins Astyanax and Brycon tend to be more abundant in these habitats. Compare, for example, the sample from R. Yure at Las Delicias (just above the station at Yure village) with the R. Yure at Yure samples (Figs. 11.7b-d). Two sets of samples from R. Yure at the Humuya confluence can similarly be compared (Table 11.5).

The fish communities of larger rivers are more difficult to characterize in terms of relative biomass or numerical abundance because of the variety of gears needed to adequately sample these habitats. For example, a local "tapesca" (a form of fish weir; see plate 5a, p. 5-106, Vol. 1) built across the R. Sulaco was monitored in April 1981. This gear captured only Brycon and Pomadasys (Table 11.5). Gill-netting in both the Sulaco and Humuya rivers, however, tended to catch mainly Arius, Rhamdia and Brycon. From the existing data, therefore, not only is the relative biomass of these larger-growing

species unclear, but also their contribution to total community biomass is difficult to estimate. This is a common problem encountered when sampling large, highly seasonal rivers. A considerably more intensive sampling effort than was feasible during the present study needs to be invested in order to better understand these riverine fish communities.

Additional discussion of community composition will be included in the following species accounts.

11.6.2 SPECIES ACCOUNTS

11.6.2.1 Characidae:

Astyanax fasciatus (Cuvier) "Sardina"

Distribution and Taxonomy: This is one of the most ubiquitous species of Central America, and occurs in all major drainages in Honduras and at elevations up to 1200m (Martin 1972). Its range extends from Mexico to Argentina (Miller 1966). It is an extremely variable species and, although a number of sub-species have been described, its taxonomy is in need of further study. Carr and Giovannoli (1950) assigned populations from the Choluteca drainage to the sub-species aeneus on the basis of anal ray counts (Hubbs 1935).

The preferred habitat of A. fasciatus consists of deeper pools, although it is also found under overhanging banks and in riffle areas. In rivers containing a high proportion of pool habitat, it probably often represents the dominant species in terms of both numbers and biomass. Its preferred habitat made it difficult to sample with an electroshocker and thus a truly reliable estimate of its importance in the riverine community cannot be made. However,

samples collected from pools with small explosive charges demonstrate its dominance at least in these pool communities (Fig. 11.7b , Table 11.5).

A spectacular upstream migration of sardinas has been recorded from Costa Rica (Lopez 1978) but no such movements were observed during the present study. Fish taking part in the Costa Rican migration were immature and presumably did not represent a spawning migration. Although it is not known how common this behavior is, seasonal migrations have been recorded for the closely related A. mexicanus in Texas, with fish moving upstream in April prior to spawning between April and September (Edwards 1977).

Population Structure: Because of problems in obtaining representative samples of this species with an electroshocker (and gill nets), pool collections made with explosive charges are most suitable for analysis of size frequency distributions. Two of these collections, both made from the R. Yure, are presented in Fig. 11.8. These size frequency distributions, together with those of electroshocker and gill-net caught samples, clearly demonstrate a size difference between the sexes, with females being larger than males. This has been noted for other Astyanax species (Breder and Rosen 1966). In the sample from Las Delicias, for example, the average length (\pm 1 standard deviation) of females was 77.2 (\pm 7.7) mm, while that for males was 69.8 (\pm 7.1) mm. There is some indication of different cohorts in a few of these size distributions, but they are not at all clear and cannot be used for cohort analysis of growth rates. The length-weight relationship for A. fasciatus is shown in Fig. 11.9.

Scales were examined from a number of individuals in an attempt to determine whether they would be useful for growth rate determinations. Growth

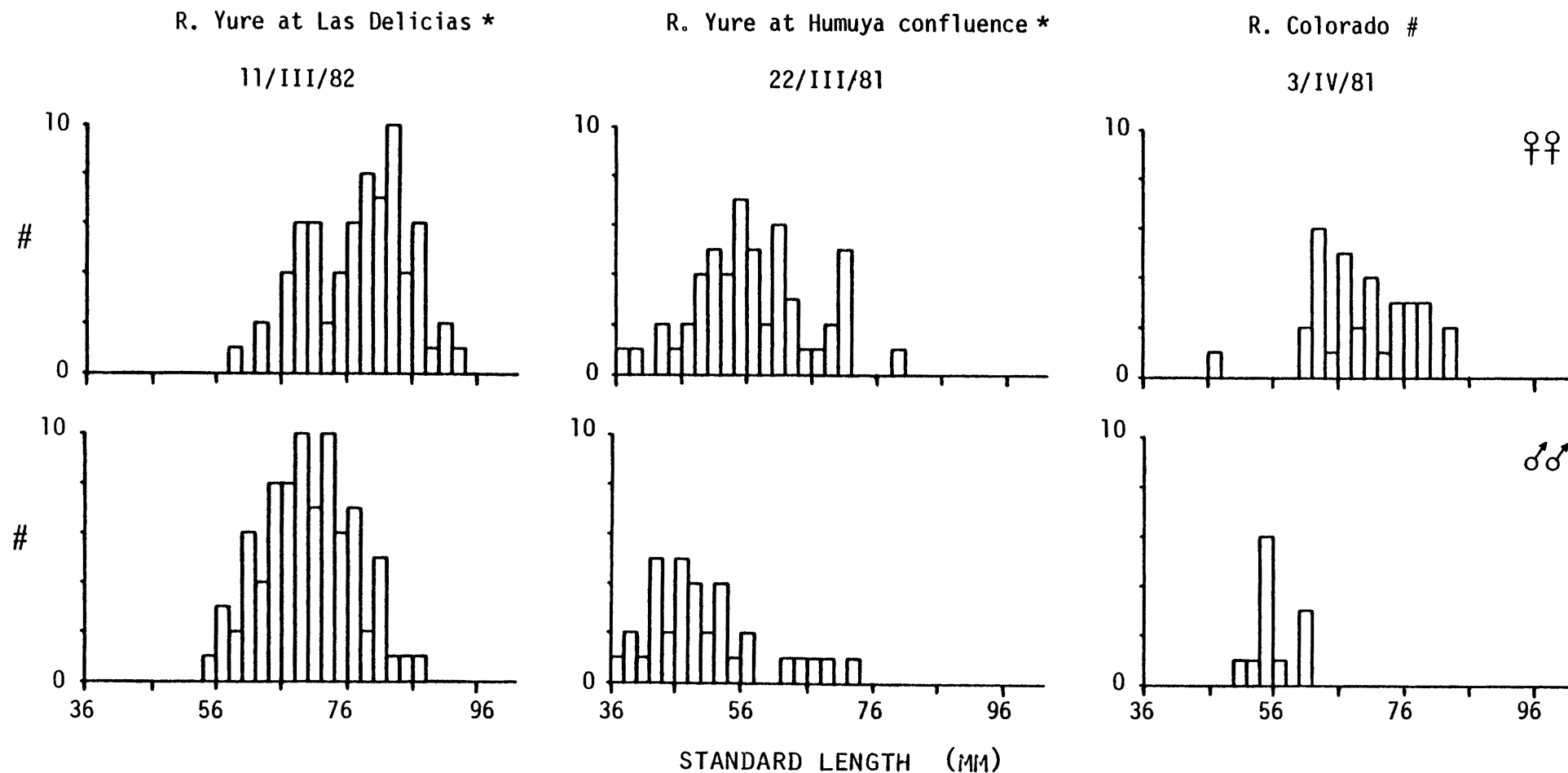


Figure 11.8: Size frequency distributions of *Astyanax fasciatus* in the R. Yure and R. Colorado.

Figura 11.8: Distribuciones por tamaño de poblaciones de *Astyanax fasciatus* en los ríos Yure y Colorado.

(* sampled with small explosive charges; # sampled with electroshocker)

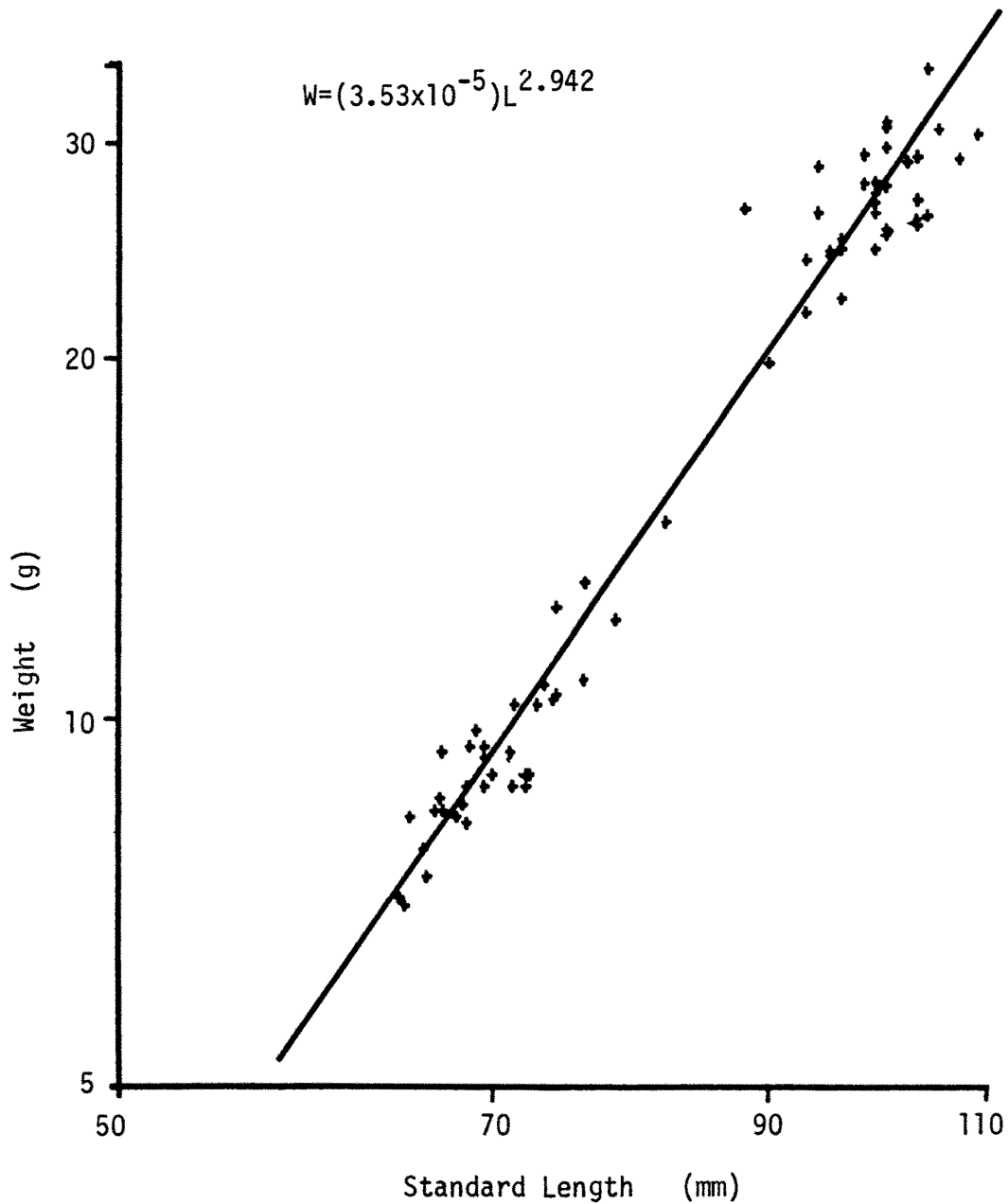


Figure 11.9: Length-weight relationship of *Astyanax fasciatus*.

Figura 11.9: Relación longitud-peso de *Astyanax fasciatus*.

(Note: In this and other length-weight regressions, W = weight (g) and L = standard length (mm).)

checks were seen on some scales from the larger size classes (primarily from L. Yure) but it was not possible to determine the time or frequency of their formation. Nomura (1975b) studied the growth of this species in Brazil and concluded that scale checks were being formed once per year. Growth curves derived from scale readings indicated that Astyanax reaches a (total) length of about 50mm in one year and about 80mm by the end of the second year of growth. Future identification of the frequency of check formation in Honduran populations may enable age and growth to be calculated for these as well.

Reproduction: Spawning of riverine sardina populations occurs at the end of the dry season and beginning of the wet season. Fig. 11.10 illustrates the variation in GSI values for a series of four samples taken between March and May. Unfortunately, adequate samples are not available from later in the year so the duration of reproduction is uncertain. Breder and Rosen (1966) have noted that a related species of Astyanax (A. ruberrimus) spawns in the wet season and that A. fasciatus is "probably similar" in its reproductive behavior. In L. Yure, there is evidence for a second spawning peak at the end of the wet season (see Section 11.7) but reproductive seasonality cannot be assumed to be identical in lentic and lotic habitats. A few individuals taken from the R. Yure in December, however, had mature gonads so it is probable that all the spawning does not occur in April - June. Also, juveniles were noted from samples collected in March.

Egg size frequency distributions (Fig. 11.48) show that in mature ovaries there is one primary size class of oocytes, indicating that fractional spawning does not occur. Oocytes measure approximately 0.8-1.0mm and turn a translucent golden-yellow shortly before being shed. The other size class of oocytes in mature ovaries consists of eggs which are small (<0.2mm), clear and

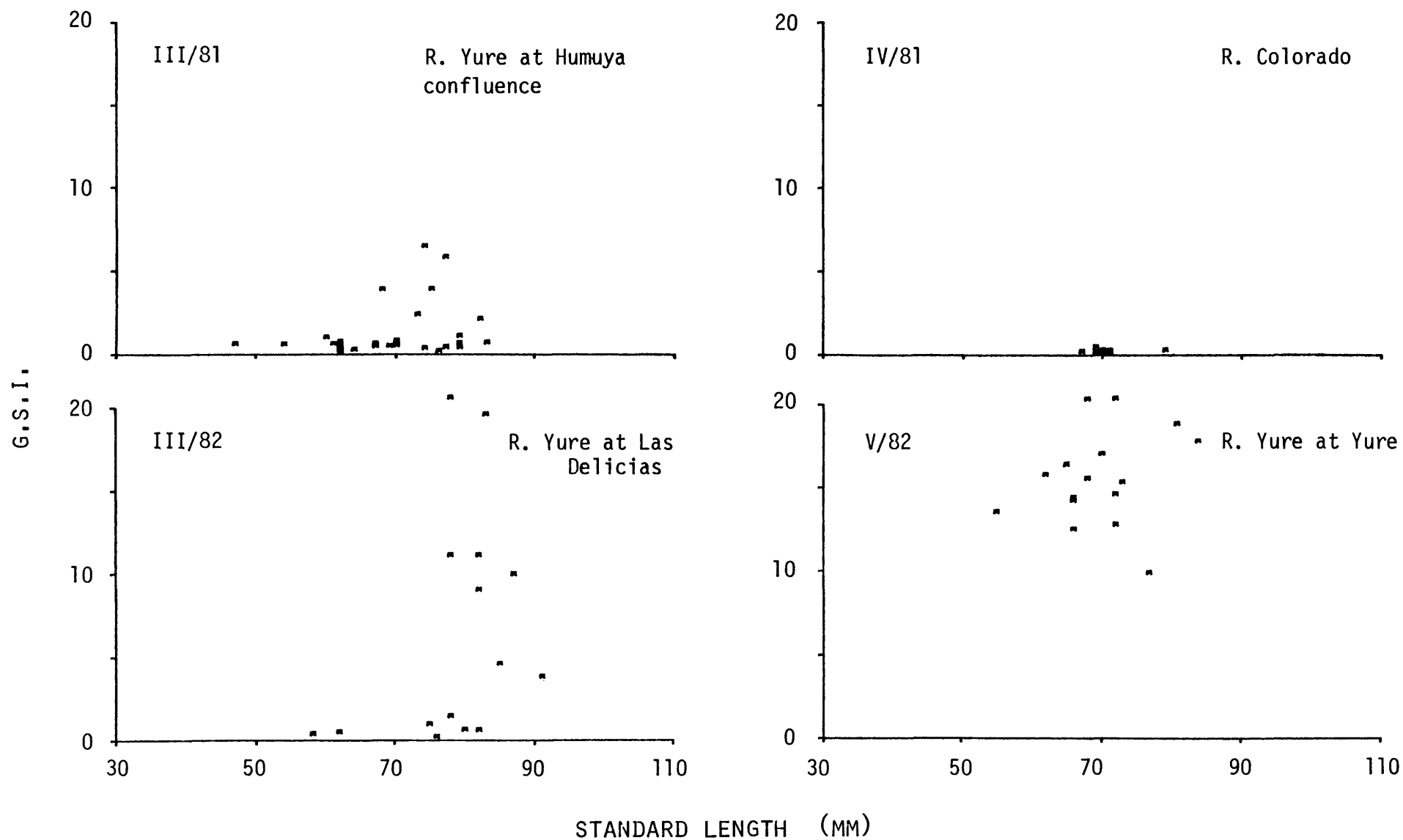


Figure 11.10: Seasonal variation in gonosomatic index of *Astyanax fasciatus*.

Figura 11.10: Variación estacional en el índice somático-gonadal de *Astyanax fasciatus*.

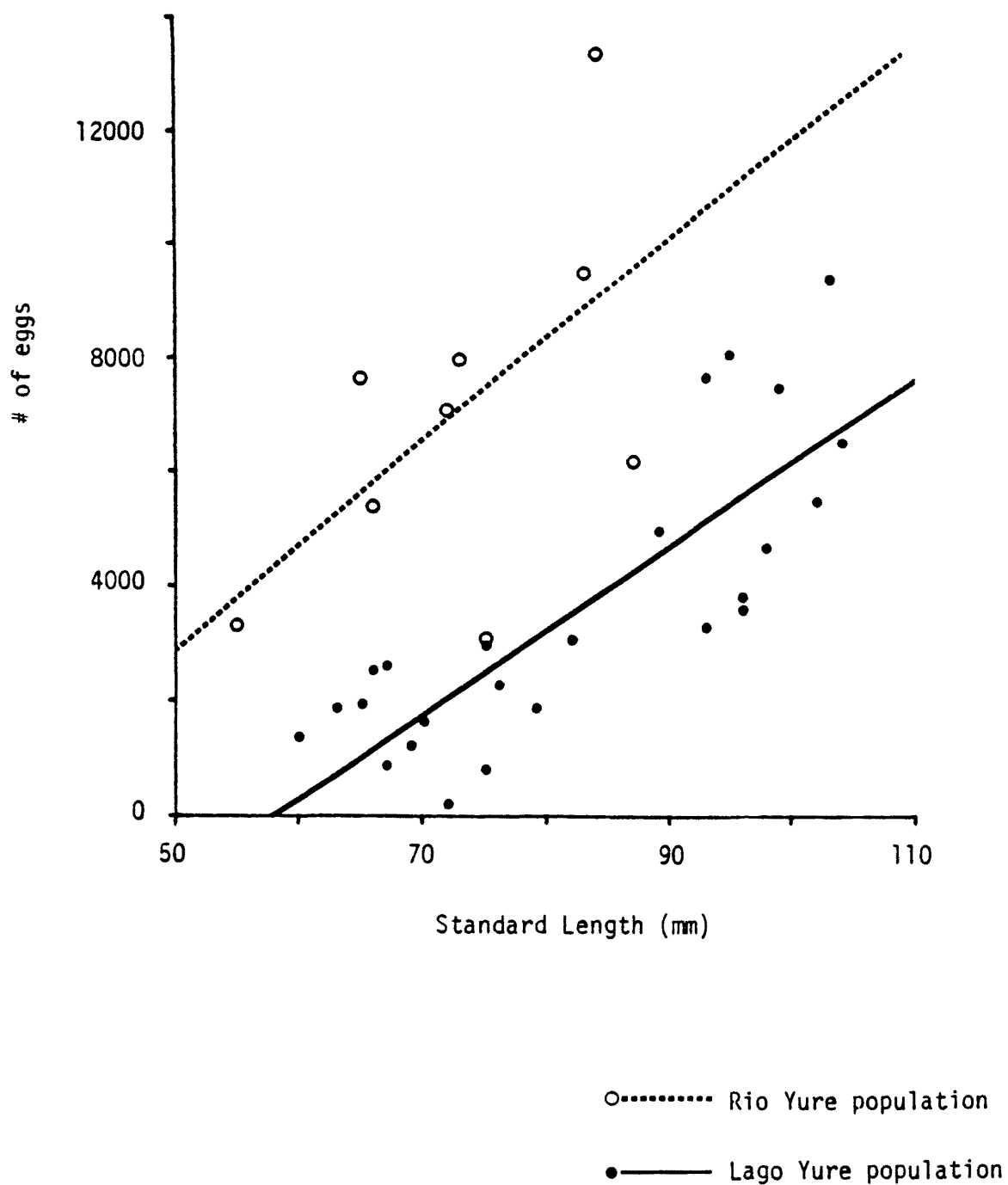


Figure 11.11: Relationship between fecundity and standard length for riverine and lacustrine populations of Astyanax fasciatus.

Figura 11.11: Relación entre fecundidad y longitud estandar en poblaciones de ríos y lagos de Astyanax fasciatus.

pre-vitellogenic (i.e. have not yet started to deposit yolk). The maximum egg dry weight measured from R. Yure samples was 96mg. However, these oocytes were not completely mature, measuring between 0.7 and 0.8mm diameter and being opaque. Data from L. Yure samples indicate that fully mature oocytes weigh slightly more than the 96mg recorded from R. Yure samples (see Section 11.7.3). Females mature at lengths above 65mm and males at a slightly smaller size.

The relationship between female length and fecundity is shown in Fig. 11.11 which compares egg counts from river and lake populations. Although sample size for the R. Yure population is not large, a clear difference is seen between the fecundities of lentic and lotic populations. This will be further discussed in the context of the L. Yure fishery (Section 11.7).

Diet: A. fasciatus is a typical omnivorous species and is well noted for striking at almost anything that falls into pools (e.g. Carr and Giovannoli 1950). Plant material, primarily leaf fragments but also small seeds when they are abundant, represent a major portion of the diet, as illustrated in Fig. 11.12. This was especially so for a sample collected from a moderately deep pool in the R. Yure (Fig. 11.12b). Fish taken from shallower, riffle areas of this river tended to be eating a higher proportion of aquatic insect larvae, especially Trichoptera, Chironomidae and Ephemeroptera. Astyanax is primarily a drift-feeder, i.e. it ingests material being carried along by the river flow. However, the importance of filamentous algae in some samples (e.g. Fig. 11.12c) indicates that benthic feeding occurs as well. Non-aquatic insects (ants) are an additional important food item for sardinas.

The sample collected from a deep R. Yure pool (Fig. 11.12b) was of

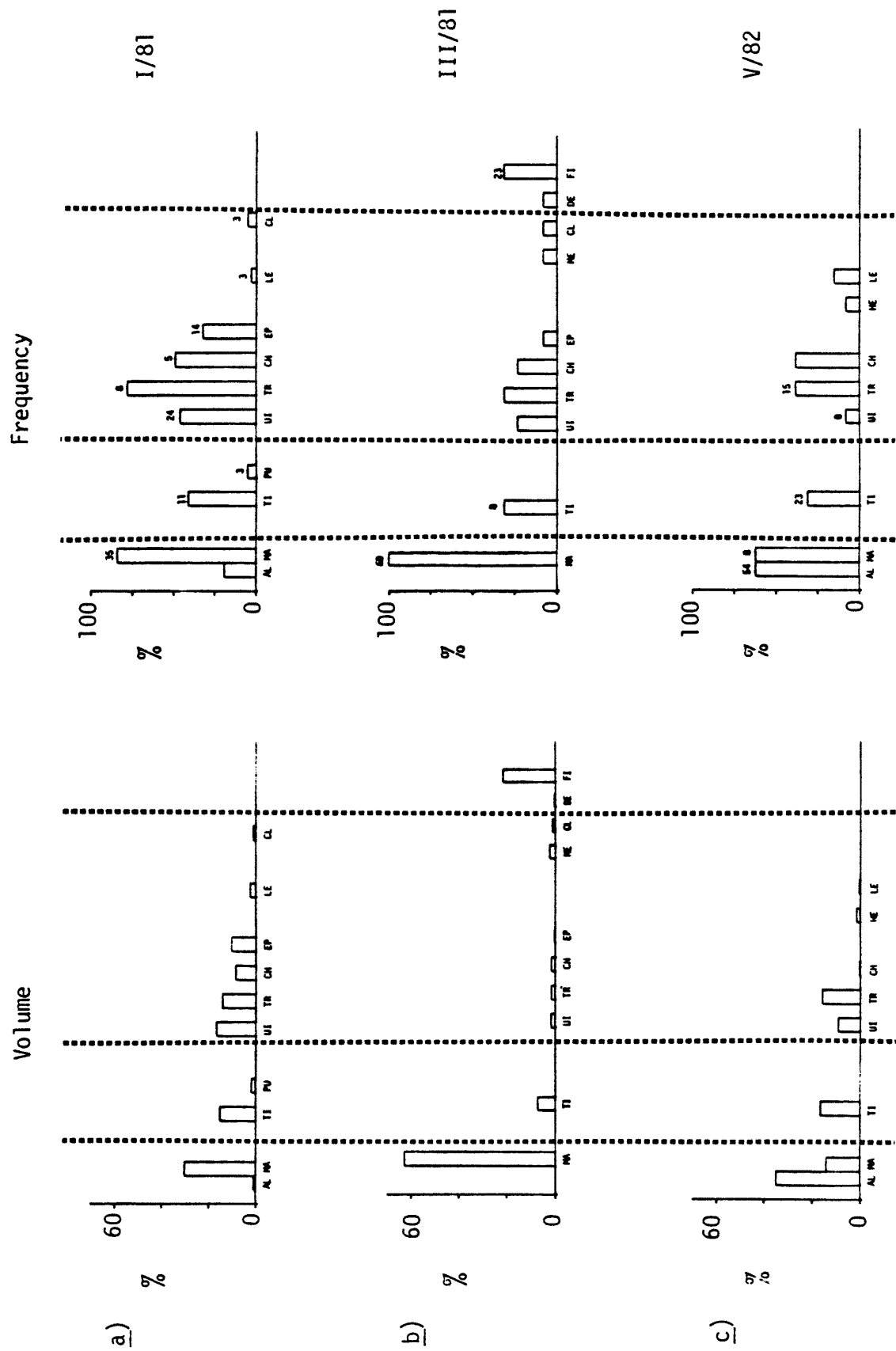
Figure 11.12: Food of Astyanax fasciatus in the R. Yure.

Figura 11.12: Alimentación de Astyanax fasciatus en el río Yure.

KEY:

AL: Algae
MA: Macrophyte fragments
TI: Terrestrial insects
PU: Unidentified pupae
UI: Unidentified insects
TR: Trichoptera lv.
CH: Chironomidae lv.
EP: Ephemeroptera lv.
HE: Hemiptera
LE: Lepidoptera lv.
ME: Megaloptera lv.
CL: Coleoptera lv.
DE: Detritus
FI: Fish

(Numbers over the "frequency" histograms refer to % dominance of the food item. See Section 11.5 for discussion of presentation of diet data.)



special interest in that four individuals were found with fish (sardina juveniles) in their stomachs. Carnivory was never noted in any other sample of this species and in this case the prey fish may have represented individuals stunned by initial sampling activity in the pool. However, at least one other study has documented fish remains in Astyanax stomachs (Hildebrand 1925) and scales were frequently seen in the guts of a Brazilian population (Nomura 1975a). The plasticity in sardina diets will be further illustrated with data from L. Yure (Section 11.7.3).

Brycon guatemalensis (Regan) "Machaca"

The genus Brycon contains many species, a large number of which are important components of large river fisheries in South America (e.g. Goulding 1980). B. guatemalensis is distributed from Mexico to Panama (Miller 1966) and in Honduras has been recorded primarily from the western half of the country (Martín 1972). It was taken from most of the drainages sampled during the present study with the exception of smaller streams. Its upstream limit in the R. Yure lies somewhere between Las Delicias and the L. Yure dam. Before this dam blocked the R. Yure, juveniles of Brycon may have extended up into the steeper-gradient tributaries such as Q. del Cerro. However, the species is now apparently absent from this region.

B. guatemalensis is the second of the two characin species recorded from the El Cajón area. Juveniles are very similar in appearance to Astyanax fasciatus but may be distinguished from the latter species by the slightly different coloration, somewhat larger eyes and characteristic protruding upper jaw of Brycon. Like A. fasciatus, juvenile B. guatemalensis are found mainly in pools but probably prefer swifter water than Astyanax. Two samples taken

Plate 2: Head of Brycon guatemalensis showing characteristic upper jaw dentition.

Foto 2: Cabeza de Brycon guatemalensis mostrando los dientes características de la mandíbula superior.

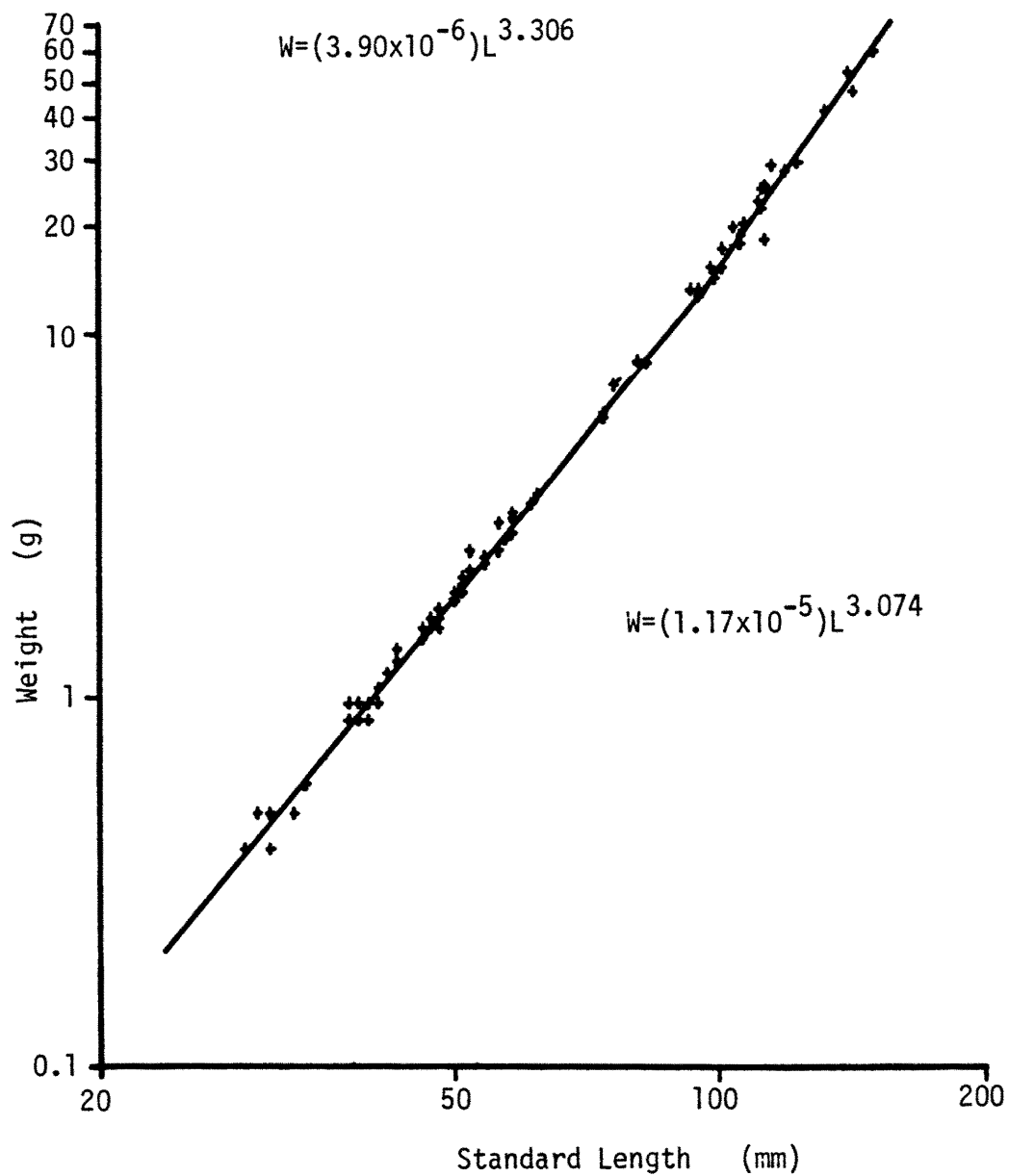


Figure 11.13: Length-weight relationship of Brycon guatemalensis.

Figura 11.13: Relación longitud-peso de Brycon guatemalensis.

with small explosive charges from R. Yure pools indicate that Brycon becomes more abundant relative to Astyanax at lower elevations. At Las Delicias, the Brycon:Astyanax ratio was 1.0:9.2 and 1.0:5.0 in terms of numbers and biomass, respectively. Downstream, near the Humuya confluence, the equivalent ratios were 1.0:1.7 and 1.0:0.9 (Table 11.5, Fig. 11.7).

Although Brycon juveniles closely resemble Astyanax, the former species grows to a much larger size than the latter. The largest individual recorded during the present study measured 363 mm S.L. and weighed 1.2 kg. This does not represent the maximum size for the species, however, which probably exceeds 5 kg (Carr and Giovannoli 1950). The larger size classes were captured only from the main Humuya and Sulaco rivers, primarily with gill nets. The length-weight relationship for B. guatemalensis is shown in Fig. 11.13. This regression has been compiled from samples collected in different seasons throughout the study and includes both sexes.

Information on the reproductive ecology of machaca is limited since large individuals were only captured during the dry season (March-April) and only two of these had mature gonads. One was male (S.L. = 355 mm, GSI = 0.99) and the other female (S.L. = 360, GSI = 7.25). Both were taken from the Sulaco near Salitrón Viejo in April. Two other males (363 and 355 mm) caught at the same time were spent, i.e. had just reproduced. The female referred to above contained an estimated 12,122 clear yellow eggs, most of which measured 2.0 - 2.2 mm in diameter. Mean egg wet weight was 5.2 (± 0.2) mg and mean dry weight 1.6 (± 0.03) mg. The size at first reproduction in this species is not known, but individuals smaller than 220 mm consistently showed no gonad maturation. Apart from the fact that spawning occurs in April, nothing is known of the seasonality of reproduction in B. guatemalensis. The existence of two

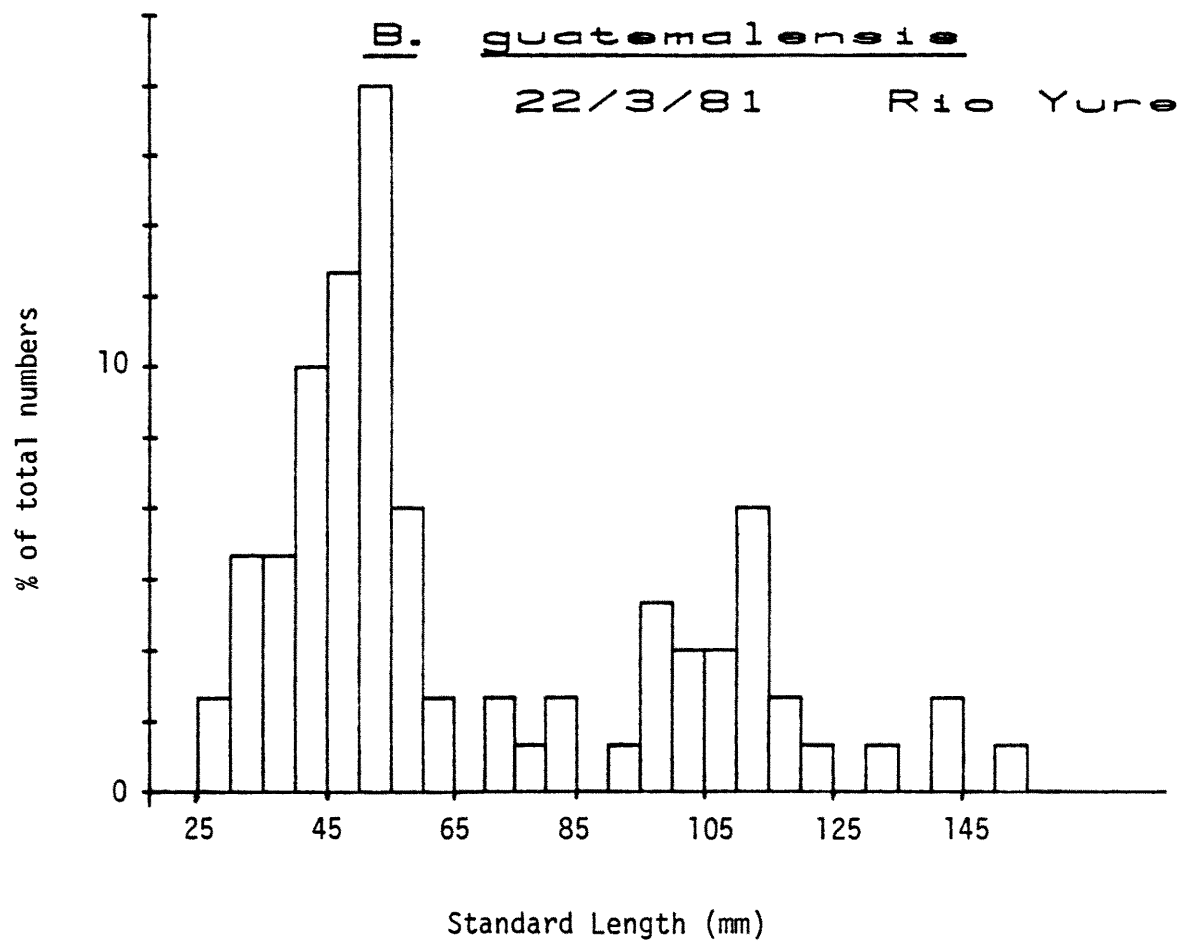


Figure 11.14: Size frequency distribution of Brycon guatemalensis R. Yure, March 1981.

Figura 11.14: Frecuencia de tamaños de Brycon guatemalensis en el río Yure, marzo de 1981.

reasonably distinct juvenile size classes in the March 1981 sample from the R. Yure (Fig. 11.14) suggests that spawning may be quite restricted in time. Other Brycon species in the Amazonian region of South America exhibit distinct seasonal reproductive migrations. Adults move from flooded forest and tributary rivers to main river channels in the wet season, where they spawn before moving back up the tributaries (Goulding 1980). Reproductive migrations may also occur in Honduran Brycon populations, but of course the enormous food resource represented by seasonally flooded forest in the Amazon basin is largely absent from most Honduran rivers. Another Central American Brycon species, B. petrosus, spawns outside the water, on wet gravel (Kramer 1978).

Machaca exhibit a distinct change in diet as they grow (Fig. 11.15). In juveniles smaller than about 90mm., aquatic insect larvae (mainly Trichoptera and Ephemeroptera) and non-aquatic insects (ants, especially) make up 50% or more of the diet, with the remainder being composed of leaf fragments, fern prothalli, and seeds. Larger size classes become increasingly herbivorous, with seeds representing the major item in the diet. The food analyses presented in Fig. 11.15 refers to one sample date only (March) in order to better show the relationship between fish size and diet. However, other samples conclusively demonstrated the importance of plant material, especially seeds and fruits, in the diet of large Brycon. Guts of individuals larger than 150mm contained no invertebrates at all. A variety of seeds and fruits were being eaten, with Enterolobium ("guanacaste") and Guazuma ("caulote") being especially common. Other plant material included Inga, Mimosa and Phalaris.

The jaws of B. guatemalensis are strong and presumably well adapted for

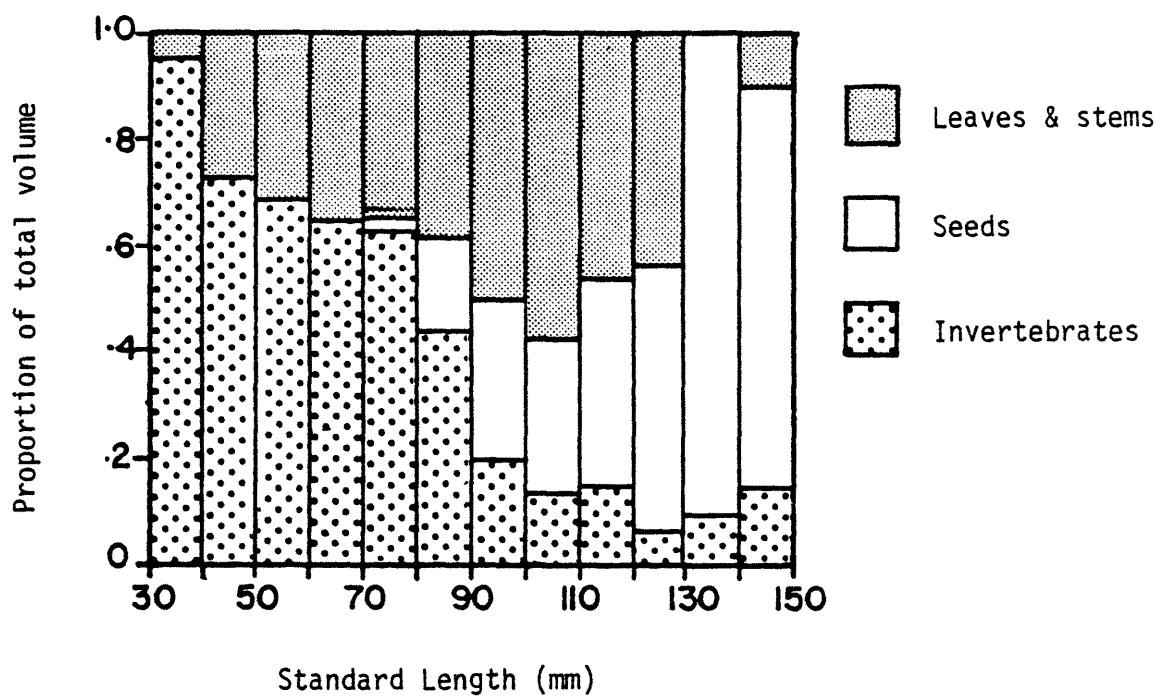


Figure 11.15: Food of *Brycon guatemalensis* in the R. Yure, March 1981.

Figura 11.15: Alimentación de *Brycon guatemalensis* en el río Yure en marzo de 1981.

crushing hard-shelled seeds. In adults, the upper jaw is distinctly longer than the lower and possesses a characteristic dentition. The adaptive value of this morphology is unclear but may assist in manipulating large seeds and fruits. However, other species of Brycon are well known for their fruit/seed eating habits (Knoppel 1970, Goulding 1980) but do not have the jaw characteristic of B. guatemalensis.

11.6.2.2 Gymnotidae:

Gymnotus cylindricus (La Monte)

G. cylindricus is the only gymnotid species which occurs as far north as Honduras. Martin (1972) states that both Atlantic and Pacific populations should be assigned to G. cylindricus, whereas Miller (1966) had previously considered Pacific slope populations as a different, undescribed species. The identification of gymnotids from the Choluteca drainage as G. carapo (Carr and Giovannoli, 1950) is apparently incorrect (Martin 1972). G. cylindricus is a member of the family that includes the well known electric eel (Electrophorus electricus) of S. America. Although all gymnotids possess electrogenic organs, most produce only very weak discharges.

G. cylindricus is apparently rare in the El Cajón area, since only five specimens were collected during the entire study. If it had been abundant, electroshocker sampling should have caught many more individuals, since its preferred habitat is beneath boulders and along stream banks, places which are relatively easily sampled with an electroshocker. It was recorded from L. Yure as well as further downstream in the R. Yure (Table 11.5).

Samples collected during the present study ranged from 161 to 195mm total

Table 11.6 : Food of Gymnotus cylindricus.

Tabla 11.6 : Alimentación de Gymnotus cylindricus.

<u>Item</u>	<u>Vol. (%) *</u>	<u>Freq. (%) *</u>	<u>Dom. (%) *</u>
<u>Desmidium</u>	4	66	-
Uniden. insect frag.	5	33	-
Anisoptera lv.	23	66	33
Trichoptera lv.	5	33	-
Chironomidae lv.	2	33	-
Ephemeroptera lv.	14	66	-
<u>Paragyractis</u>	10	66	-
Detritus	37	66	66
<hr/>			
N analyzed :	5		
N + food :	3		
Length range (mm)	161-195		

* In this and all subsequent food analysis tables, Vol., Freq., and Dom. refer to the three methods of diet representation explained in Section 11.5.

N analyzed: refers to total number of fish examined for food description.

N + food : refers to number of fish containing food.

length (12.4-31.4g). One female, taken in November from the R. Cacaguapa was mature, the ovary containing eggs which ranged in size from 0.4 to 2.5mm diameter. There were two fairly distinct size classes, the first 0.5-1.5mm, the second 2.2-2.5mm. In the latter size class, a total of 82 eggs was counted. The egg size frequency distribution suggests that this species is a fractional spawner. A reservoir population of G. carapo in Brazil spawns from October to December (Barbieri and Barbieri 1983). Individuals first attain maturity in their second year and males grow to a larger size than females.

G. cylindricus is a nocturnally active species. Diet analyses of the three individuals that contained food in the stomach are summarized in Table 11.6, and indicate that this species is primarily insectivorous. Note, however, that a relatively high proportion of the stomach contents consisted of unrecognizable detritus. Studies of the closely related species G. carapo and G. anguillaris in the central Amazonian region have likewise shown the importance of aquatic insects in gymnotid diets while additionally revealing G. carapo to be partially piscivorous (Knöppel 1970). It is clear that more information on the reproductive and feeding ecology of G. cylindricus is needed.

11.6.2.3 Pimelodidae:

Rhamdia cabrerai (Meek) "Bagre"

Distribution: This catfish species is easily distinguished from the other Honduran species of Rhamdia by its relatively short adipose fin and short maxillary barbles. It is distributed in Central America from Guatemala to the Choluteca drainage along the Pacific slope and to the Ulúa basin along the Atlantic slope (Martin 1972, Miller 1966).

R. cabreræ is a species characteristic of smaller rivers and higher elevations. For example, in the El Cajón area, it was the only Rhamdia species recorded from the upper part of the R. Yure, (at San Bartolo and in the L. Yure tributaries; but see discussion of R. guatemalensis distribution, below). It is especially common in the R. Tamalito (Table 11.5). In larger rivers, R. cabreræ is less abundant, but remains a persistent part of the fauna (Fig. 11.7). It is a nocturnally active species and during the day is found under boulders and along river banks.

Population Structure: Samples from the R. Tamalito are used here to illustrate size frequency distributions of R. cabreræ because many more fish were collected from this river than from the R. Yure. Data from the Yure samples, however, indicate that population structure was essentially the same in this river as in the R. Tamalito. Fig. 11.16 summarizes the Tamalito population structure in November and January. Individuals larger than about 140mm were almost certainly present in the population but were probably inhabiting deeper pools downstream from the sampling site (which consisted mainly of riffle areas). Although modal lengths of both sexes were very similar, the female size frequency distribution differed from that of the males by being more skewed towards the larger size classes. Females were usually more abundant than males in the Tamalito and other riverine populations (Table 11.7), so it is possible that additional sampling of Tamalito males would have revealed a skewed size structure similar to that of the females. In both the Tamalito and Yure rivers there was some evidence for slightly more even sex ratios in January and March than during the rest of the year, but the trend was not very strong (except for the Tamalito 1982-83

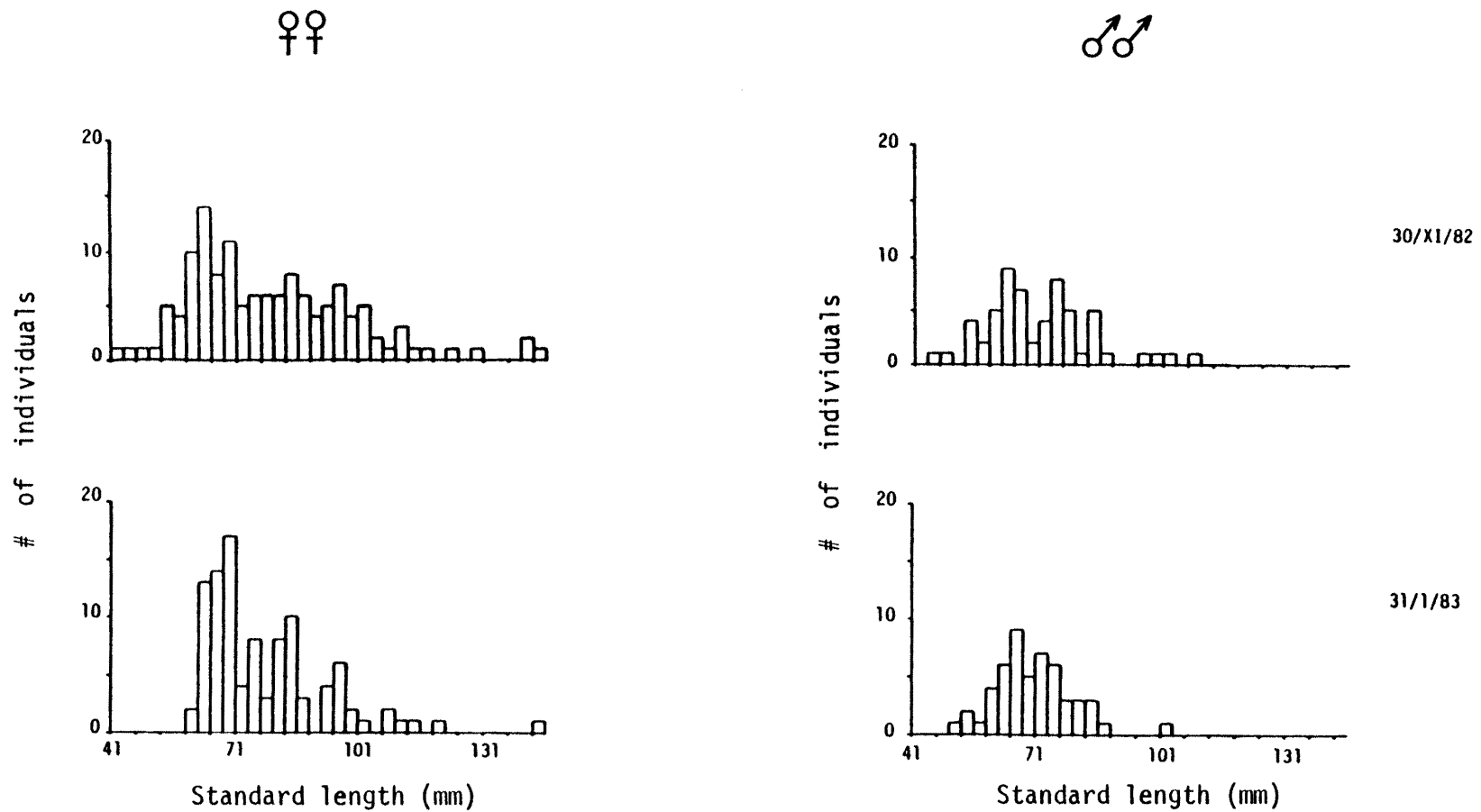


Figure 11.16: Size frequency distributions of Rhamdia cabrerai in the R. Tamalito.

Figura 11.16: Distribuciones por tamaño de Rhamdia cabrerai en el río Tamalito.

Table 11.7 : Sex ratio of riverine populations of Rhamdia cabreræ.

Tabla 11.7 : Proporción de sexos en poblaciones riverinas de Rhamdia cabreræ.

<u>River</u>	<u>Date</u>	<u>♀ : ♂</u>	<u>N</u>
Tamalito	XII/81	2.1 : 1	243
" "	I/82	1.9 : 1	108
" "	XI/82	2.3 : 1	237
" "	I/83	1.0 : 1	248
Yure	VI/81-III/82	1.8 : 1	86
Colorado	IV/81	1.7 : 1	41

data).

R. cabreræ spawns over a period of several months (see below) and this behavior presumably produces the relatively broad peaks in the size frequency distributions illustrated in Fig. 11.16.

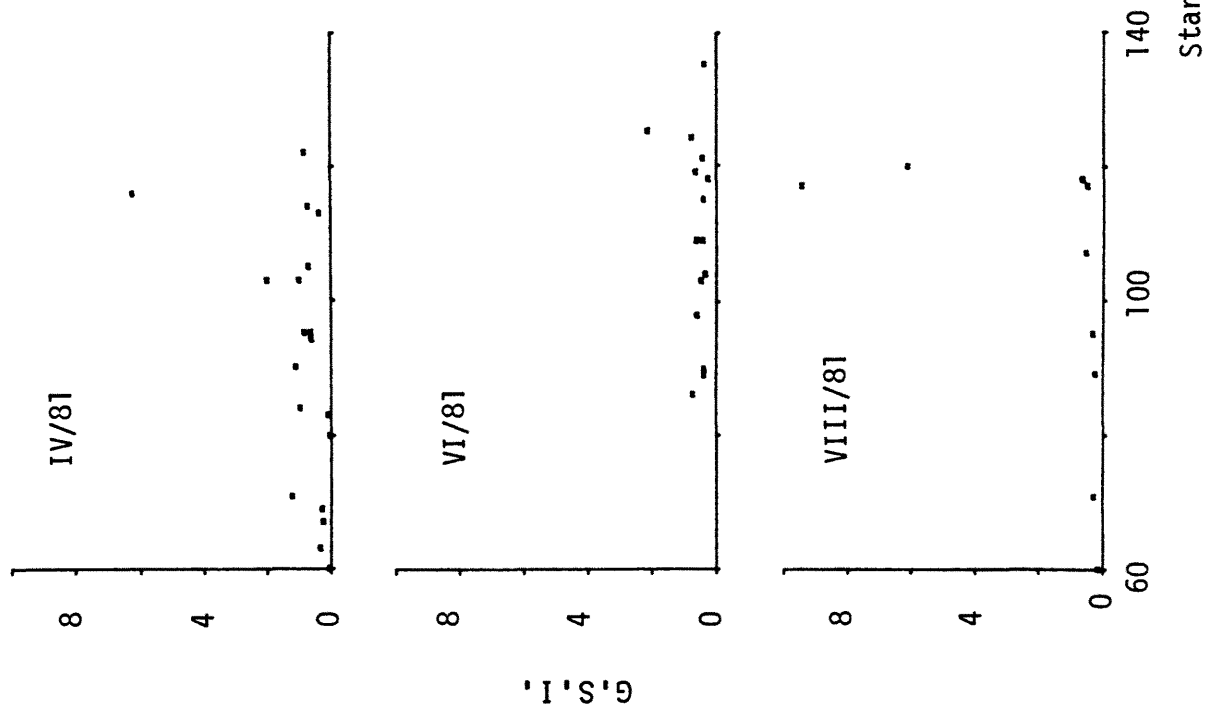
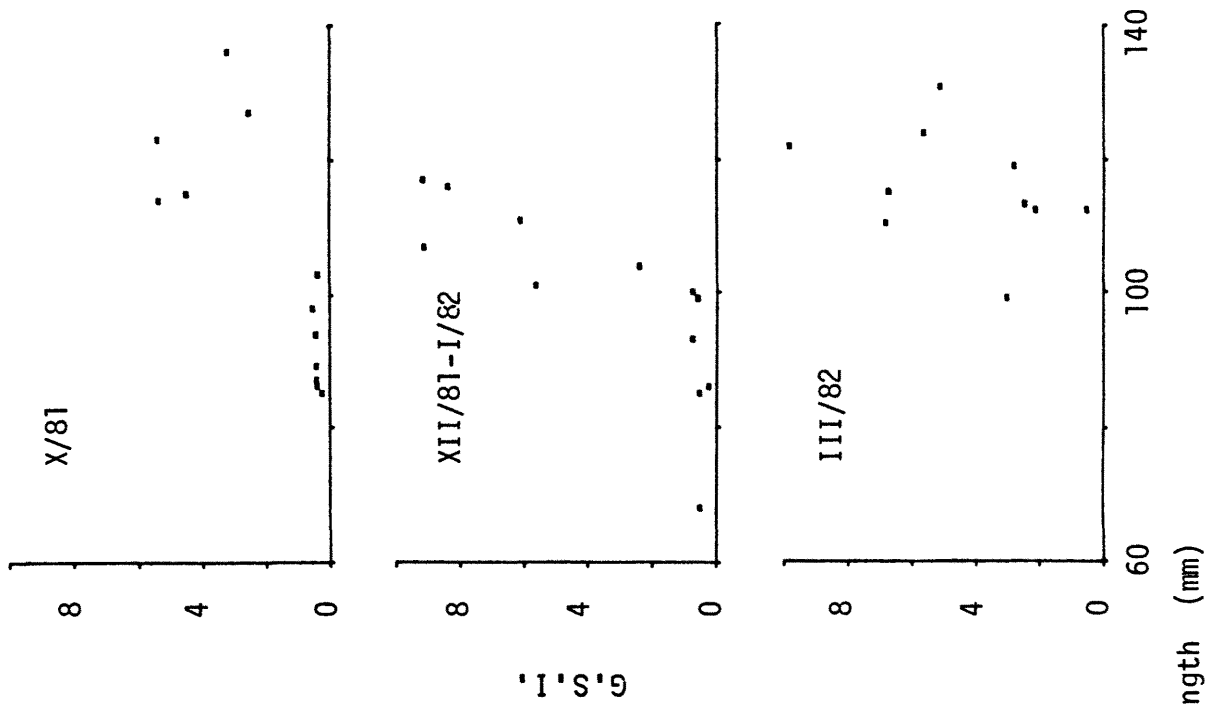
Reproduction: Scatter diagrams of GSI vs. standard length are shown in Fig. 11.17 for R. Yure and R. Colorado populations of R. cabreræ. These plots, together with data from the R. Tamalito, indicate that this species first reaches maturity at a length of about 65mm.

In April the ovaries of most females (in the Colorado population) were in the resting stage with oocytes usually measuring less than 0.2mm. However, a few individuals were reproducing. By June yolk, deposition in the oocytes had begun and the modal diameter was between 0.2 and 0.4 mm. From August to January an increasing proportion of females had mature ovaries and reproductive activity was still relatively high in mid-March. In no month was the stage of gonadal development uniform between individuals; only a section of the population was reproductively active at any one time. It is not yet clear whether individuals spawn more than once during the year. Mature ovaries contain two egg size classes, one measuring approximately 1.3-1.5 mm diameter, the other representing immature eggs and measuring less than 0.3mm (see Fig. 11.48, Section 11.7).

Although an extended time series does not exist for the R. Tamalito population, data collected in December 1981 and January 1982 suggest that the dry season peak in reproductive activity may be less broad than it is in the case of the R. Yure population. Mean values (± 1 standard deviation) of the gonadal-length index (GLI - see Methods Section, 11.5) were as follows:

Figure 11.17: Seasonal variation in the gonosomatic index of Rhamdia cabrerae in the R. Colorado (IV/81) and the R. Yure at Yure (VI/81-III/82).

Figura 11.17: Variación estacional en el índice somático-gonadal de Rhamdia cabrerae en el río Colorado (IV/81) y el río Yure en Yure (VI/81-III/82).



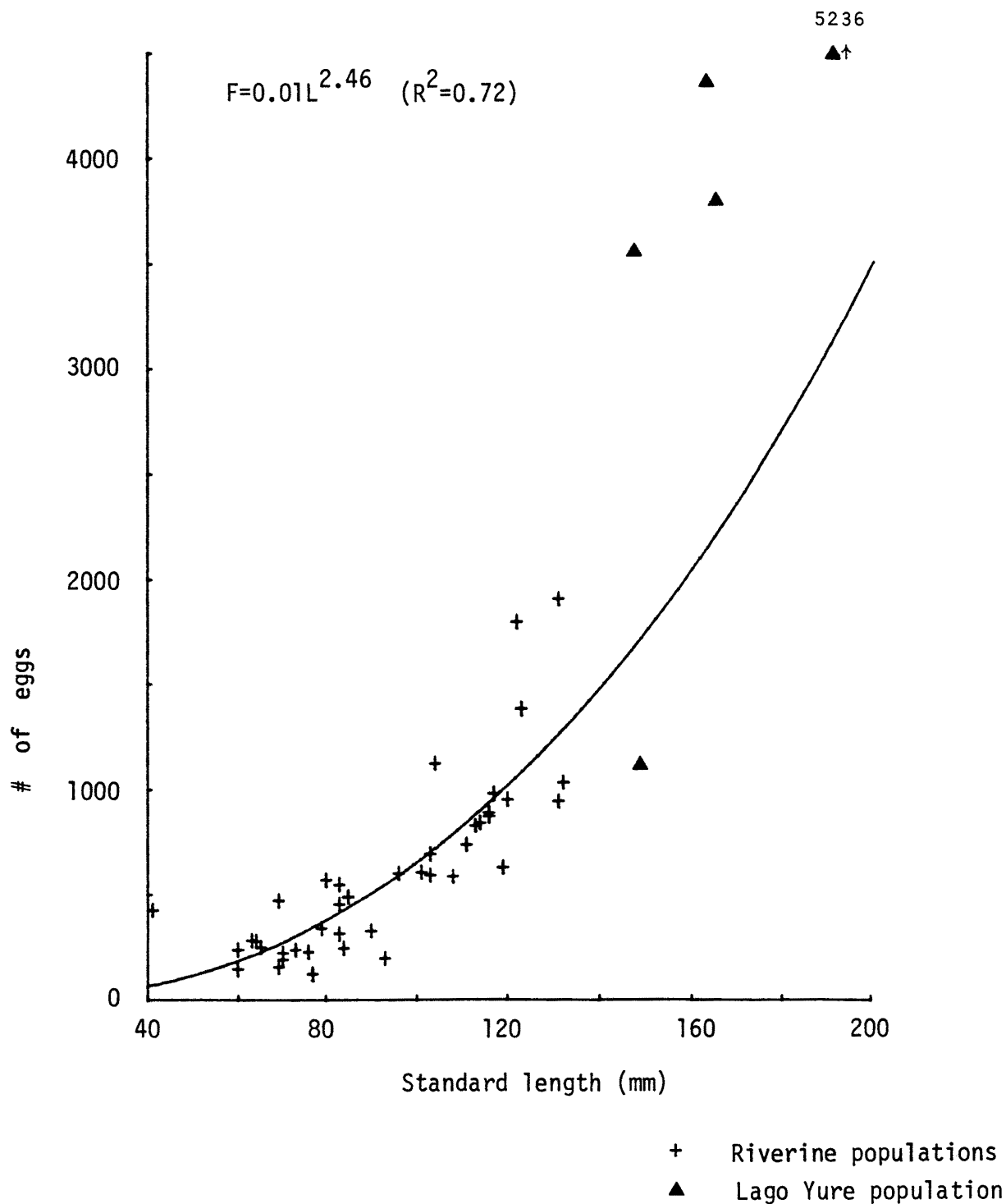


Figure 11.18: Relationship between fecundity and standard length for riverine and lacustrine populations of *Rhamdia cabrerarae*.

Figura 11.18: Relación entre fecundidad y longitud estandar en poblaciones de ríos y lagos de *Rhamdia cabrerarae*.

<u>Month</u>	<u>GLI</u>	
	<u>Females</u>	<u>Males</u>
XII/81	8.87 (± 5.62)	5.46 (± 3.10)
I/82	3.04 (± 3.51)	2.20(± 1.87)

These data show that there was a relatively sharp decrease in the gonad maturation index between December and January (compare with the data in Fig. 11.17).

The relationship between fecundity and female size is shown in Fig. 11.18 in which egg counts from the Yure and Tamalito populatons are compared with those from the L. Yure population.

Diet: R. cabreræ feeds at night, almost entirely on benthic aquatic insect larvae. Fig. 11.19 summarizes diet analyses carried out on a sample series from the R. Yure. A major proportion of stomach contents had to be categorized as unidentified insect fragments on account of their maceration by the pharyngeal teeth and/or digestion within the stomach. However, this fraction appeared to be composed primarily of Ephemeroptera and Plecoptera. Apart from this fraction of uncertain identity, the major food item consisted of Trichoptera larvae, both cased and caseless forms. Helicopsyche, Agarodes and Oecetis were common members of the first category. Several species of the family Hydropsychidae, especially Leptonema and Smicridea, represented the second category. Dipteran larvae were also being eaten, but rarely in large quantities. They included members of the Chironomidae and Heleidae. Simuliidae larvae were only seen in the stomachs on one occasion, during the wet season. Non-aquatic insects were generally of low importance in the diet of this catfish, a feature to be expected from its benthic habits.

Fig. 11.19 shows that diet composition varied little through the year.

Figure 11.19: Food of Rhamdia cabreræ in the R. Yure at Yure.

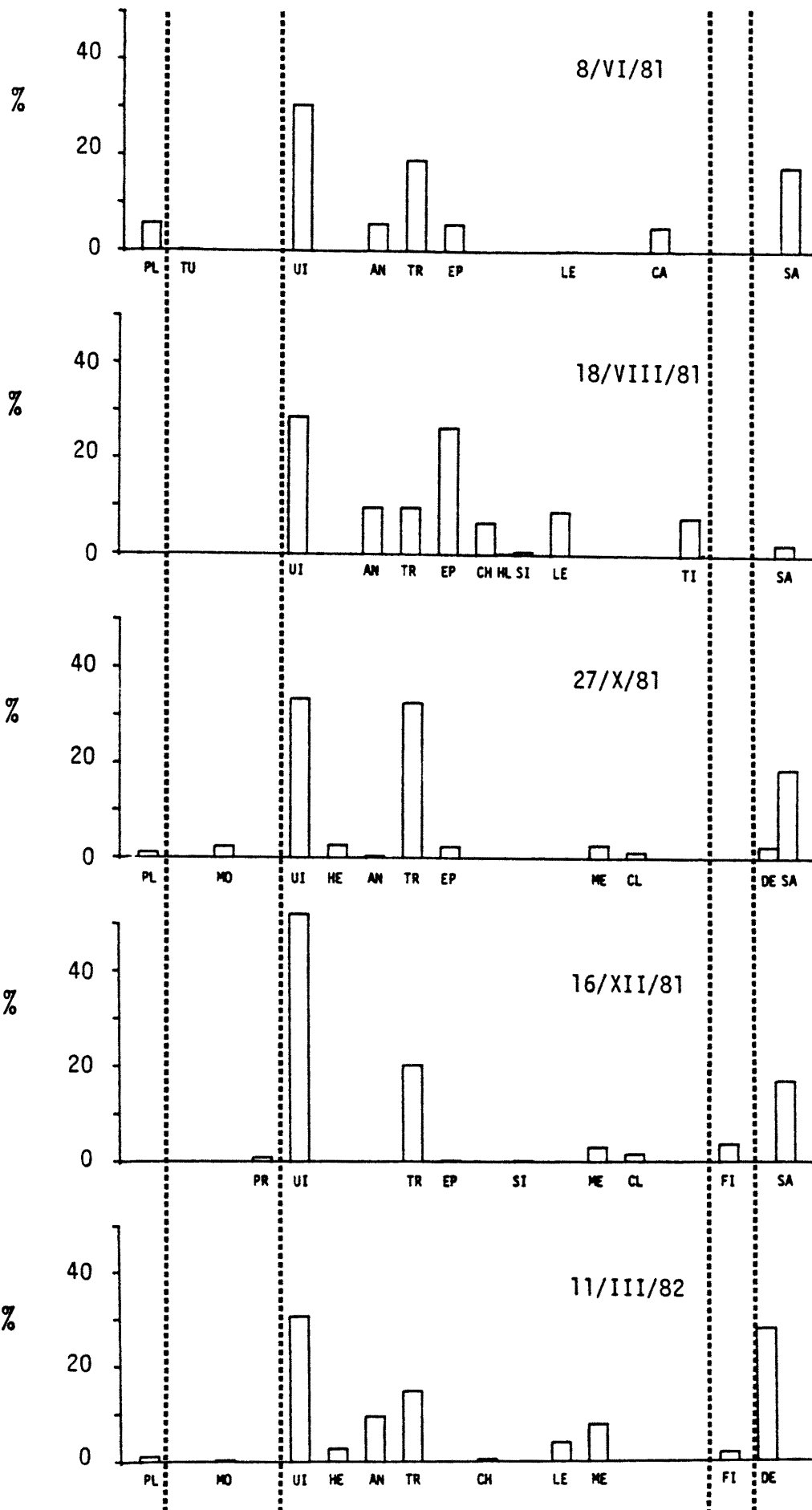
Figura 11.19: Alimentación de Rhamdia cabreræ en el río Yure en Yure.

KEY:

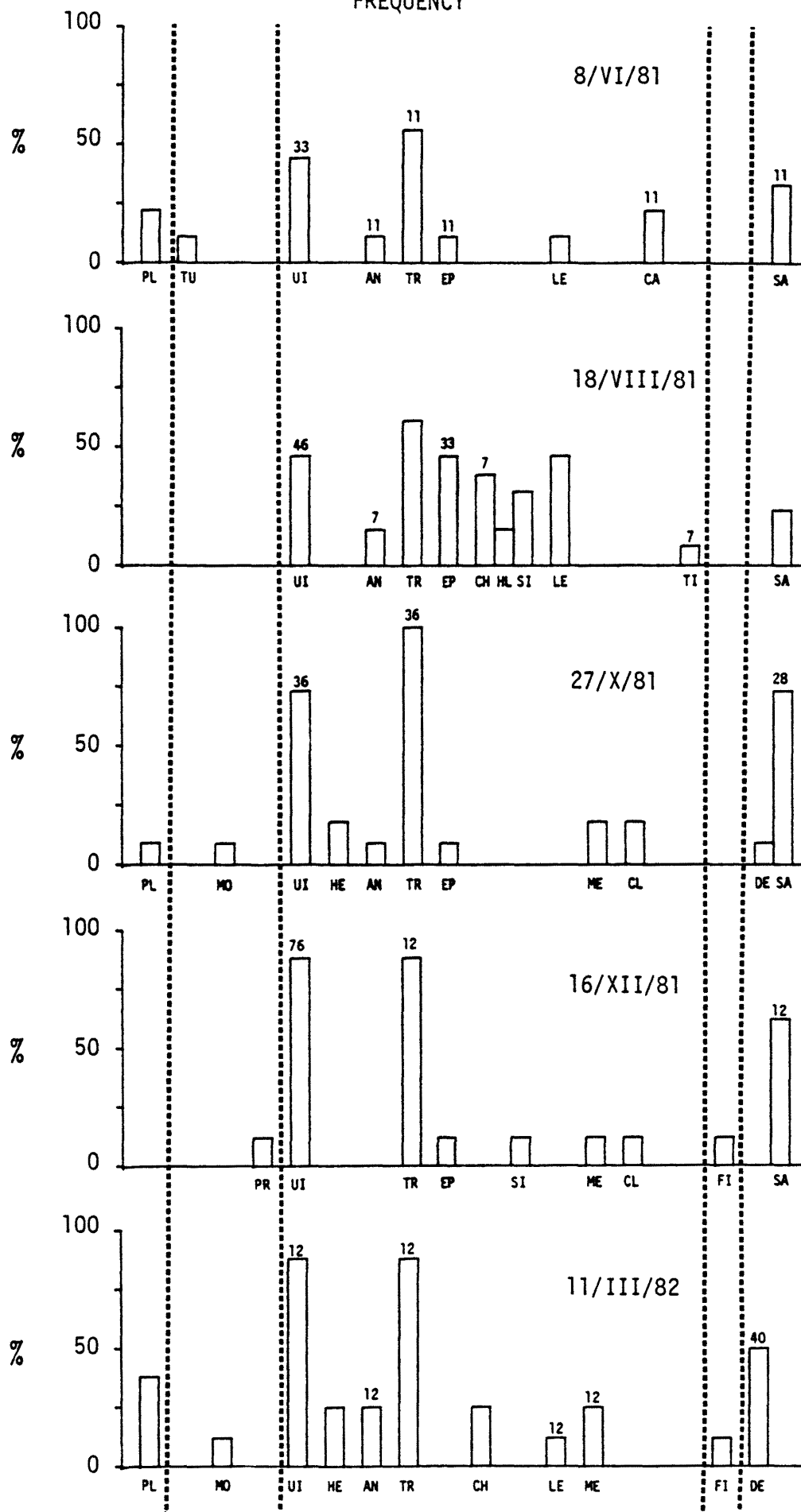
PL: Plant fragments
TU: Turbellaria
MO: Molluscs
PR: Prawns
UI: Unidentified insects
HE: Hemiptera
AN: Anisoptera
TR: Trichoptera lv.
EP: Ephemeroptera lv.
CH: Chironomidae lv.
HL: Heleidae lv.
SI: Simuliidae lv.
LE: Lepidoptera lv.
ME: Megaloptera lv.
CL: Coleoptera lv. CA: Coleoptera adults
TI: Terrestrial insects
FI: Fish
DE: Detritus SA: Sand

(Numbers over the "frequency" histograms refer to the % dominance of the food item.)

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Although 50% or more of stomachs were often empty, this reflects the nocturnal feeding habit of the species rather than low environmental food levels. The intestinal tract was over 2/3 full in most specimens. Greatest fat accumulation was observed in samples taken at the beginning of the wet season (June) when reproductive activity was at its lowest (Table 11.8). At this time, the modal fat stage (see p. 5.113, Vol. 1) was 4 (range = 2-4). By the end of the reproductive season (March), fat accumulation was at its lowest level (modal stage = 1). In other months, most fish exhibited index values within the range 1-3 (mode always = 2).

Age and Growth: Data from the R. Tamalito indicate the possibility of determining growth rates of Rhamdia by cohort analysis. This method would be especially useful for these catfish since they lack scales. Size frequency distributions from the R. Tamalito population (e.g. Fig. 11.16) suggest growth rates of about 5-8mm per month, which would support the hypothesis that the peak in the size distribution of this population in November (Fig. 11.16) represented individuals spawned during the previous dry season. A more extended time series of samples is needed to better document growth rates of R. cabreræ. It should be noted that, if sufficiently large samples of R. guatemalensis could be obtained, cohort estimates of growth rates might well be more feasible for this species than for R. cabreræ, since R. guatemalensis has a shorter reproductive season, and thus is more likely to produce distinct cohorts.

Rhamdia guatemalensis (Günther) "Bagre"

Distribution and Taxonomy: R. guatemalensis is more widely distributed than

Plate 3: Rhamdia cabreræ (bagre), 133 mm S.L.

R. cabreræ, being present on both slopes of Middle America from Mexico to Costa Rica (Martin 1972, Miller 1966). It has been recorded from all the major drainages of Honduras (Martin 1972). R. guatemalensis is very similar to another catfish species, R. motaguensis, which has also been recorded from Central Honduras. Martin (1972) provides distinguishing characteristics for these two species and, more recently, Zúniga-Vega (1980) has studied the taxonomy of Rhamdia in Costa Rica. Samples taken from rivers of the El Cajón watershed during the present study agreed well with Martin's description for R. guatemalensis. However, a few individuals examined from L. de Yojoa displayed characteristics intermediate between R. guatemalensis and R. motaguensis.

R. guatemalensis does not extend as far up into stream headwaters as does R. cabreræ. For example, it was not recorded from the L. Yure tributaries, Q. del Cerro and Q. Sin Nombre. It was, however, found in L. Yure itself and so must have been present in that section of the R. Yure before impoundment. Further downstream, at the village of Yure, R. guatemalensis was routinely recorded, representing approximately 2% and 5% of the community in terms of numbers and biomass respectively (Fig. 11.7). The ratio of R. guatemalensis to R. cabreræ at this station ranged from about 2.0:1.0 to 0.3:1.0 (Table 11.5). In larger rivers, R. guatemalensis was usually more abundant than R. cabreræ.

As with other members of this genus, R. guatemalensis is nocturnal and is found principally in quieter water, in pools and beneath boulders. Carr and Giovannoli (1950) note that the young are frequently found under rocks in riffle areas.

April 1981

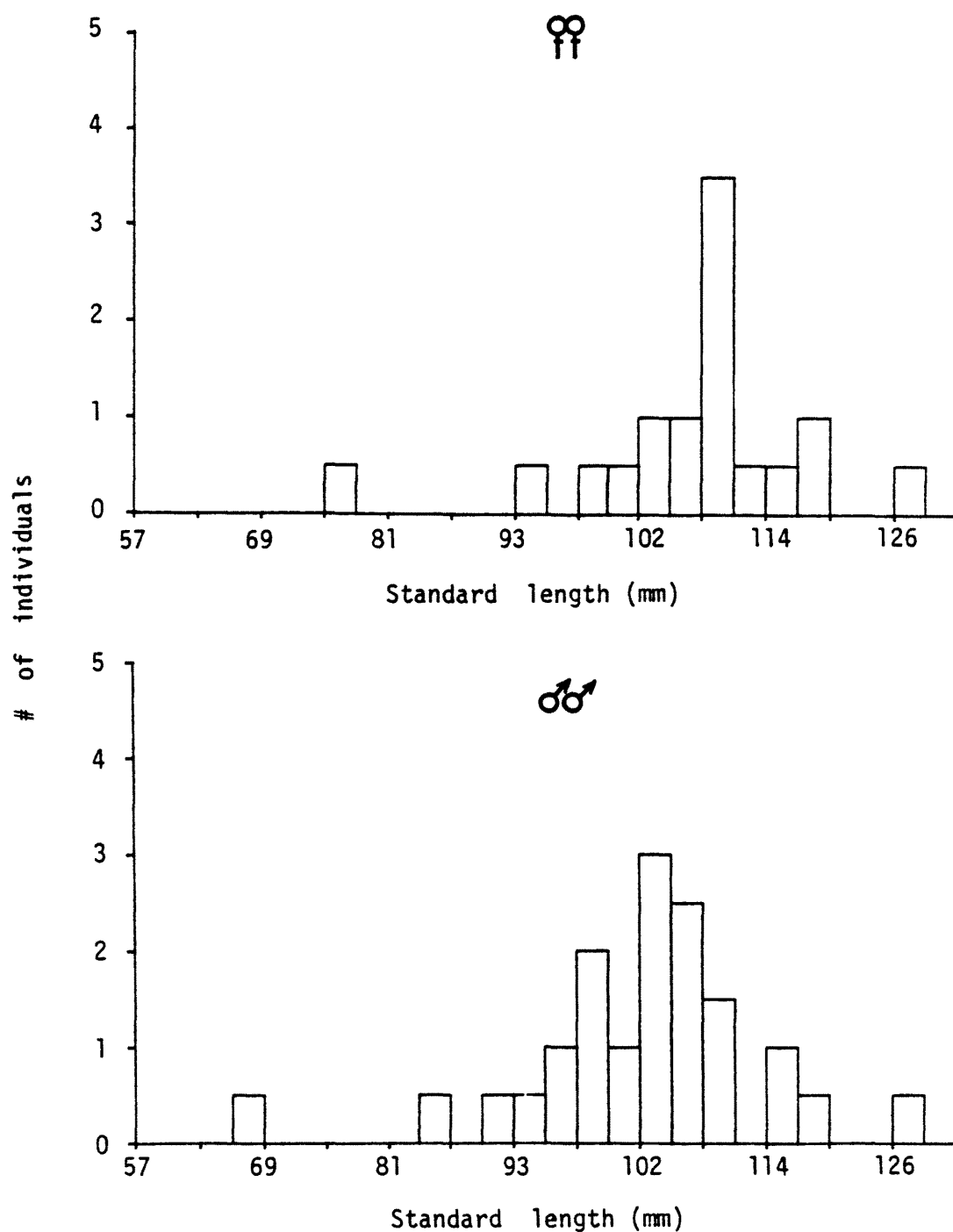


Figure 11.20: Size frequency distribution of *Rhamdia guatemalensis* in the R. Colorado, April 1981.

Figura 11.20: Distribución por tamaño de *Rhamdia guatemalensis* en el río Colorado en abril de 1981.

Population Structure: As was the case for R. cabreræ, females of R. guatemalensis were nearly always more abundant than males. For example, the average female:male ratio for a series of six samples from the R. Yure was 1.9:1.0, remarkably similar to the ratios encountered with R. cabreræ (Table 11.7). Samples collected during the present study generally were not large enough to allow preparation of detailed size-frequency distributions. Nevertheless, the distribution presented in Fig. 11.20, (from a sample collected in April from the R. Colorado) is probably typical of most populations in rivers of this size. Sample size is obviously too low to permit any conclusive analysis, but two major size classes are suggested by this figure. More extensive sampling of this species in the future may demonstrate the feasibility of using cohort analysis to estimate growth rates.

Reproduction: Samples collected in April (R. Sulaco and R. Colorado) and June (R. Yure) contained a larger proportion of individuals with maturing or mature gonads. In all other samples, few if any mature individuals were taken. Thus it appears that R. guatemalensis spawns mainly towards the end of the dry season and beginning of the wet season, at precisely the time when the other species of catfish in these rivers, R. cabreræ, is not reproducing. However, it should be noted that, because samples sizes are relatively small, low spawning frequencies during other months may not have been registered in these collections. Specifically, it is unclear whether significant reproduction occurs during the first half of the dry season since Carr and Giovannoli (1950) collected mature females from the R. Choluteca in February.

Length at first reproduction is about 120mm and 90mm for females and males respectively. Mature oocytes measure 0.9-1.0mm in diameter and have a dry weight of approximately 0.1mg. The egg counts made from riverine samples

Figure 11.21: Food of Rhamdia guatemalensis , R. Yure.

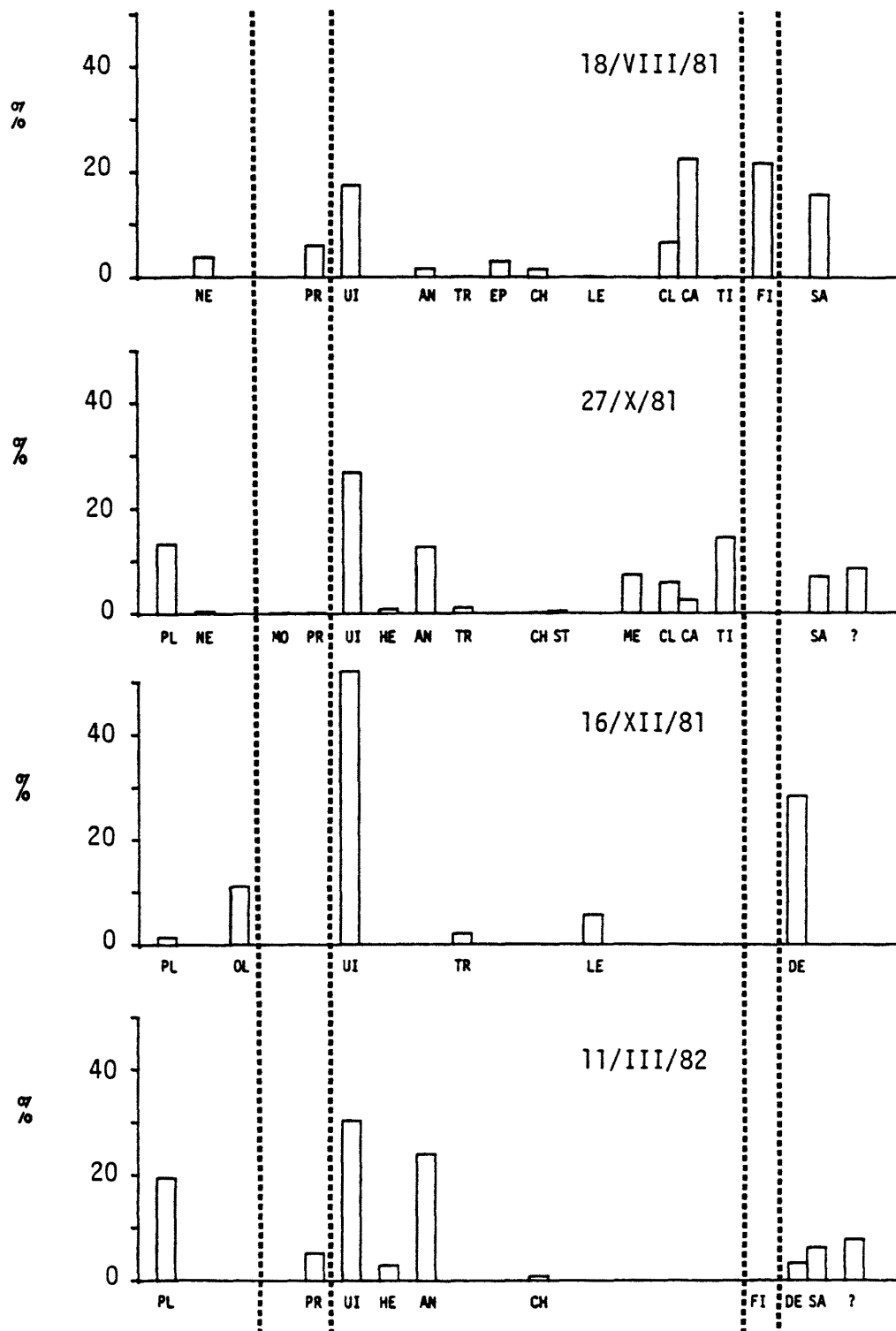
Figura 11.21: Alimentación de Rhamdia guatemalensis en el río Yure.

KEY:

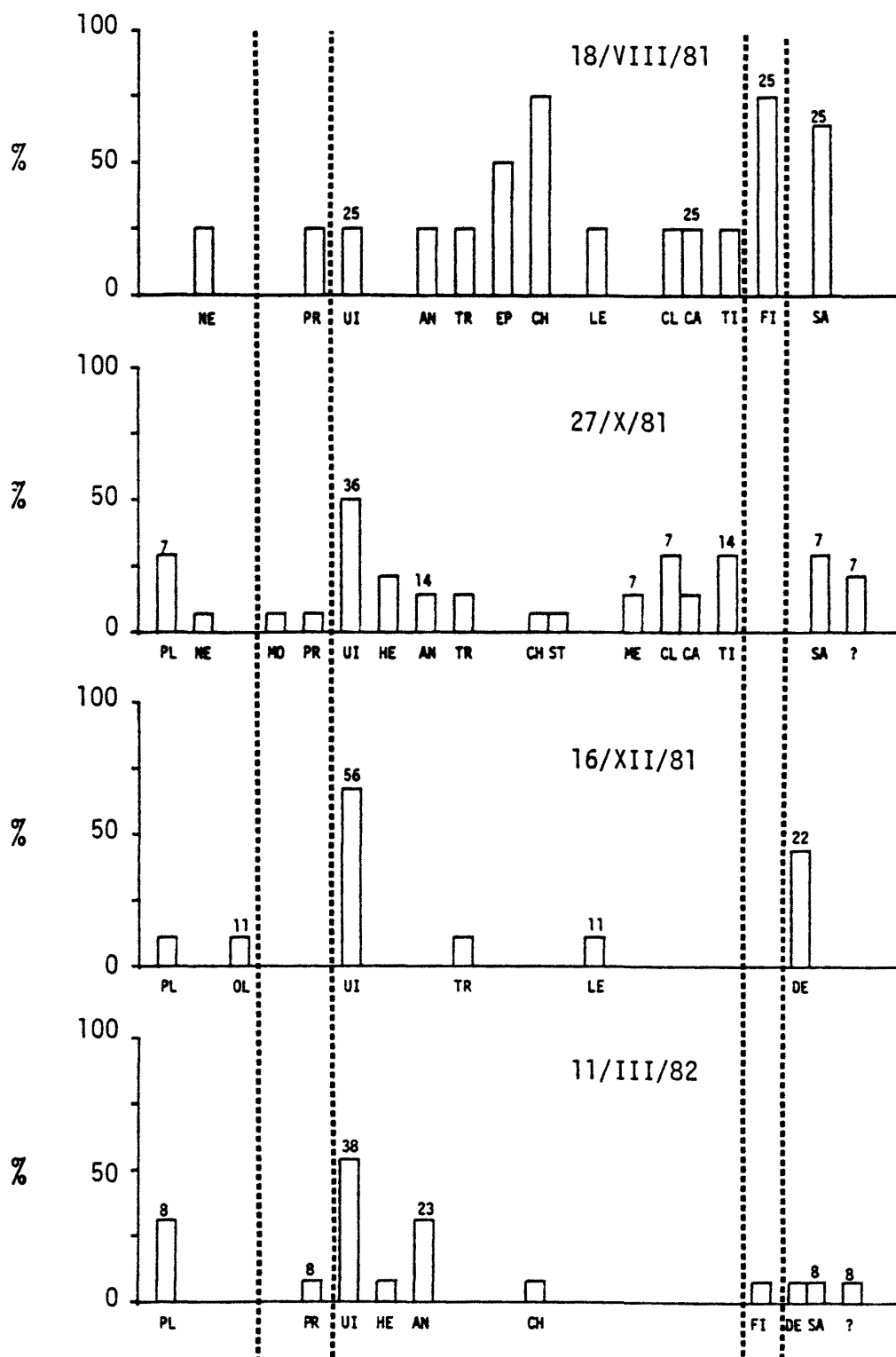
PL: Plant fragments
NE: Nematodes
OL: Oligochaetes
MO: Molluscs
PR: Prawns
UI: Unidentified insects
HE: Hemiptera
AN: Anisoptera lv.
TR: Trichoptera lv.
EP: Ephemeroptera lv.
CH: Chironomidae lv.
ST: Stratiomyidae lv.
LE: Lepidoptera lv.
ME: Megaloptera lv.
CL: Coleoptera lv. CA: Coleoptera ad.
TI: Terrestrial insects
FI: Fish
DE: Detritus SA: Sand
? : Unidentified components

(Numbers above "frequency" histograms refer to % dominance)

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are included in the length-fecundity regression for the L. Yure population of R. guatemalensis (Fig. 11.49). These data do not indicate any significant difference in the fecundity of river and lake populations.

Diet: R. guatemalensis is, like R. cabreræ, primarily insectivorous. Diet analyses from both dry and wet season samples are summarized in Fig. 11.21. The diet of R. guatemalensis differed from that of R. cabreræ in one major respect; Trichoptera larvae were relatively unimportant for the former species whereas they were a major item in the latter species' diet. In addition, non-aquatic insects (mainly ants) tended to be more common in the stomachs of R. guatemalensis.

Larval and adult Coleoptera were important diet components in samples taken during the latter half of the wet season, but were not encountered in dry season samples. Ephemeroptera at times represented a major food item and were perhaps even more important than suggested by the data in Fig. 11.21, since the unidentifiable component probably often included macerated mayfly larvae.

Variation in the fat accumulation index showed a fairly distinct difference between the two Rhamdia species, particularly for the June sample (Table 11.8). At the beginning of the wet season low reproductive activity was correlated with higher fat indices for R. cabreræ, whereas peak spawning in R. guatemalensis was associated with relatively low fat accumulation.

11.6.2.4 Cyprinodontidae:

Profundulus guatemalensis (Günther) "Olomina"

This is the only cyprinodont species collected during the present study.

Table 11.8 : Fat accumulation in R. cabreræ and R. guatemalensis.*

Tabla 11.8 : Acumulación de grasa en R. cabreræ y R. guatemalensis.*

	<u>R. cabreræ</u>					<u>R. guatemalensis</u>				
Fat Index Value:	0	1	2	3	4	0	1	2	3	4
<u>Date</u>										
3/IV/81	1	2	24	5	-	-	4	12	4	2
8/VI/81	-	-	4	7	12	-	1	6	1	-
8/VIII/81	1	2	8	1	1	-	-	4	1	-
27/X/81	-	-	10	8	1	-	-	11	2	2
16/XII/81	-	1	5	1	1	-	-	7	2	1
25/I/82	1	1	10	2	-	-	-	8	1	1
11/III/82	-	9	3	1	-	-	3	12	1	-

* Data refer to number of individuals at each index value.

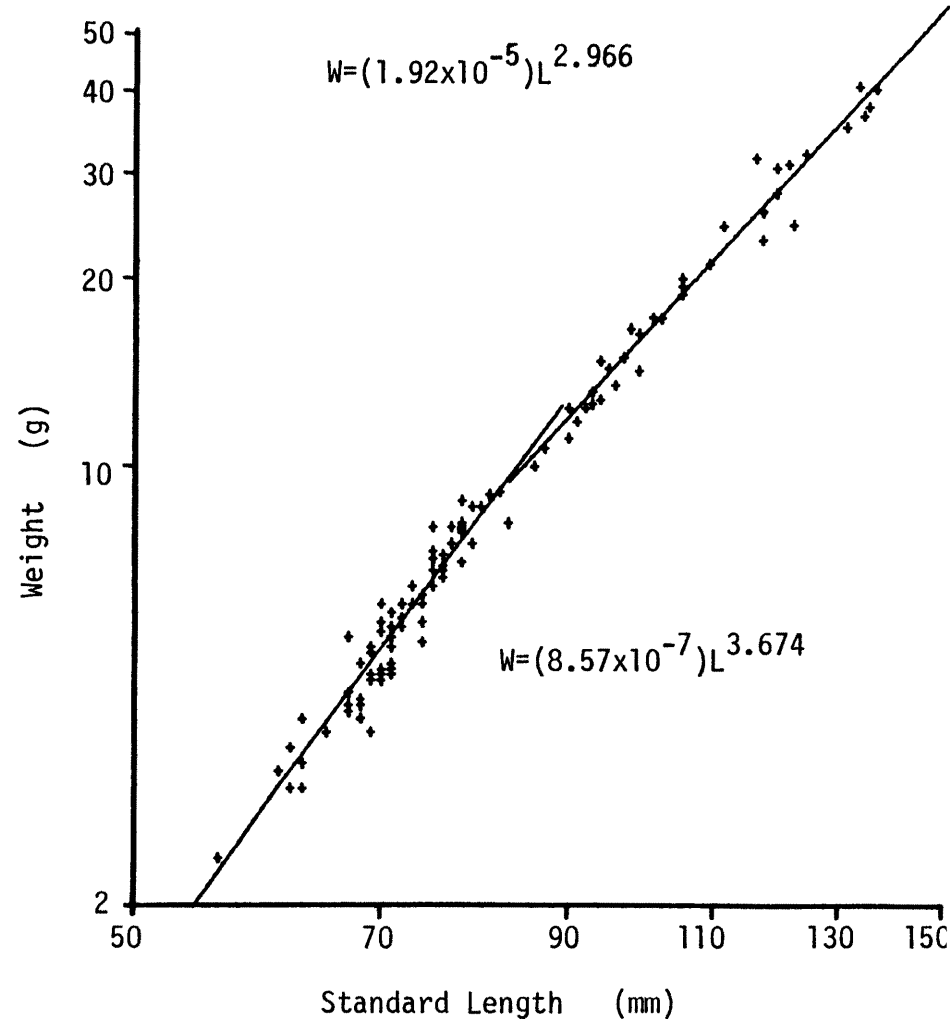
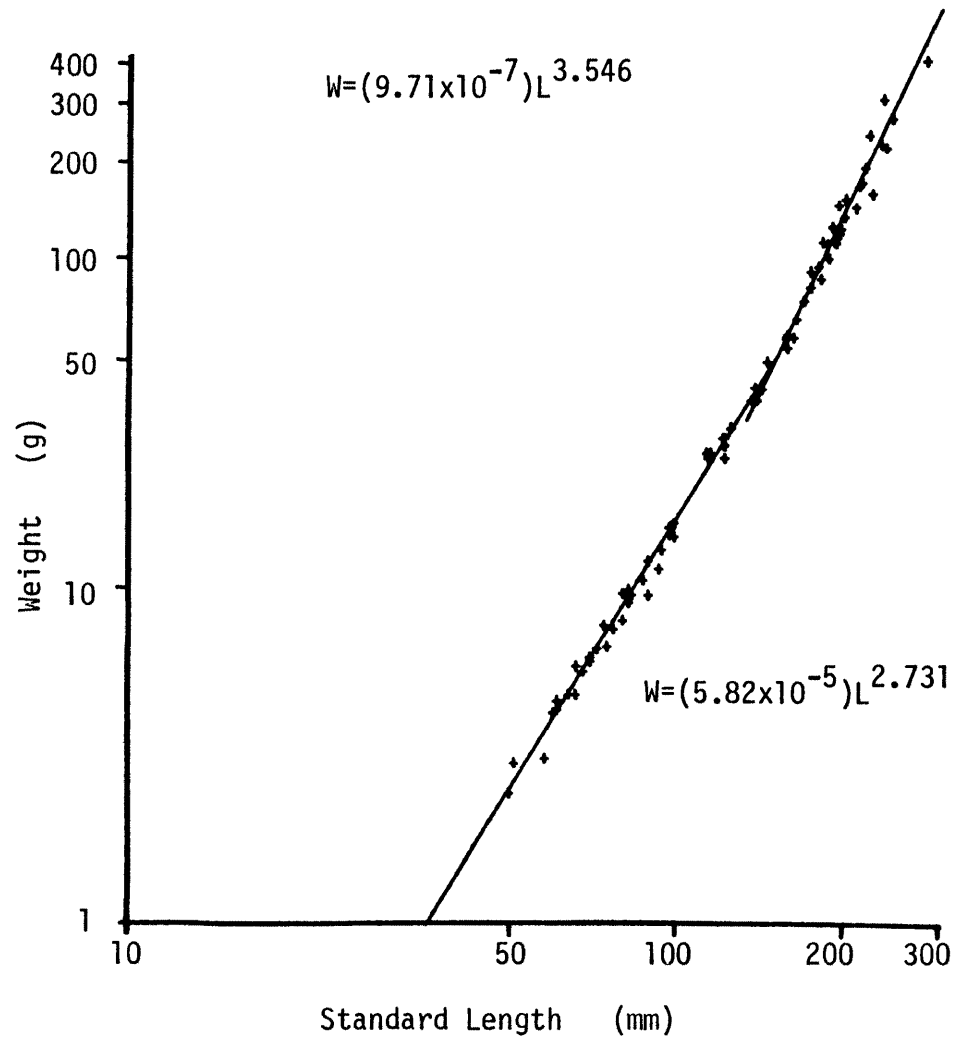


Figure 11.22: Length-weight relationship of *Rhamdia guatemalensis* and *R. cabrerarae*.

Figura 11.22: Relación longitud-peso de *Rhamdia guatemalensis* y *R. cabrerarae*.

It was recorded only from the R. Tamalito (outside the El Cajón drainage), in one sample collected in January 1982. Martin (1972) recorded this species from the R. Lempa and R. Motagua headwater drainages in Honduras. Its range includes Guatemala and El Salvador. The Tamalito samples represent a new locality record for the species.

Miller (1955) discusses the taxonomy and distribution of P. guatemalensis. Distinguishing characteristics for the species include 1) well developed scales covering the pre-orbital, 2) presence of a humeral spot, 3) proximal half of the caudal fin densely scaled and 4) the head rectangular in shape. P. guatemalensis is the most abundant species in streams at elevations of over 1500m, and Miller (1955) states that low abundance of this species is correlated with scarcity of pool habitat.

The five specimens taken from the R. Tamalito ranged in length from 48 to 54mm. All but one were females and all of these contained mature eggs. In these females, ovarian weight represented an average of 15% of body weight. Mature eggs measured 1.6-2.0mm in diameter and, typically, at least two size classes were present as illustrated in Fig. 11.23. The female represented in this figure contained a total of 179 eggs 1.2mm and larger which were a clear yellow; smaller size classes were opaque.

P. guatemalensis is insectivorous and has a short gut typical of carnivorous species (total gut length measured 35mm in a 48mm S.L. individual). Anisoptera (Libellulidae) and Ephemeroptera (Gomphidae) larvae represented the main food items in the stomachs, but other insects such as Ambrysus (Hemiptera) and Heleidae (Diptera), and ostracods were also found in some individuals.

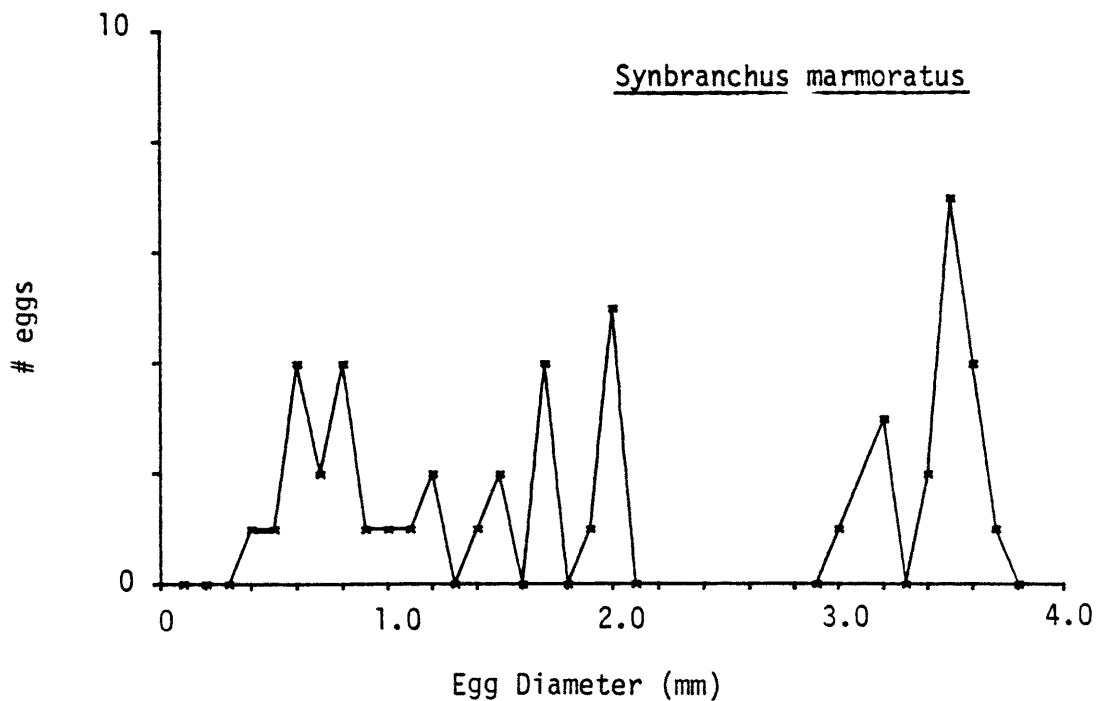
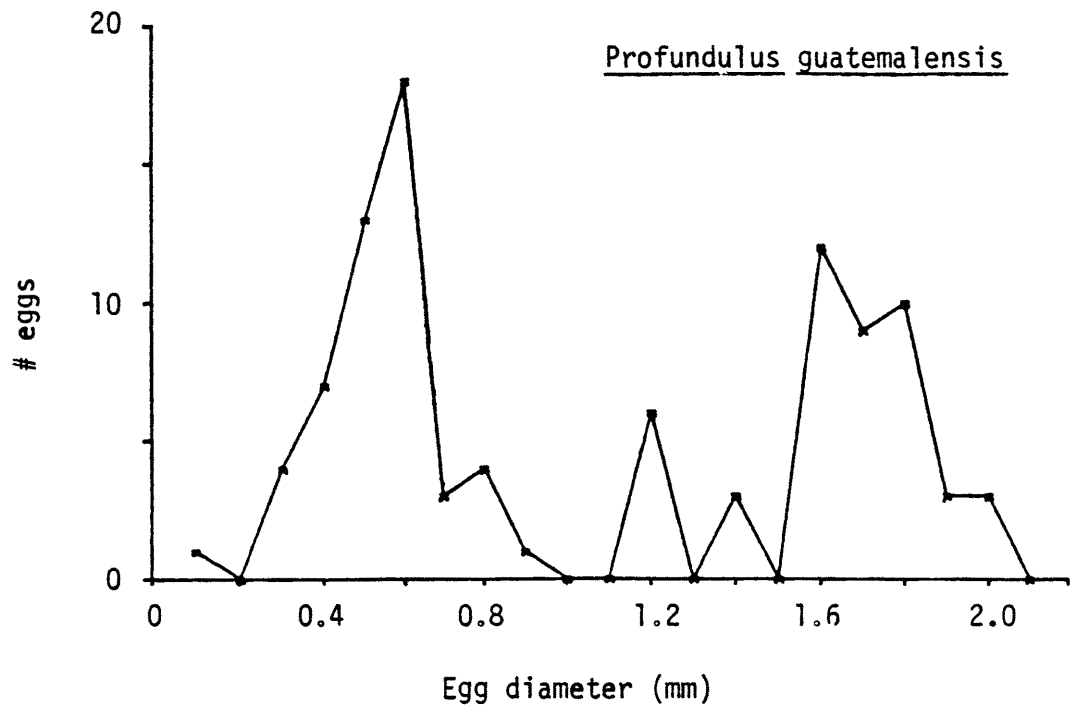


Figure 11.23: Egg size frequency distributions for Profundulus guatemalensis and Synbranchus marmoratus.

Figura 11.23: Distribución del tamaño de huevos de Profundulus guatemalensis y Synbranchus marmoratus.

11.6.2.5 Poeciliidae:

Six poeciliid (olomina) species were collected from the El Cajón watershed:

Poecilia mexicana (Steindachner)

P. sphenops (Valenciennes)

Poecilia, new species A

Alfaro huberi (Fowler)

Heterandria bimaculata (Heckel)

Poeciliopsis gracilis (Heckel)

They are all small species and are frequently abundant in streams and rivers. In the following discussion, aspects of their taxonomy, distribution and ecology will be briefly summarized; each species will not be treated in detail.

Taxonomy and Distribution: Poeciliids are common throughout Middle America, being most diverse in Mexico. They are viviparous (i.e. fertilization is internal and young are born in a well developed state). The reproductive ecology of several species is especially interesting since it can involve superfetation (i.e. simultaneous development of more than one "batch" of embryos), "placental" nourishment of the developing young, prolonged sperm storage by females and the existence of all-female "species" which are, in effect, parasitic on males of other poeciliid species. Because of these and other peculiarities, many studies have been done on poeciliid reproduction and genetics (e.g. Hubbs 1964, McKay 1971, Moore and McKay 1971, Schultz 1977 and Thibault and Schultz 1978).

Because of their diversity, poeciliids have also been the subject of many taxonomic studies (e.g. Rosen and Bailey 1963). The Poecilia mexicana-

Alfaro
huberi

Heterandria
bimaculata

Poeciliopsis
gracilis

Poecilia
sphenops

Poecilia
mexicana

Plate 4: Five poeciliid species from the El Cajon area.

Foto 4: Cinco especies de poecílidos (olominas) del área de El Cajón.

sphenops complex has caused a number of taxonomic uncertainties. Miller (1983) has recently reviewed the status of the Mexican "mollies" (i.e. poeciliids in the sub-genus Mollienesia of Poecilia). P. sphenops is probably a species-complex in itself containing at least 16 "species", (Miller, 1975). Alpírez-Quesada (1971) has also studied the P. mexicana-sphenops complex and suggests that the mexicana form in Honduras is actually P. gillii (but see below). The key and distribution maps prepared by Alpírez-Quesada are reproduced in Appendix 3, for future reference.

Mollies collected during the present study have been referred to P. sphenops and P. mexicana. Although Miller (pers. comm.) does not believe that the "true" P. sphenops occurs in Honduras, Honduran specimens are obviously of the sphenops type. The mexicana molly collected in the El Cajón area agrees well with the description of P. mexicana given by Alpírez-Quesada (1971) and Miller (pers. comm.).

In addition to the P. sphenops just discussed, a second "sphenops-like" species was taken from the R. Cacaguapa (Fig. 11.3). This form agrees well with Martin's (1972) description of "Poecilia new species A", recorded also from the R. Cacaguapa (Miller, pers. comm.). (This undescribed species differs from P. sphenops in having the tricuspid inner teeth arranged in a narrow band. It is discussed at greater length by Martin, 1972). The taxonomic status of the other three poeciliids, Alfaro huberi, Heterandria bimaculata and Poeciliopsis gracilis is much less confused than that of the molly complex.

There is a distinct longitudinal zonation in the distribution of the five El Cajón poeciliids (the undescribed Poecilia species was recorded only from the R. Cacaguapa). In the smallest streams (e.g. Q. Agua Caliente), only

Alfaro huberi was recorded. A. huberi, P. sphenops and H. bimaculata are the three poeciliids usually found in larger, upper elevation streams (e.g. Q. del Cerro and R. Yure at Yure; Fig. 11.7, Table 11.5). Further downstream, at the Humuya confluence for example, P. mexicana and Poeciliopsis gracilis are added to the assemblage. P. mexicana is especially characteristic of slower-flowing water and habitats with abundant periphyton growth, although large individuals were collected from riffle areas of the R. Humuya. Fig. 11.7 illustrates the change in the ratio of P. sphenops:P. mexicana from higher to lower gradient rivers (the latter group being represented by the R. Colorado and R. Sulaco).

Reproduction: As previously mentioned, poeciliids are live-bearers. Reproduction occurs throughout the year. Females are generally larger than males and, especially in P. mexicana and Poeciliopsis gracilis, attain a greater maximum length. Poecilia females first mature at lengths of approximately 45mm, and the equivalent value for Alfaro is slightly less, about 35mm. Mature eggs measure 3.0-3.5mm diameter in the two Poecilia species. Eggs of Alfaro and Heterandria are smaller, ranging from 2.3-2.8mm.

When young are released from the female, they have a length of about 7-10mm. There is some evidence for superfetation in Alfaro, however this was not observed in all individuals and may have represented simply retarded development of certain embryos.

Fecundity vs. female length relationships for the three most abundant poeciliids are shown in Fig. 11.24. There is some indication that P. mexicana contains fewer eggs (for a specific female length) in the wet season than in the dry season. If this difference is real, a possible explanation would be a

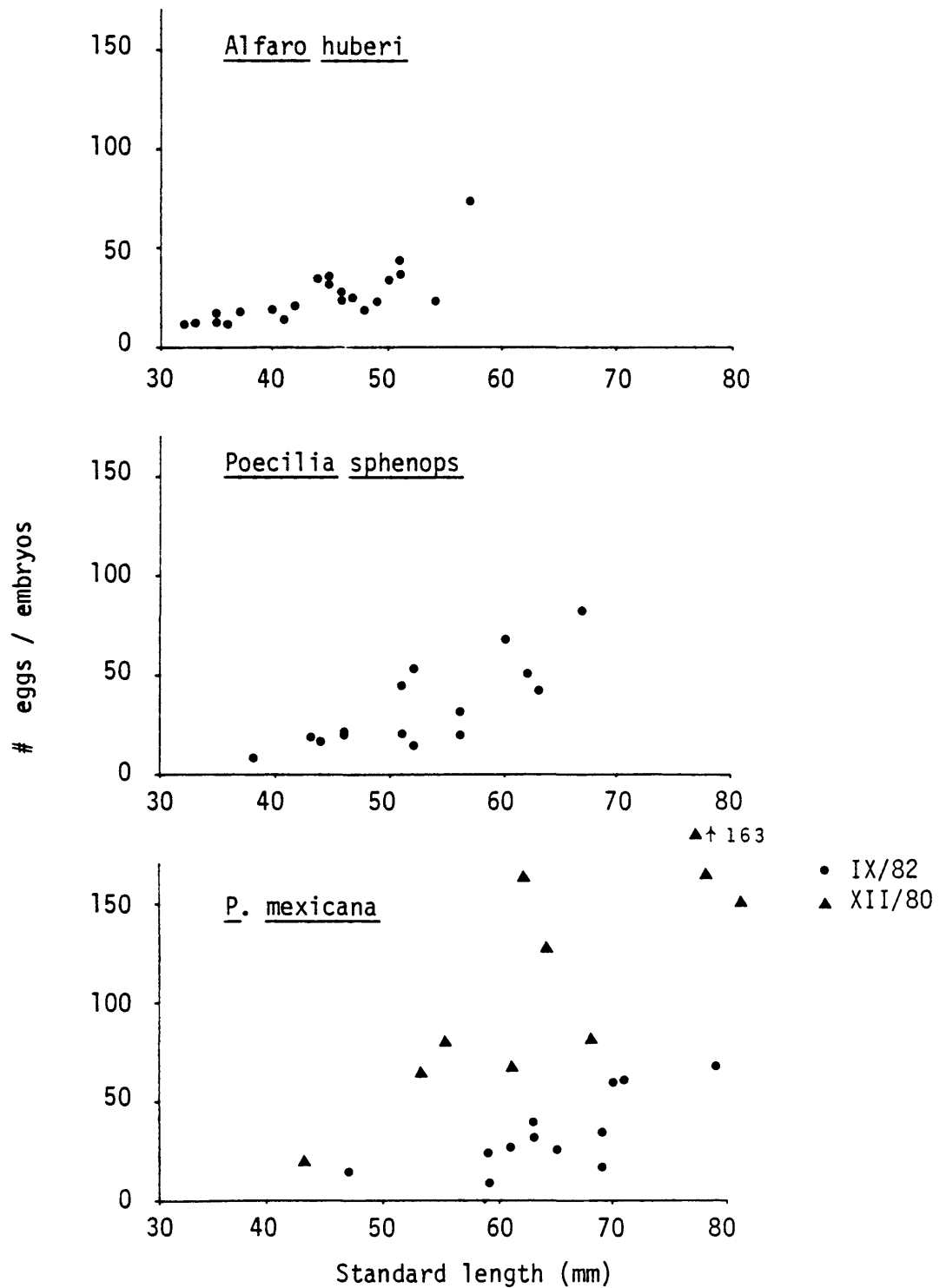


Figure 11.24: Relationship between fecundity and standard length for three species of poeciliids.

Figura 11.24: Relación entre fecundidad y longitud estandar en tres especies de poecílicos.

reduction in food supplies during the wet season as a result of scouring of periphyton by elevated river discharge rates. It should be noted that the number of eggs per female may have little relationship with the number of offspring produced per unit time, because intervals between successive broods may differ between seasons and between species. This is a common problem in the determination of fertility (number of eggs produced per unit time) for repeat spawners.

Diet: There is a clear division in terms of diet between the molly and non-molly poeciliids. The two mollies (P. sphenops and P. mexicana) are herbivorous, eating primarily periphyton. The fact that they usually feed on diatoms growing on sand and silt substrata in slowly-flowing water is demonstrated by the presence of a silt/algal mixture in the gut.

In contrast to the long, coiled intestine of Poecilia, the gut of Alfaro and Heterandria is much shorter. These species are omnivorous, but feed primarily on a wide range of aquatic insect larvae and non-aquatic insects (ants). Filamentous green algae and diatoms are also frequently observed in the intestinal tracts of these poeciliids.

The plasticity in the diet of Alfaro and Heterandria (i.e. the fact that they can rapidly change to taking different food types) may be a factor influencing their distributions. In higher elevation streams, where flooding and periphyton scouring are often more extreme than in lower gradient rivers, an omnivorous diet probably represents a significant advantage over an herbivorous (periphyton grazing) feeding mode.

Poeciliids are an important element in the diet of riverine piscivorous species (e.g. guapote, see Section 11.6.2.7). In L. Yure, predation pressure from cichlids and bass has apparently been sufficiently high to drive

poeciliids to extinction although they still exist in the tributaries. The restriction of poeciliids to the littoral zone and the scarcity of shelter-providing vegetation were presumably factors increasing their vulnerability to predation in this reservoir.

11.6.2.6 Synbranchidae:

Synbranchus marmoratus (Bloch) "Anguilla"

Samples of anguillas ("eels") were taken from three sites only: L. Yure, R. Yure at Yure and Q. de Chamo (Table 11.5). At the R. Yure station, this species was a minor, but persistent component of the community (Fig. 11.7, Table 11.5). Although apparently uncommon in the El Cajón area, Synbranchus is probably present in most drainages of the region. Its range is from southern Mexico to Brazil and Peru and it has been recorded throughout Honduras (Martín 1972).

Preferred habitat for this species consists of aquatic vegetation and shelters under overhanging banks. It is capable of moving considerable distances overland, especially through wet vegetation. The distensible gill-chamber functions as an accessory respiratory organ which enables these fish to inhabit poorly oxygenated water (Sterba 1966, Lowe-McConnell 1975).

Summary data for the 12 individuals taken in the river collections are given in Table 11.9. The length-weight relationship calculated from these samples is:

$$W = (7.99 \times 10^{-7}) L^{3.10}, \quad \text{where } W = \text{weight (g)} \quad \text{and } L = \text{length (mm)}.$$

All of the females (with the possible exception of those collected in August) had ovaries with developing or mature eggs. This finding, together with egg size frequency distributions (Fig. 11.23), suggest that Synbranchus

Table 11.9 : Size distribution and reproductive condition of Synbranchus marmoratus, (R. Yure and Q. de Chamo).

Tabla 11.9 : Distribución de tamaño y condición reproductiva de Synbranchus marmoratus, (río Yure y quebrada de Chamo).

<u>Date Collected</u>	<u>Total Length (mm)</u>	<u>Weight (g)</u>	<u>Sex</u>	<u>GSI</u>	<u>Egg Diameter (mm)*</u>
8/VI/81	345	54.0	♀	7.47	3.0-3.7
" "	239	18.8	♀	0.41	0.1-0.9
18/VII/81	264	24.4	♀	0.40	0.1-0.5
" "	161	5.1	♀	0.69	0.1-0.4
27/X/81	230	16.1	♀	0.30	0.05-0.7
11/III/82	273	30.9	♀	6.19	2.0-3.7
21/IV/82	408	102.2	♀	0.85	0.1-1.3
" "	447	134.8	♂	0.32	-
18/V/82	365	60.0	♂	0.24	-
" "	205	12.3	♀	0.64	0.1-0.8
" "	232	17.3	♀	0.49	0.1-0.8
" "	239	19.0	♀	2.83	0.1-1.7

* Range refers to largest egg size class, if this is discrete, or to total size range if distribution is continuous.

Table 11.10: Food of Synbranchus marmoratus, (R. Yure and Q. de Chamo).

Tabla 11.10: Alimentación de Synbranchus marmoratus (río Yure y quebrada de Chamo).

<u>Item</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Filamentous algae	12	-
Turbellaria	25	-
Molluscs	12	-
Uniden. insect frag.	38	13
Anisoptera lv.	25	-
Zygoptera lv.	12	-
Trichoptera lv.	12	-
Chironomidae lv.	25	-
Ephemeroptera lv.	38	13
Coleoptera lv.	12	13
Coleoptera ad.	12	-
Non-aquatic insects	12	-
"Detritus"	62	61
Fish remains	25	-
<hr/>		
N analyzed :	12	
N + food :	8	
Length range (mm)	161-408	

is a repeat spawner with an extended period of reproduction.

Eight of the twelve fish had some food in the stomach. A wide variety of food items were being eaten (Table 11.10), but "detritus" usually represented the major component. (This "detritus" may have been primarily well-digested food, since all of the stomachs were less than 1/2 full). Fish remains were found in the two largest Synbranchus.

11.6.2.7 Cichlidae:

Cichlasoma maculicauda (Günther) "Boca colorada"

C. maculicauda is the only species from the Theraps section of this family that was encountered in the El Cajón area. It is widespread in Central America, being reported from the Petén region of Guatemala to Panama (Miller 1966). In Honduras, it is distributed along the Atlantic slope. Its preferred habitat consists of the pools and backwaters of larger rivers (Martin 1972).

This species is apparently not very common in the El Cajón area since juveniles were infrequently encountered in electroshocker samples taken along river banks and adults were captured on only one occasion, with gill-nets at the R. Yure/Humuya confluence (Table 11.5). Adults were, however, observed a number of times in the R. Humuya, primarily in deeper, slower-flowing water near the river banks.

Of the four adults captured (September 1982), the males were larger than the female (187-203mm S.L. vs. 153mm). Although sample size is too low to determine if males of this species are in general larger than females, this pattern is expected since it is commonly observed in other cichlid species

Plate 5: Cichlasoma maculicauda (boca colorada)
and C. spilurum (congo).

(see below). Furthermore, for brooding pairs of C. maculicauda in Gatún Lake, Panama, males were always the larger individual in the pair (Perrone 1978a).

The length-weight regression calculated for samples taken during the present study is:

$$W = (4.8 \times 10^{-5}) L^{3.02}$$

Table 11.11 shows that this species is primarily herbivorous. While juveniles contained mainly small Paspalum and Panicum seeds, adults were eating the larger seeds of Inga ("guanigiquil") as well as those of grasses. In addition, aquatic insect larvae were only found in juvenile fish. It should be noted that, since the stomach of C. maculicauda is small and was frequently empty in these samples, the data in Table 11.11 refer to the entire gut contents.

Few data on the reproductive ecology of this species are available from the present study because the gonads of all the adult fish captured were in the resting stage (GSI's < 0.4). The males, however, displayed a dark red coloration on the throat region, the color extending in some to include the lower jaw and opercula. The female did not display this color pattern. A red coloration is characteristic of this species "during the breeding season" (Sterba 1966), so these samples may have been immediately post-reproductive individuals.

Observations on the reproductive behavior of C. maculicauda in L. Jilóá, Nicaragua (McKaye, 1977) and in Gatún Lake, Panama (Perrone 1978a, b) have shown that, similar to most Cichlasoma species, it is monogamous, with both parents defending a nest site or territory 1 to 2 m across. Broods of eggs and young are tended by the parents, which protect them from predation by conspecifics and other species. In Gatún Lake, females of 110mm S.L. and

above were observed with broods; the modal length of spawning females was about 150mm (Perrone 1978a). Males were larger than females (modal length about 180mm) and it was shown that male size was 1) negatively correlated with the susceptibility of the nest site to destructive wave action and 2) positively correlated to growth rate of the progeny. The number of spawned eggs per female ranged from about 800, for individuals of approximately 110mm, to over 1,800 for those females above 150mm. Unlike some other cichlid species, males of C. maculicauda establish and defend a territory before beginning courtship.

Cichlasoma spilurum (Günther) "Congo"

Distribution: C. spilurum occurs along the Atlantic slope of Central America from Belize to Nicaragua. Martin (1972) recorded it from a wide variety of sites in Western Honduras, but from fewer in the eastern half of the country. It is the most common cichlid species in the El Cajón region and was recorded in all rivers and streams sampled during the present study, with the exceptions of the L. Yure tributaries and the small Q. Agua Caliente near Ojos de Agua. The upstream distributional limit of C. spilurum in the R. Yure occurs somewhere between the village of San Bartolo (525 m.a.s.l.) and the L. Yure dam (625 m.a.s.l.; section 11.6.1). River gradient, rather than elevation per se, is probably a controlling factor in its distribution.

In the majority of samples taken with an electroshocker, C. spilurum was one of the dominant species, both in terms of numbers and biomass. In the R. Yure at Yure, for example, it averaged 36% of total individuals and 32% of total biomass (Fig 11.7). Equivalent values for the R. Jacagua in the Sulaco watershed were 21% and 25% (Table 11.5). It was less common in samples taken

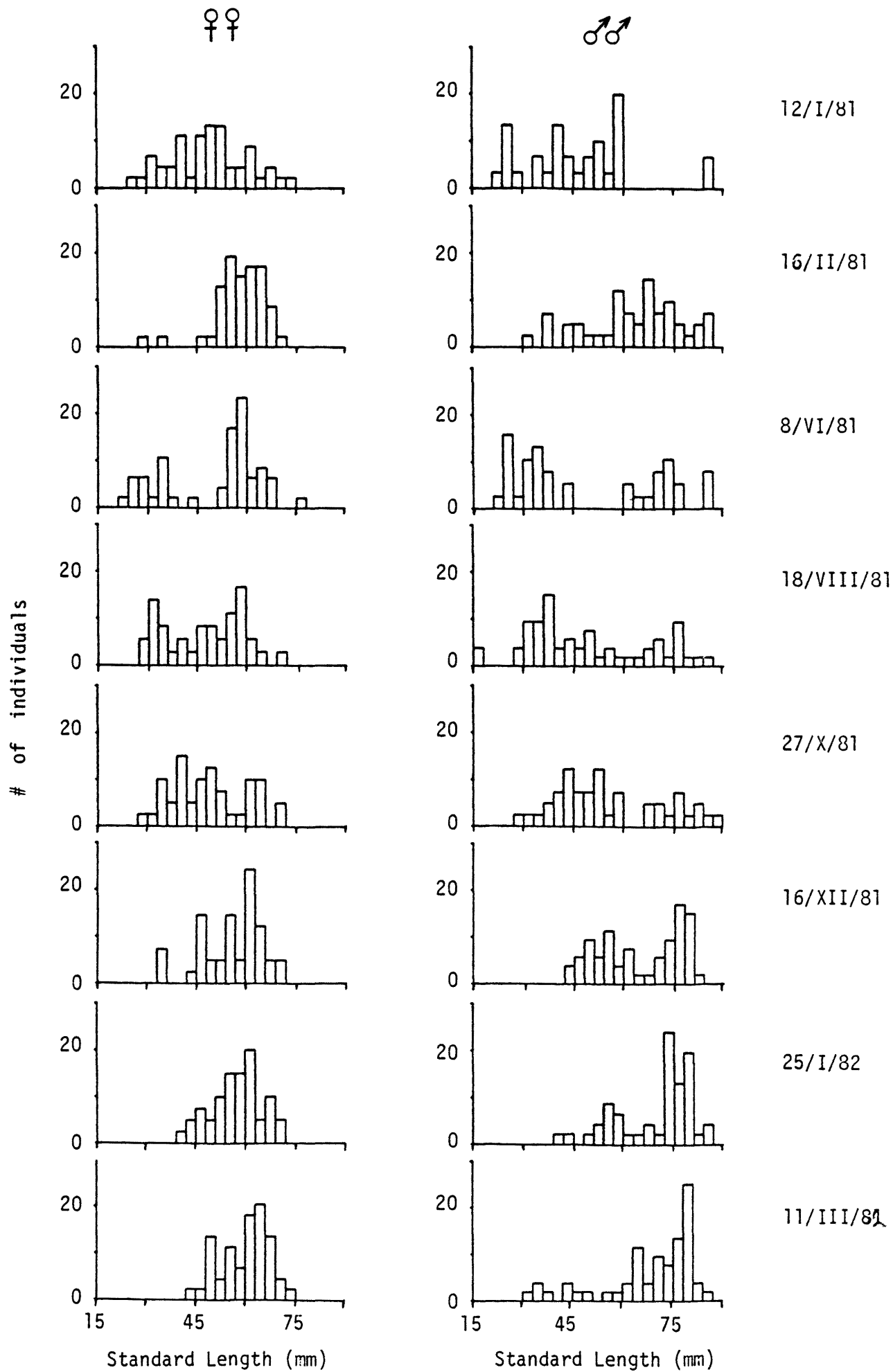
Table 11.11: Food of adult and juvenile C. maculicauda (R. Yure at Humuya confluence, Sept. 1982)

Tabla 11.11: Alimentación de adultos y juveniles de C. maculicauda (río Yure cerca de la confluencia con el río Humuya, septiembre de 1982)

<u>Item</u>	<u>Adults</u>		<u>Juveniles</u>	
	<u>Freq. (%)</u>	<u>Dom. (%)</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Seeds	100	100	100	100
Freshwater prawns	75	-	-	-
Insect fragments	-	-	50	-
Scales (ctenoid)	25	-	-	-
<hr/>				
N analyzed :	4		8	
N + food :	4		8	
Length range (mm) :	153-203		41-63	

Figure 11.25: Temporal variation in the size frequency distribution of a population of Cichlasoma spilurum in the R. Yure at Yure.

Figura 11.25: Variación temporal en la distribución de tamaño para una población de Cichlasoma spilurum en el río Yure.



with other gears.

Although it is an important member of the fish community in many Honduran streams, there is, to our knowledge, no published information on the biology or ecology of C. spilurum. Its preferred habitat, like that of many Cichlasoma species, is slower-flowing water, for example near river banks, in pools or sheltered under boulders in the main channel.

Population Structure: Population size structure over a period of 15 months at the Yure station on the R. Yure is summarized in Fig. 11.25. These data will be discussed in more detail below in the context of growth rate estimations, but it can be noted here that during certain times of the year (June-October especially) the population is clearly bimodal. The two peaks in the size frequency distributions (Fig. 11.25, 8/VI/81, for example) represent 1) the cohort of young produced at the beginning of the year and 2) the surviving adults of the previous year class. The male:female ratio averages about 1:1. Since males exhibit higher growth rates than females (see below), males are on the average larger than females and attain a greater maximum length. During the period covered by the data in Fig. 11.25, for example, the maximum standard length recorded for males and females was 87mm and 75mm, respectively. The length-weight relationship for C. spilurum is shown in Fig. 11.27. Only samples from August and October were used to calculate the regression in order to reduce variance originating from gonad development.

The smallest size classes of this species were obviously not captured in electroshocker collections. Why this occurred is uncertain because the nets used to remove the fish were of small enough mesh size to retain individuals smaller than 15mm S.L. However, larger size classes were probably being

March 1981

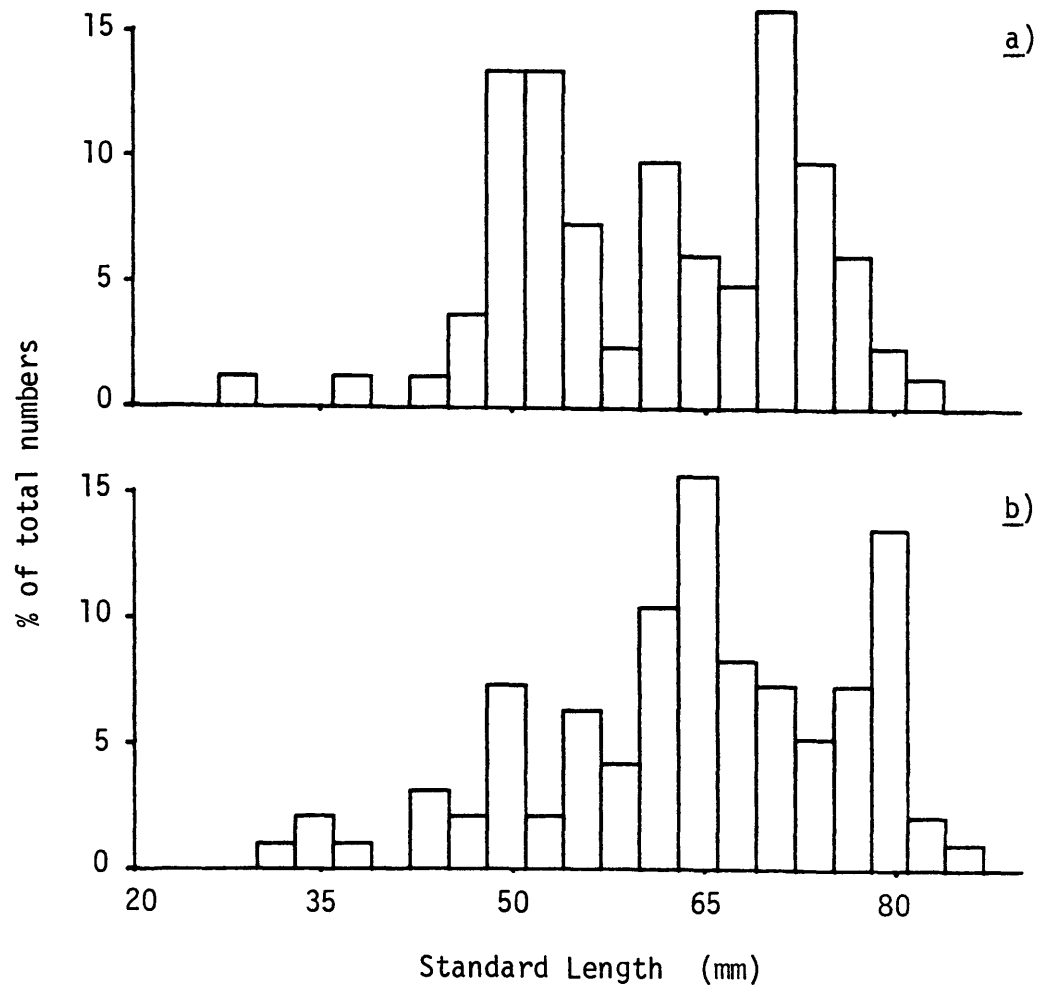


Figure 11.26: Comparison of size frequency distributions of samples of *Cichlasoma spilurum* made with a) a small explosive charge and b) electroshocker, in the R. Yure.

Figura 11.26: Comparación de distribuciones de tamaño entre muestras de *Cichlasoma spilurum* tomadas con a) cargas explosivas y b) electroshock en el río Yure.

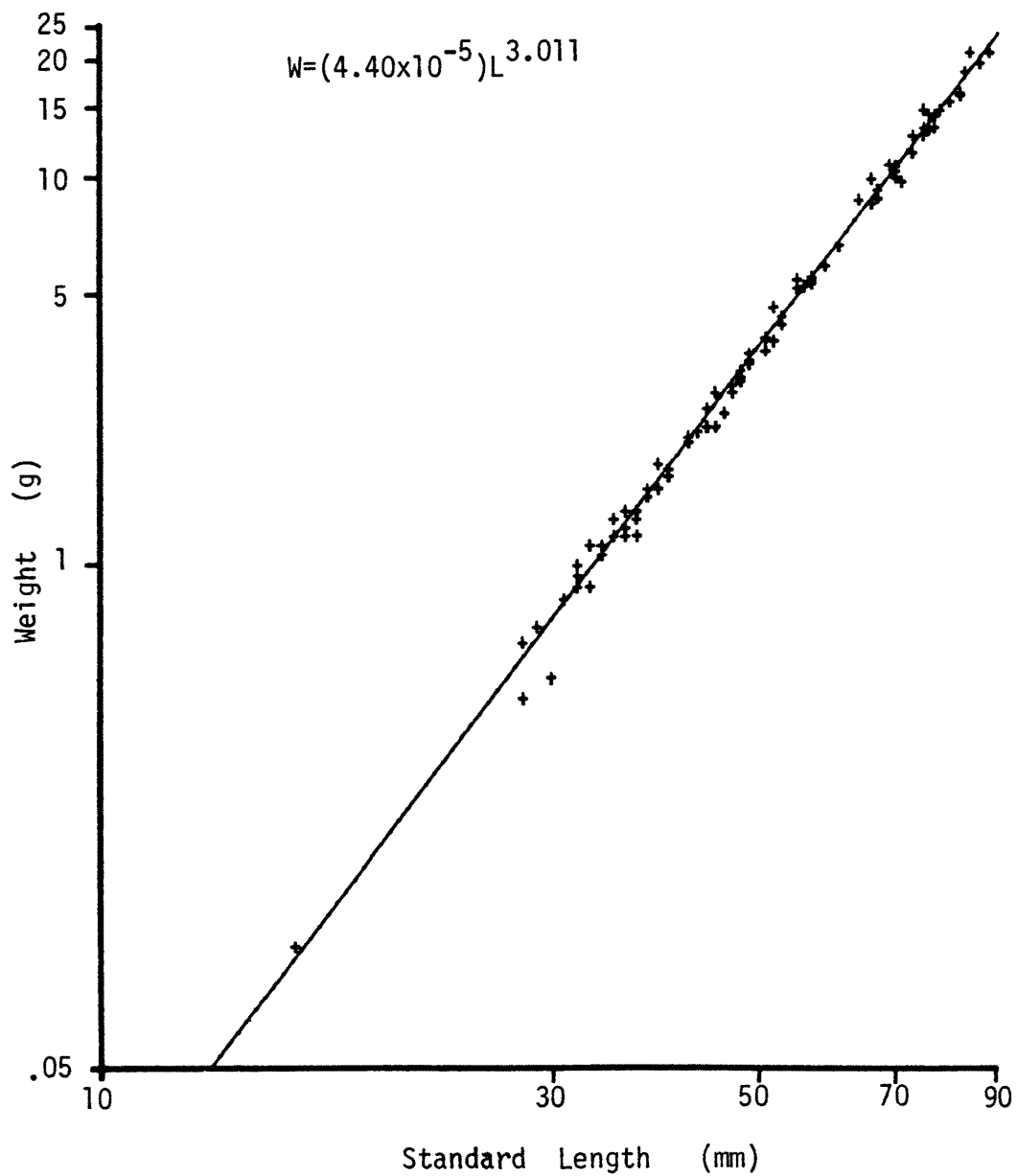


Figure 11.27: Length-weight relationship of Cichlasoma spilurum.

Figura 11.27: Relación longitud-peso de Cichlasoma spilurum.

captured fairly representatively, as Fig. 11.26 suggests. The size frequency distribution of fish sampled from a pool with a small explosive charge was similar (and had the same limits) as a sample from the same general area taken with electroshocker.

Reproduction: The bimodal population size structure of C. spilurum is a result of non-continuous reproduction, i.e. spawning is restricted to a few months in the year. This is demonstrated for 1981-82 in Fig. 11.28, in which gonosomatic index (GSI) is plotted against standard length for each individual in the sample. Table 11.12 gives the mean index values for adult individuals (>50 mm S.L.). GSI's began to increase in December and by the end of January a large proportion of individuals had fully developed gonads. Reproductive activity continued at least through March and perhaps until the beginning of the wet season (May-June) in 1982, but January and February represent the peak period of reproduction in this species. This timing presumably allows spawning to occur and many young to attain a length of 15-20 mm before river discharge rates increase at the beginning of the wet season. It is unclear whether females reproducing during the second half of the breeding season represent later-maturing individuals or those which are reproducing for a second time. A consideration of ovarian egg size frequency distributions suggests the latter. Typically, two distinct oocyte size classes are present in mature ovaries of C. spilurum (Fig. 11.29). The smaller size class may represent eggs which continue to mature after the female has spawned for the first time and are subsequently released during a second spawning. Fractional spawning such as this is common in cichlids and other tropical species (see Section 11.6.3). It is clear from Fig. 11.28 that most mature females measure 45 mm and over whereas mature males are generally larger than 65 mm.

Figure 11.28: Seasonal variation in the gonosomatic index of Cichlasoma spilurum.

Figura 11.28: Variación estacional en el índice somático-gonadal de Cichlasoma spilurum.

GONOSOMATIC INDEX

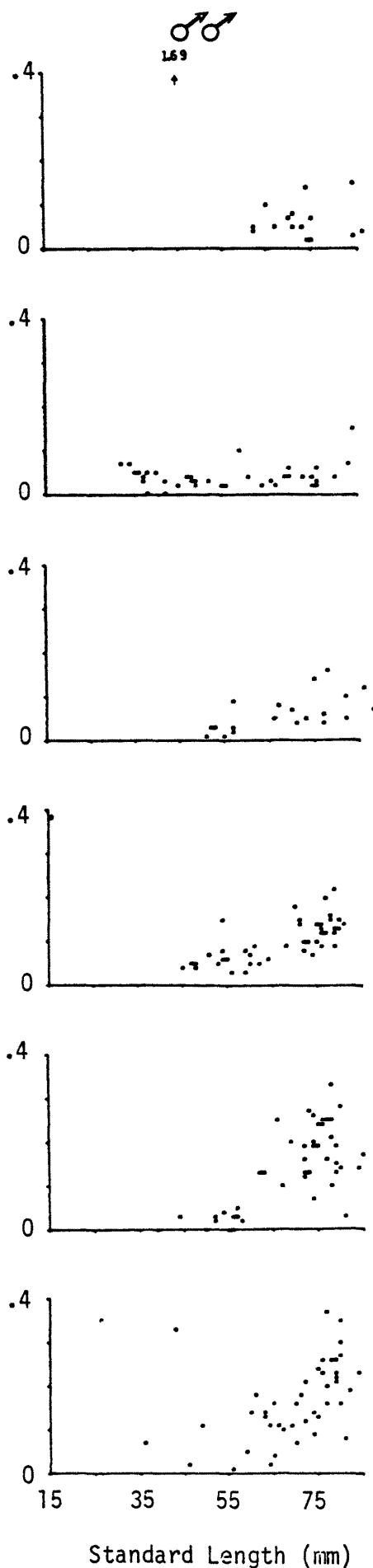
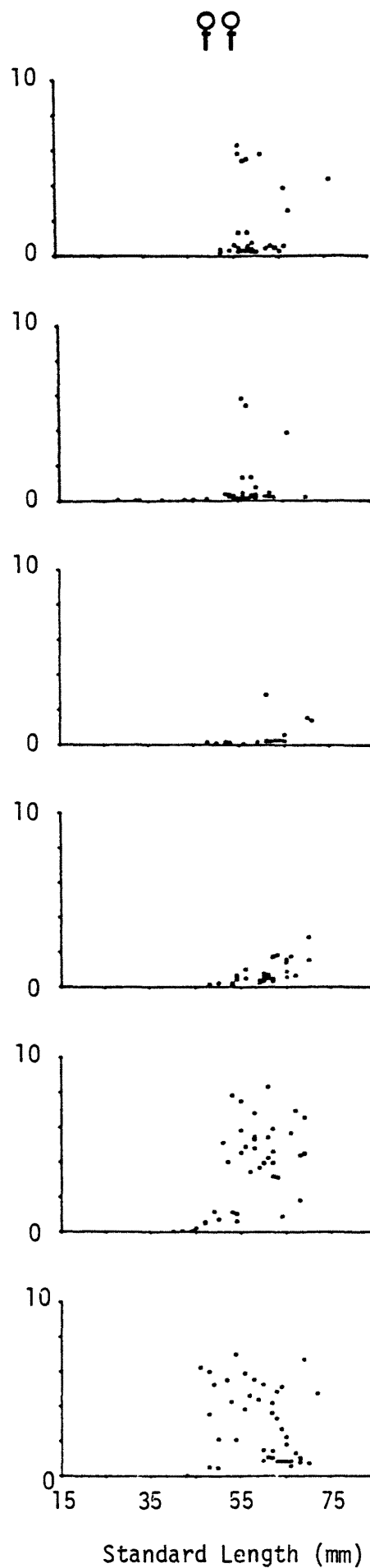


Table 11.12: Seasonal variation in the gonosomatic index of adult ($\geq 50\text{mm}$) C. spilurum, (R. Yure at Yure).

Tabla 11.12: Variación estacional en el índice somático-gonadal de los adultos ($\geq 50\text{mm}$) de C. spilurum (río Yure en Yure).

<u>Date</u>	♀♀				♂♂			
	<u>Mean</u>	<u>St. Dev.</u>	<u>N</u>	<u>Range</u>	<u>Mean</u>	<u>St. Dev.</u>	<u>N</u>	<u>Range</u>
4/XII/80	.42	.38	5	.18-1.08	.03	.02	7	.01-.05
12/I/81	.97	1.07	21	.22-4.21	.08	.05	14	.02-.18
16/II/81	5.00	2.51	44	.14-8.39	.19	.07	34	.04-.39
8/VI/81	1.66	2.10	31	.21-6.33	.07	.04	16	.02-.15
18/VIII/81	.22	.05	14	.16-.26	.05	.03	19	.02-.15
27/X/81	.55	.77	16	.08-2.89	.06	.04	21	.01-.16
16/XII/81	.78	.64	20	.18-2.87	.11	.05	35	.03-.22.
25/I/82	4.45	2.08	33	.51-7.52	.15	.09	44	<.01-.33*
11/III/82	2.80	2.00	34	.59-6.72	.11	.08	42	.01-.37

* One unusually high value, 1.42 has been omitted from these calculations.

This observation is directly related to differential growth rates and the seasonality of reproduction.

Mature eggs of C. spilurum are ovoid with an average diameter of approximately 1.5 mm. Maximum egg dry weight is 0.9 - 1.0 mg, which represents approximately 50% of wet weight.

Fecundity increases with female size as shown in Fig. 11.30a. In most fish species, fecundity is related to length by a power function:

$$F = aL^b$$

where F = fecundity, L = length, and a and b are constants

For the data in Fig. 11.30, however, a linear relationship provides a better fit. The equation is:

$$F = 82.34 + 3.98 L \quad (R^2 = .328)$$

Although this regression is statistically highly significant ($p < .01$), there is a lot of scatter about the regression line. In other words, there is considerable variation in the number of eggs carried by females of the same size. The fecundity-length relationship for a second population of C. spilurum (from the R. Tamalito) is shown in Fig. 11.30b and suggests a between-population difference in this relationship. Additional samples are needed from the R. Tamalito to determine if the observed trend is a real one. Again, a linear relationship ($F = -260.2 + 9.9 L$, $R^2 = 0.75$) accounts for a slightly higher proportion of the total variance than does a power relationship ($F = 0.19 L^{1.82}$, $R^2 = 0.74$). Both are highly significant ($p < 0.01$).

Few field observations were made on the reproductive behavior of C. spilurum and there is apparently no published information on this subject. Reproductive territories are actively defended by both sexes and females in

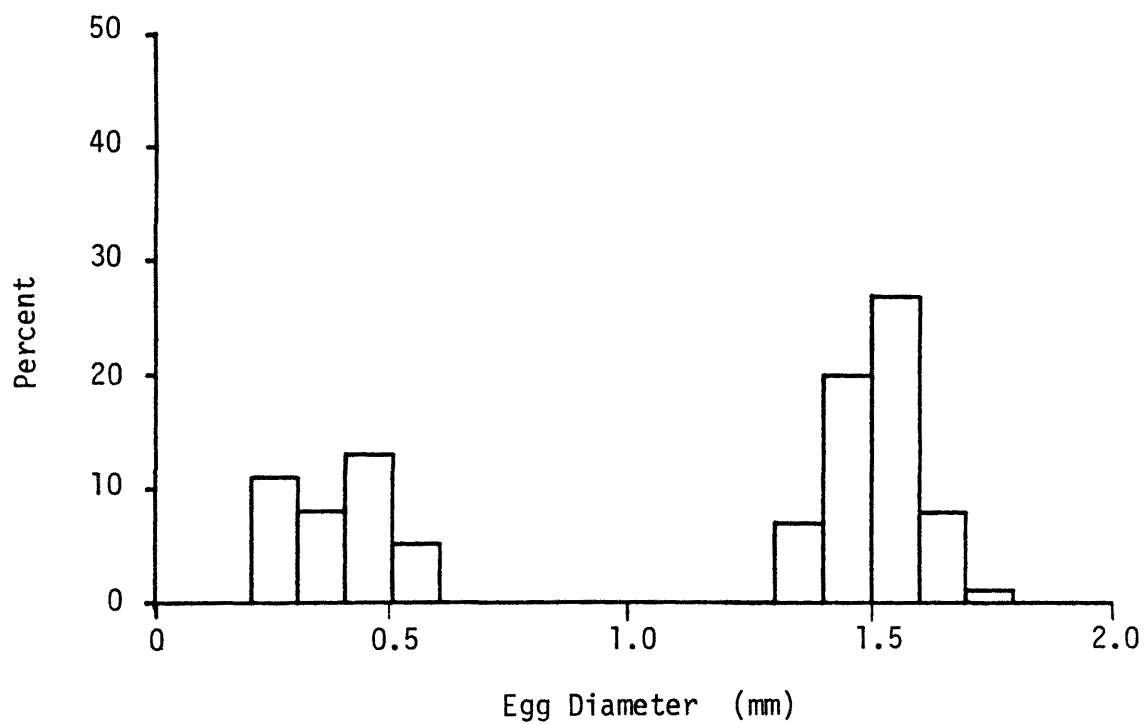


Figure 11.29: Egg size frequency distribution of mature Cichlasoma spilurum.

Figura 11.29: Distribución por tamaño de los huevos de una Cichlasoma spilurum madura.

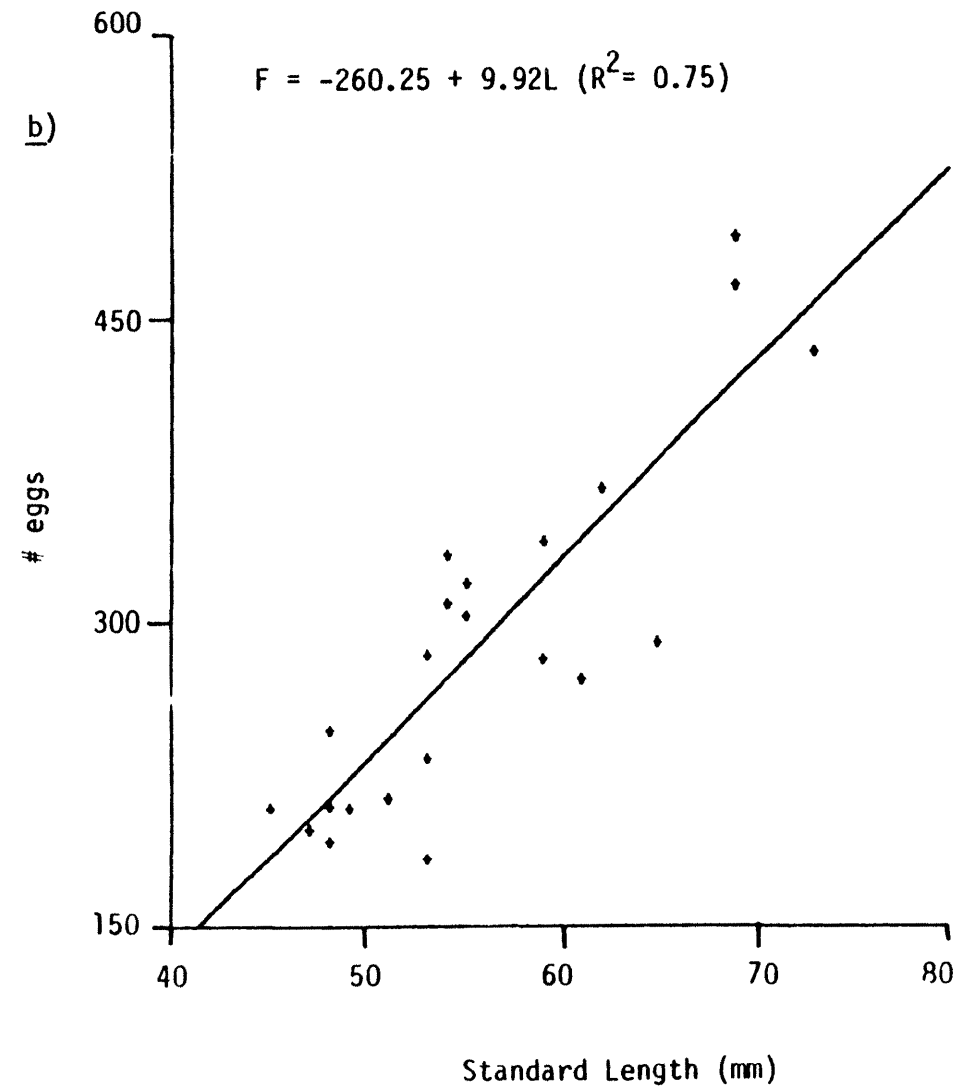
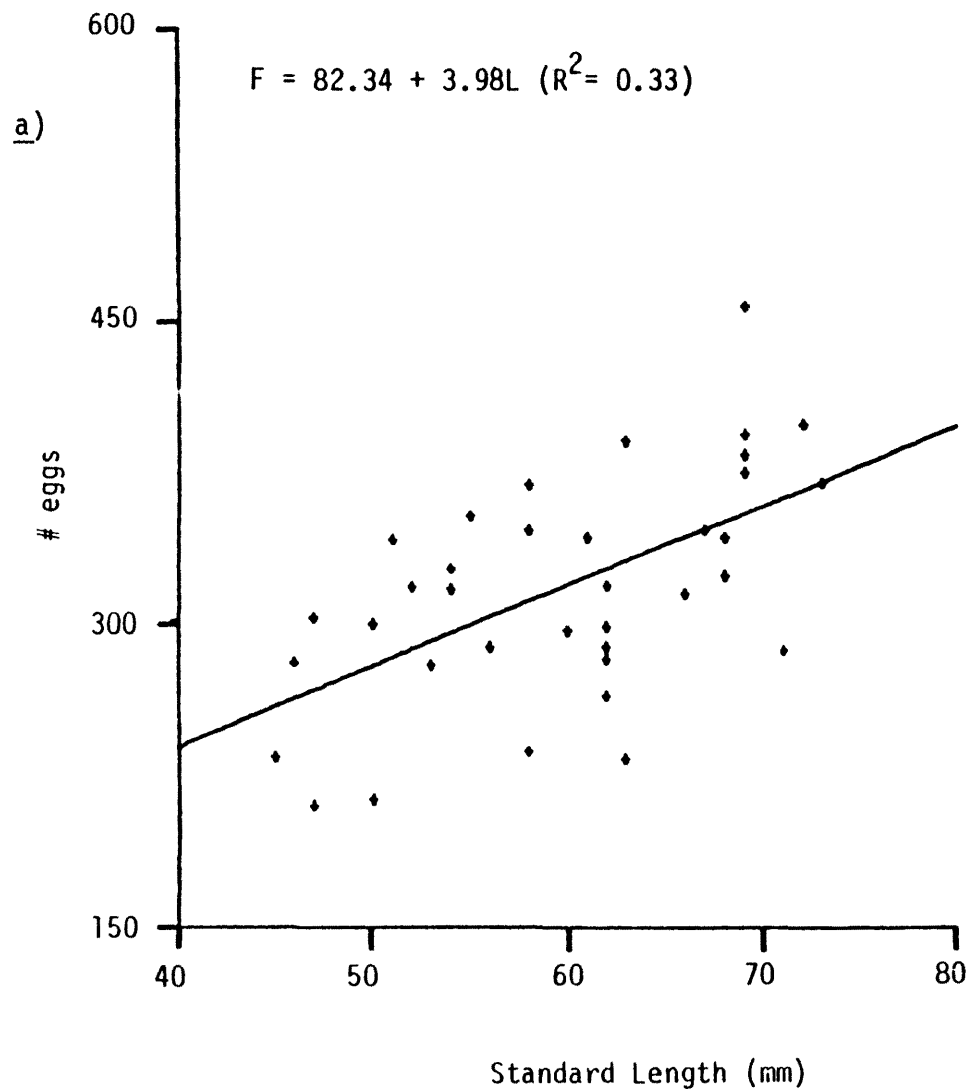


Figure 11.30: Relationship between fecundity and standard length for two riverine populations of C. spilurum.

Figura 11.30: Relación entre fecundidad y longitud estandar en dos poblaciones riverinas de C. spilurum.

breeding condition show a characteristic dark grey coloration of the throat region, similar to that exhibited by female guapote (C. motaguense).

Diet: Seasonal variations in the diet of C. spilurum are summarized in Fig. 11.31. This species is omnivorous but feeds mainly on plant material. It has the relatively long, coiled intestine characteristic of herbivores and its tooth structure appears adapted to scraping periphyton (attached algae) from stones. Sand/silt represented a major component of stomach contents on most sampling dates and was presumably ingested incidentally with plant material. Nevertheless, in areas where current flow was reduced, periphyton may have been growing on coarser sand and thus have represented a significant food item. Between 30% and 60% (by volume) of material in the stomach was usually composed of filamentous algae and macrophyte fragments. Oscillatoria, Fragillaria and Microspora were the most abundant algal genera. Macrophyte fragments included a terrestrial vegetation component but were primarily composed of the aquatic plant Mayaca and the moss Polystrichum, both of which are abundant on boulders in the R. Yure. Macrophytes were the dominant item in over 50% of the stomachs containing food (Fig. 11.31).

Various invertebrate taxa were also eaten, but only two of these, Trichoptera and chironomid larvae, ever represented major diet components. On average, they represented a total of between 20 and 40% of stomach contents. Their relative nutritional value may, of course, have been greater than their volume contribution suggests. Trichopteran larvae were represented primarily by species with sand-grain cases; generic level identification was usually not possible since food is well macerated by the pharyngeal teeth before it reaches the stomach, and, in addition, larvae were often separated from their

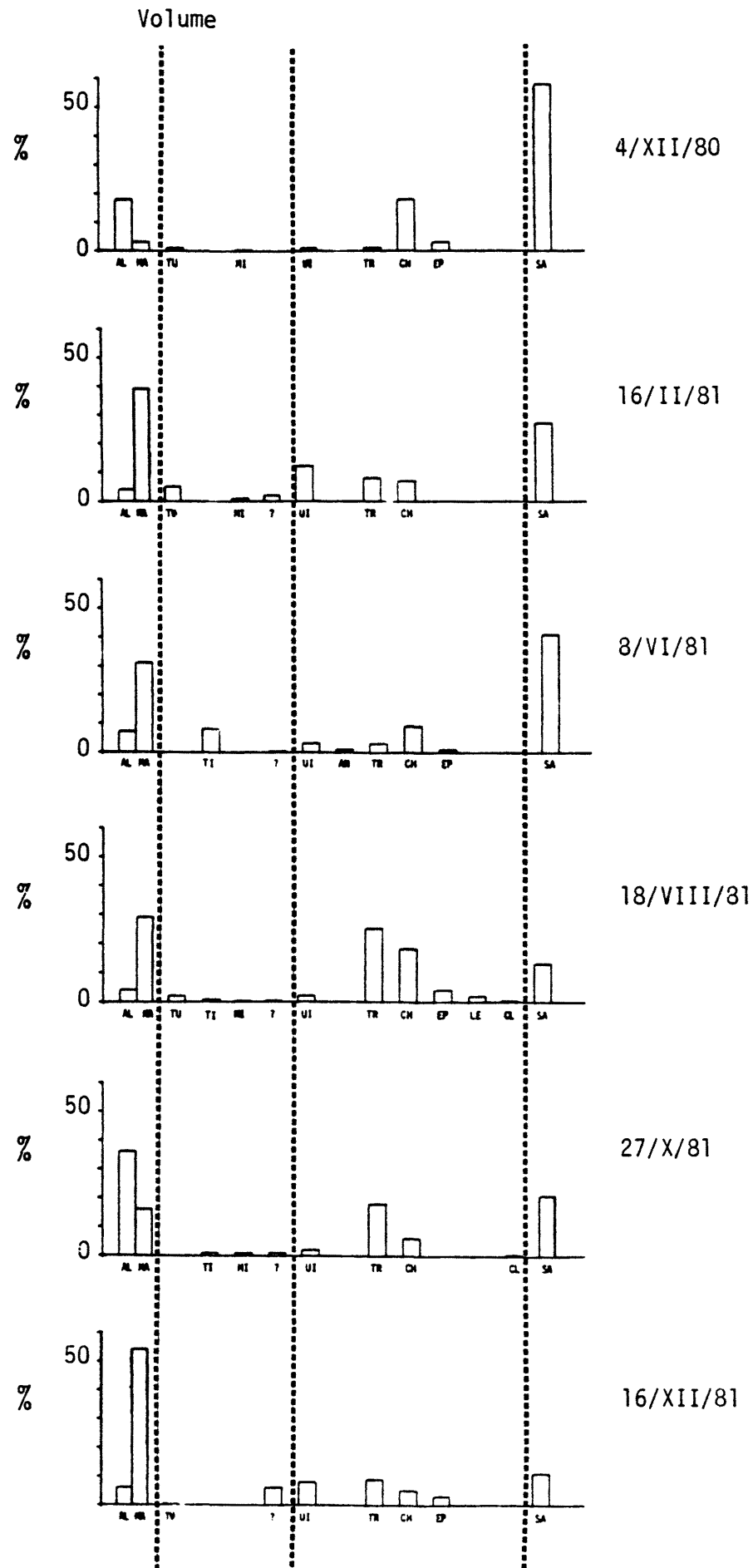
Figure 11.31: Food of Cichlasoma spilurum , R. Yure.

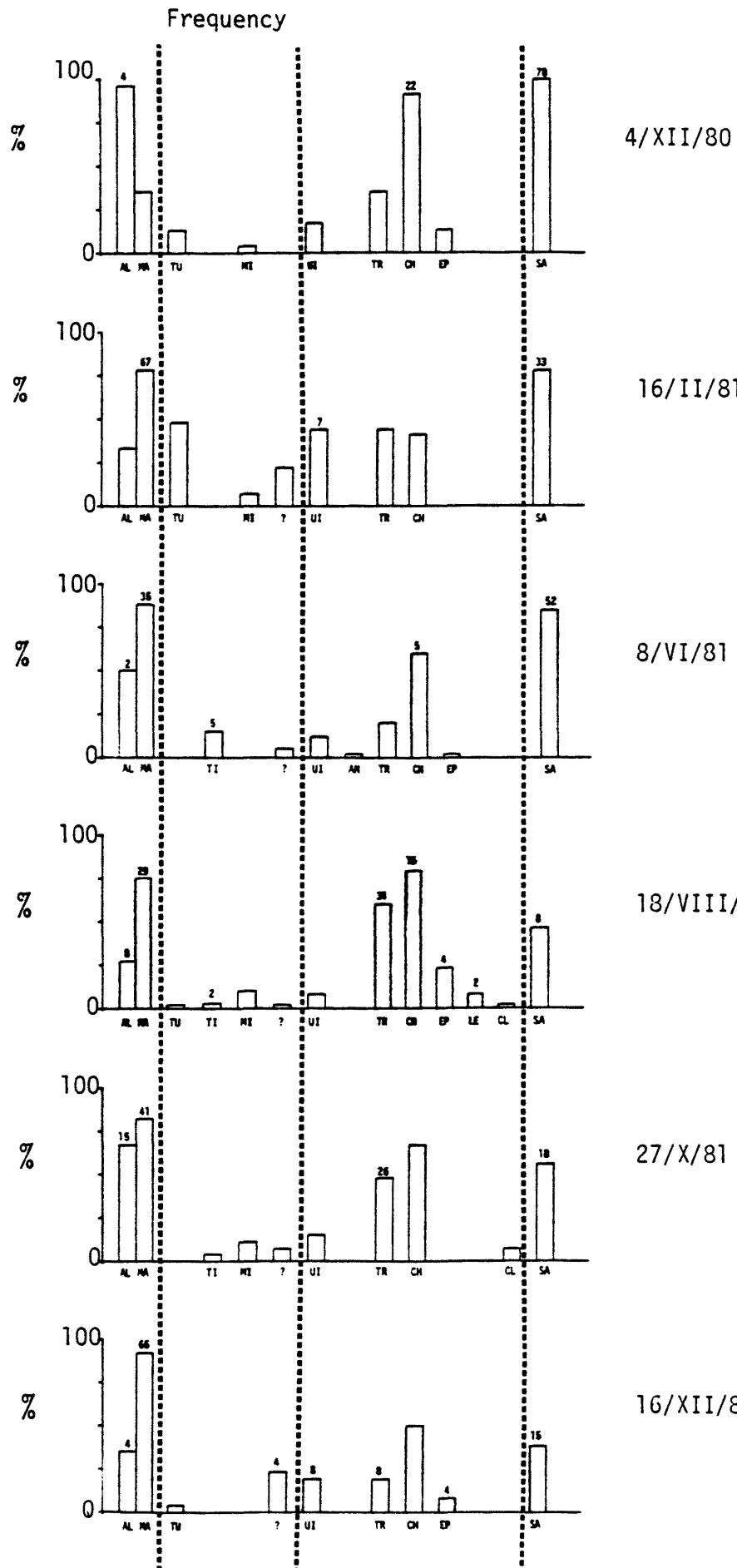
Figura 11.31: Alimentacion de Cichlasoma spilurum en el rio Yure.

KEY:

AL: Algae
MA: Macrophytes
TU: Turbellaria
TI: Terrestrial insects
MI: Mites
? : Unidentified components
UI: Unidentified insects
AN: Anisoptera lv.
TR: Trichoptera lv.
CH: Chironomidae lv.
EP: Ephemeroptera lv.
LE: Lepidoptera lv.
CL: Coleoptera lv.
SA: Sand

(Numbers over the "frequency" histograms refer to % dominance of the food item)





cases. Food maceration made recognition of Ephemeroptera especially difficult and it is likely that a large proportion of the component labelled "unidentified insect fragments" in Fig. 11.31 was composed of these mayfly larvae.

The food habits of C. spilurum in the R. Yure exhibited little seasonal variation during 1980-81. The most notable between-month difference is the higher proportion of individuals in the August sample for which Trichoptera and chironomid larvae were the dominant food item. This pattern may in part have been influenced by the sampling procedure. On this date three sets of samples were taken, at 09:00, 13:00 and 18:00 hrs, instead of the usual single morning sample. The August data in Fig. 11.31 refer to a composite sample from all three sampling times. However, diet composition differed with the time of day. Aquatic insect larvae, especially Trichoptera and chironomids, were more important in the afternoon and evening samples than in the one collected in the morning. These apparent diel shifts in food intake may have resulted from a number of potential factors, including differential digestion and evacuation rates from the stomach of invertebrate and plant food items, changes in invertebrate behavior patterns and increased invertebrate drift around the time of sunset. These data well illustrate a common problem in fish food habit studies, i.e. the adequate characterization of the entire daily food intake. Diel changes in feeding behavior of the riverine fish communities will need to be studied in greater detail in the future through a higher frequency sampling schedule.

Age and Growth: The cohort structure of the R. Yure C. spilurum population can be used to obtain an estimate of growth rates in this species, especially of the younger age classes. Fig. 11.25 shows clearly the first appearance of

young-of-the-year fish in the June sample. The average length of this cohort was approximately 25mm. The cohort can be followed through at least until December, by which time the males had attained a length of about 60mm and the females about 45mm. The average growth rate over this period of time was therefore approximately 6mm/month and 4mm/month for males and females respectively. After December this cohort tended to merge with the cohort of the previous year, making it difficult to follow. It does appear, however, that females larger than about 65mm and males larger than 75mm grow much more slowly than smaller size classes, since the peaks in the size frequency distributions from December onwards change very little in position.

Cichlasoma nigrofasciatum (Günther)

C. nigrofasciatum is the second of two species in the Archocentrus taxonomic grouping of Cichlasoma which was recorded from the El Cajón area. Although previous workers have at times apparently confused this species with C. spilurum (Martin 1972), C. nigrofasciatum has a quite distinctive appearance, with a characteristic oblique dark band extending onto the nape and the upper part of the head. (Its common name in English is "convict cichlid").

The distribution of this species in the El Cajón area is especially interesting and has been previously discussed in detail (11.6.1) in relation to the distribution of C. robertsoni. Martin (1972) recorded C. nigrofasciatum as being most abundant in moderately large, perennial streams. In the Choluteca drainage of southern Honduras it is the most common cichlid (Carr and Giovannoli 1950), a position held by C. spilurum in many of the streams of the El Cajón area.

Apart from one individual taken at the Yure/Humuya confluence, C. nigrofasciatum was recorded only from drainages within the Sulaco watershed (Fig. 11.6). In four of these rivers (Canquique, Jacagua, Colorado and Yunque) it represented between 14% and 60% (\bar{x} = 30%) of total cichlid numbers and between 5% and 21% (\bar{x} = 12%) of total cichlid biomass (Table 11.5, Fig. 11.7).

All samples of C. nigrofasciatum were collected during March and April and ranged in size from 17 to 59 mm. The length-weight relationship calculated from these fish is as follows:

$$W = (9.4 \times 10^{-5}) L^{2.83}$$

Males were on average larger than females in these collections (mean standard length = 47.7mm vs 41.9mm) but sample size was not large enough to enable a reliable comparison to be made. Carr and Giovannoli (1950) reported that males were "consistently" larger than females in a R. Choluteca population. Comparison to the closely related C. spilurum would also suggest a male-female size difference for C. nigrofasciatum. There was no indication of discrete cohorts in the samples of C. nigrofasciatum collected during this study but low sample size may have obscured any pattern that was present.

GSI values indicate that reproduction occurs in the dry season (Fig 11.32a), but the length of the reproductive season is unclear. Mature or maturing oocytes were observed in females larger than 43mm S.L. Approximately 80% of females in this size range contained maturing oocytes during March and April. A typical egg size frequency distribution for a stage V ovary is shown in Fig. 11.32.b As in other Cichlasoma species, a second batch of oocytes begins to mature before the larger size class is released from the ovary. Mature oocytes are about 1.7-1.9m in diameter. The relationship between fecundity and female standard length shown in Fig. 11.32a suggests a close

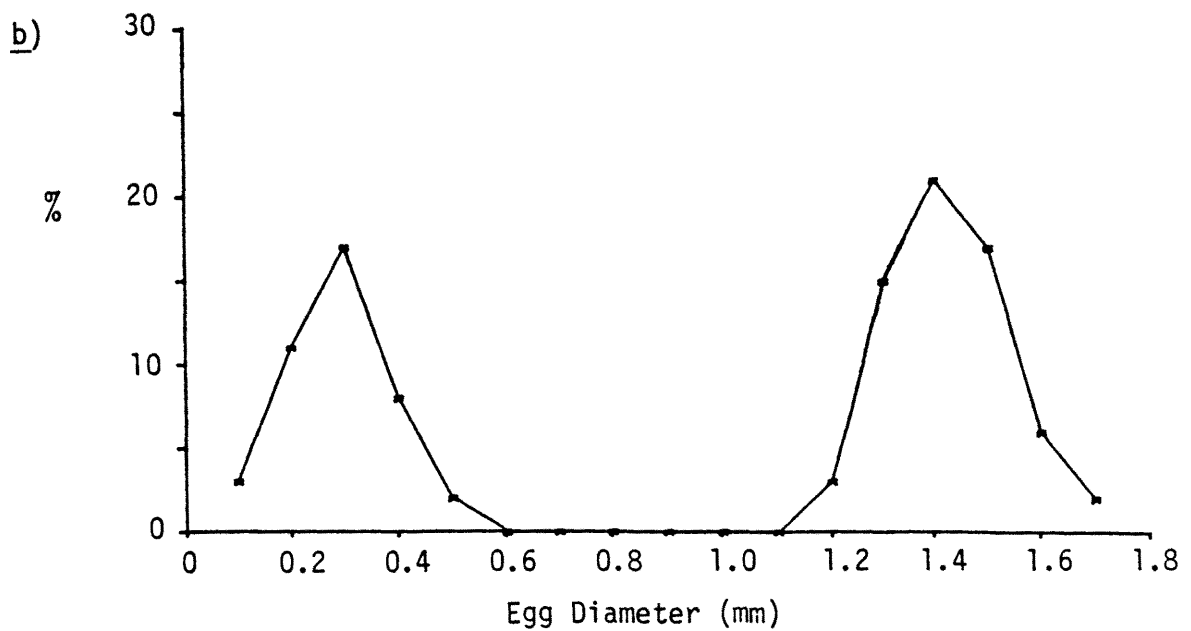
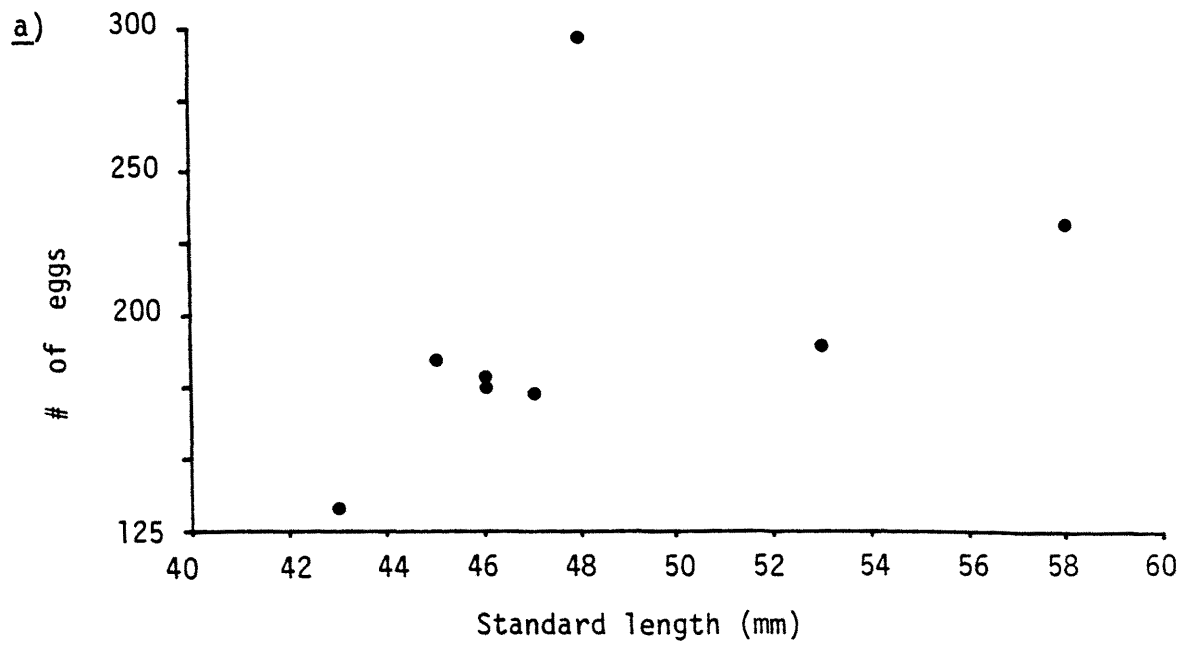


Figure 11.32: Relationship between fecundity and standard length (a), and egg size frequency distribution (b) of Cichlasoma nigrofasciatum.

Figura 11.32: Relación entre fecundidad y longitud estandar (a), y la distribución por tamaño de los huevos (b) en Cichlasoma nigrofasciatum.

similarity to that for C. spilurum. Typical of Cichlasoma species, C. nigrofasciatum is a substrate brooder, with both sexes guarding the eggs and young. The nest is often about 5-10 cm in diameter and consists of a hollow excavated in the substratum, often beneath overhanging boulders (Carr and Giovannoli 1950). In L. Jiloá, a small crater lake in Nicaragua, C. nigrofasciatum breeds during the wet season (McKaye 1977).

The stomach of C. nigrofasciatum is small and was frequently empty in samples collected for the present study. Diet analyses were therefore done on the entire gut, with some consequent loss of diet resolution. Table 11.13 summarizes the food of C. nigrofasciatum during the latter part of the dry season. It is primarily an insectivorous species (in contrast to the population of L. Jiloá, which is herbivorous; McKaye 1977), but does ingest some plant material in the form of filamentous algae (Spirogyra and filamentous diatoms). The food item labelled "detritus" in Table 11.13 appeared to be mainly of insect origin made unrecognizable through maceration and digestion, and does not represent detritus ingested by the fish. Non-aquatic insects are apparently of little importance for this cichlid in contrast to aquatic insect larvae which comprise a major fraction of the diet. Caddis, mayfly and chironomid larvae were especially important in these dry season samples. Ephemeroptera probably contributed even more to the diet than indicated by the data presented here because they are easily macerated by pharyngeal teeth and thus liable to be classified as unidentified insect fragments.

Cichlasoma robertsoni (Regan)

The range of C. robertsoni has its southern limit in Honduras (Miller

Table 11.13: Food of C. nigrofasciatum (Sulaco drainages, April 1981)

Tabla 11.13: Alimentación de C. nigrofasciatum (los afluentes del río Sulaco, abril de 1981).

<u>Item</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Algae	13	3
Mites	6	-
Uniden. insect frag.	32	10
Trichoptera lv.	13	13
Chironomidae lv.	16	6
Ephemeroptera lv.	32	13
Coleoptera lv.	13	-
Coleoptera ad.	3	-
Ants	3	3
Detritus	81	65
<hr/>		
N analyzed :	44	
N + food :	31	
Length range (mm)	17-59	

1966, Martin 1972), probably within the El Cajón watershed itself (Fig. 11.6). The taxonomy and distribution of this species have been discussed within the context of the Amphilophus group by Bussing and Martin (1975). Collections of C. robertsoni from the Humuya drainage present a rather confusing picture of its relative abundance. Samples taken from the Humuya/Yure confluence in the 1980-81 dry season contained either few if any C. robertsoni. Moderate numbers were taken at the same site in March 1982 and in September of the same year it was abundant (Table 11.5). It is possible that increased river flow on the latter sampling date acted to confine this and other cichlids to side pool areas, thus making them much more susceptible to collection by electroshocking.

Individuals taken in the two main samples (March and September 1982) ranged in length from 21 to 139 mm. There is some indication that two cohorts or year classes were present in the dry season collection, but sample size is too small to allow adequate resolution of size frequency distributions. The length-weight relationship, calculated from 29 individuals, is:

$$W = (2.76 \times 10^{-5}) L^{3.06}$$

No information is available on the reproductive ecology of this species because all individuals captured were immature. All ovaries examined contained small, clear eggs whose diameters were 0.2mm or less and all GSI's were less than 0.5. Based on a comparison with other species of Cichlasoma, it would seem likely that individuals larger than about 60-70mm S.L. are adult. Thus the breeding season does not appear to include March and September, further suggesting that it may be quite restricted. Additional studies will be needed to better understand the reproductive ecology of this species.

Table 11.14: Food of C. robertsoni (R. Humuya/ Yure confluence).

Tabla 11.14: Alimentación de C. robertsoni (la confluencia de los ríos Humuya y Yure).

<u>Item</u>	March '82		September '82	
	<u>Freq. (%)</u>	<u>Dom. (%)</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Filamentous algae	25	-	5	-
Seeds and flowers (Poaceae)	-	-	52	5
Ostracods	12	-	33	-
Ants	-	-	5	5
Mites	-	-	14	-
Molluscs	-	-	10	-
Uniden. insect frag.	12	-	71	5
Odonata lv.	25	-	-	-
Hydroptilidae lv.	-	-	10	-
Chironomidae lv.	50	50	19	-
Ephemeroptera lv.	25	-	14	-
Coleoptera lv.	-	-	29	-
Detritus	88	50	95	85
Sand	-	-	24	-
<hr/>				
N analyzed :	8		21	
N + food :	8		21	
Length range (mm) :	8		21	

Results of food analyses, separated according to season, are shown in Table 11.14. As with several other cichlid species, the stomach of C. robertsoni is small and was empty in the majority of samples. Data in Table 11.14 therefore refer to entire gut contents. Unfortunately, these data do not provide a satisfactory diet description since the major component in most individuals was unrecognizable "detritus". This was probably of plant origin and may have represented "true" detritus, but it is impossible to be certain of this. Seeds and flowers of unidentified species in the family Poaceae were major diet components in fish from the wet season sample. Aquatic insect larvae were generally less important in this sample than in that from the dry season when chironomids were a major food item for small fish (<45mm). Larger individuals from the dry season sample contained primarily detritus, however. These findings may indicate a change in diet with age in this species and may in turn explain the low importance of aquatic insect larvae in fish captured during the wet season, since the latter sample included only one individual less than 45mm.

Cichlasoma urophthalmus (Günther) "Carpa"

C. urophthalmus occurs along the Atlantic slope of Middle America from Mexico to the R. Ulúa drainage in Honduras. An apparently separate population occurs in Nicaragua (Martín 1972, Miller 1966). It was not taken from any of the drainages sampled during the present study, appearing to be restricted to larger, lower elevation rivers. A population does however occur in L. de Yojoa, possibly representing an introduction since no specimens of this species were recorded in collections taken from the lake or its tributaries prior to 1956 (Martín 1972). The fishery of L. de Yojoa was not a focus of

Plate 6: Cichlasoma urophthalmus (carpa)
and C. managuense (guapote tigre).

the present study but a few fishermen-caught C. urophthalmus were examined for reproductive condition and diet. (This species is called "carpa" in L. de Yojoa, but this is a misnomer since it is not a carp).

C. urophthalmus is omnivorous but in most of the individuals examined, molluscs (mainly Physa, with a lower proportion of Biomphalaria [?]) represented the major diet component. Filamentous algae were usually the other important food item. One individual, taken in February, contained only Anisoptera nymphs which are also an important food item for the lake's bass population. All fish examined were adults; nothing is known of the feeding ecology of younger stages.

The reproductive ecology of C. urophthalmus is presumably similar to that of other species in this genus (Breder and Rosen 1966), but data are almost non-existent. Only two of the fish examined from L. de Yojoa were females, one taken in the dry season (March) and the other in the wet season (August). Both contained mature eggs, suggesting that reproduction may continue throughout the year in the Yojoa population. (Observations of seasonal variation in the abundance of this species in the Yojoa "fish market", however, suggest that reproduction is more frequent at certain times of the year than others). Egg counts for the two mature females were as follows:

<u>Standard Length (mm)</u>	<u># eggs</u>	<u>Gonad Wt. (g)</u>
256	14,242	33.5
209	14,535	22.9

Mature eggs are ovoid, with an average diameter of approximately 1.5 mm. Wet and dry weights, calculated from one female, were 1.51 (\pm .25) mg and 0.64 (\pm .07) mg, respectively.

Although C. urophthalmus is of less importance than tilapia and bass in

the Yojoa commercial fishery, it represents the primary native food fish of the area and urgently needs additional study. It is a candidate for introduction into the El Cajón reservoir where it could become a useful food fish (see Section 11.3).

Cichlasoma motaguense (Günther) "Guapote"

Taxonomy and Distribution: C. motaguense is closely related and very similar in appearance to C. friedrichsthalii and C. dovii. Although Miller (1966) suggests that the first two species are synonymous, Martin (1972) and Moya-Meono (1979) recognize them as distinct species. The key drawn up by Moya-Meono (1979) for Central American guapotes is reproduced in Appendix 3. On the basis of this key and a morphometric analysis of 51 individuals from the Yure system (Table 11.15), guapotes collected during the present study from the El Cajón area were assigned to the species C. motaguense.

C. motaguense is widely distributed throughout western Honduras, but is replaced by C. dovii in the eastern part of the country and in Nicaragua and Costa Rica (Moya-Meono 1979). It was recorded from all areas sampled during the present study, with the exception of two small streams in the Humuya and Yure drainages (Q. Agua Caliente and Q. Agua Amarilla) and the R. Tamilito and R. Jaitique (Table 11.5). The failure to record this species from the latter two rivers is interesting since riffle and shallower pool areas were sampled intensively, which was not the case for the two streams.

C. motaguense apparently has the most extensive distribution of any of the cichlid species present in the El Cajón area. It was, for example, the only cichlid recorded from the upper part of the Yure watershed (Q. del Cerro,

Plate 7: Cichlasoma motaguense (guapote),
female (above) and male (below) showing
reproductive coloration.

Foto 7: Cichlasoma motaguense (guapote)
hembra (arriba) y macho (abajo) mostrando
los colores de reproducción.

Table 11.15: Morphometric comparison † of C. motaguense from the Yure system with Atlantic slope populations of C. motaguense and C. friedrichsthalii described by Martin (1972).

Tabla 11.15: Comparación morfométrica † de C. motaguense del sistema de Yure con las poblaciones del vertiente Atlántico de C. motaguense y C. friedrichsthalii descritas por Martin (1972).

	<u>C. motaguense</u>		<u>C. motaguense</u>	<u>C. friedrichsthalii</u>
	(Yure system, present study)		(Atlantic slope populations, Martin, 1972)	
	<u>Mean</u>	<u>St. Dev.</u>	<u>Range of population means</u>	
Eye diameter	8.77	1.71	8.2-9.5	9.8-10.6
Body depth	35.82	1.86	33.8-40.5	41.5-43.2
Prepectoral distance	38.80	1.72	38.5-39.1	39.0-40.9
Prepelvic distance	42.08	1.54	40.7-42.7	43.0-45.0
Base of dorsal fin	54.25	2.66	53.7-56.8	56.0-58.0
Base of anal fin	26.60	1.25	24.7-26.9	28.7-30.9
Length of sixth dorsal spine	8.47	1.11	8.3-9.6	10.7-12.5
Length of last dorsal spine	12.01	1.39	11.2-11.7	13.1-14.1
Length of pelvic fin	25.43	2.63	23.3-24.4	26.6-32.0
Length of pectoral fin	24.92	2.92	22.1-24.5	24.0-26.5
# dorsal spines	18.18	.68	-	-
# dorsal rays	10.55	.83	-	-
# anal spines	7.22	.50	-	-
# anal rays	8.78	.64	-	-
Standard length range (mm)	48-260		-	-
N	51		4*	4*

† All data, except for fin counts, expressed as percent of standard length. Measurements were made according to Hubbs and Lagler (1958) and Bussing and Martin (1975).

* Number of populations sampled

L. Yure; Fig. 11.7). In small to medium-sized streams, it usually represented between 4 and 8% of total fish numbers and 10-20% of total biomass. In collections containing C. spilurum, the ratio (by number) of C. motaguense to C. spilurum was usually within the range 1:4 - 1:7.

Population Structure: Guapotes sampled with the electroshocker usually measured less than 150mm S.L. Gill-net samples from L. Yure included larger individuals (Section 11.7) and it is probable that more effective sampling from deeper pools in the Yure and other rivers would have yielded individuals larger than 150mm. The length-weight relationship for guapote is shown in Fig. 11.33.

The population structure of C. motaguense from the R. Yure on four sampling dates in 1981 is illustrated in Fig. 11.34. Because sample size was always relatively low (<ca.30) it is not possible to analyze in detail the size frequency distributions. However, there is some evidence of cohort structure for this population. It should be noted that juveniles less than about 25mm were not sampled representatively with this gear, although they must have been present at least during the latter part of the year. These data (Fig. 11.34) suggest, but do not conclusively demonstrate, a general male-female size difference similar to that previously shown for C. spilurum. Data from L. Yure (see Section 11.7), further indicate that males live longer and grow to a larger size than females. In both river and lake samples, the largest individuals captured were usually males.

The male:female ratio of the four samples illustrated in Fig. 11.34 ranged from about 1:2 in June and August to approximately 1:1 in October and December. This shift in the sex ratio, if real, may have resulted from selective mortality of larger size-class females after peak reproductive

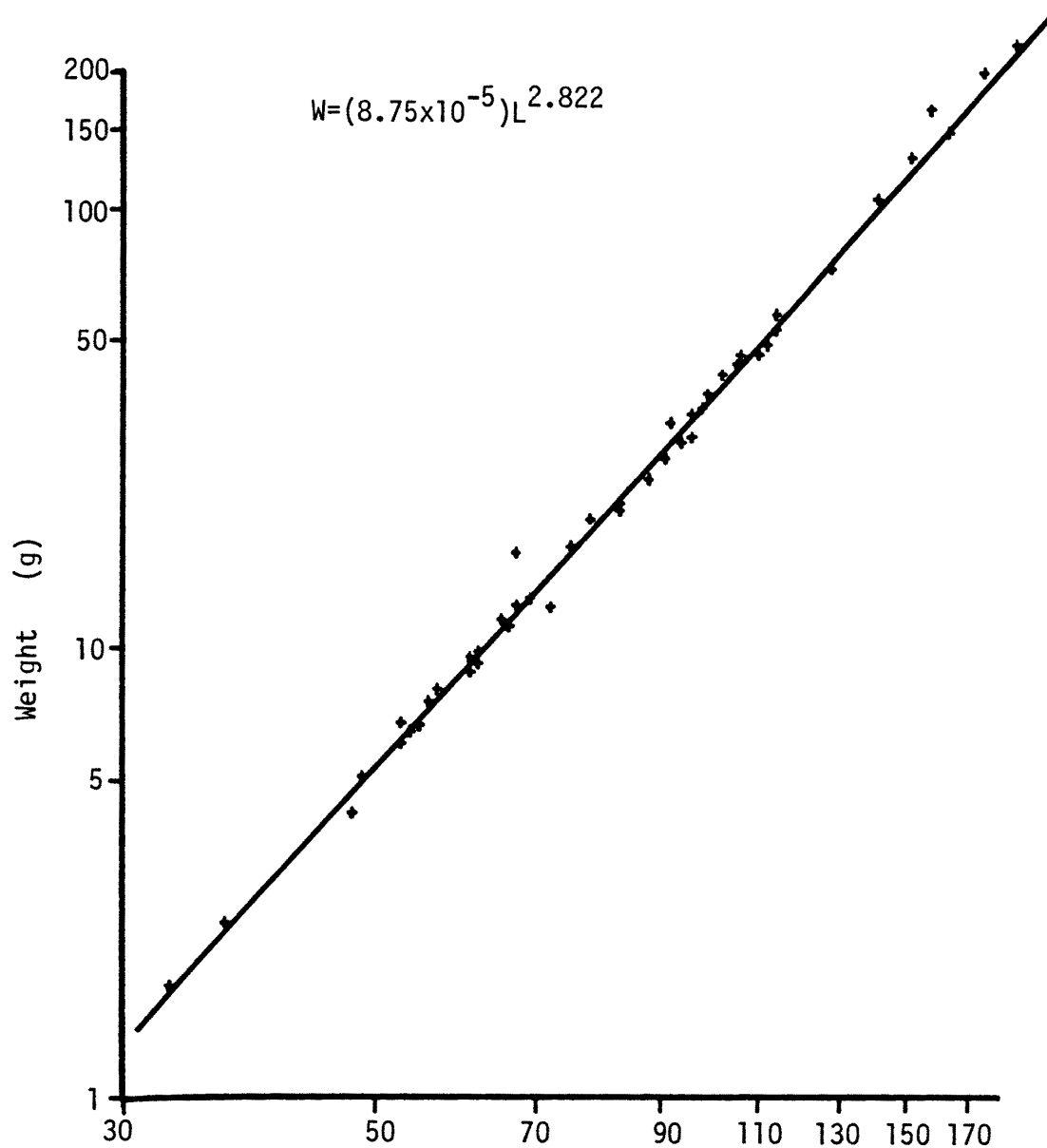


Figure 11.33: Length-weight relationship of Cichlasoma motaguense.

Figura 11.33: Relación longitud-peso de Cichlasoma motaguense.

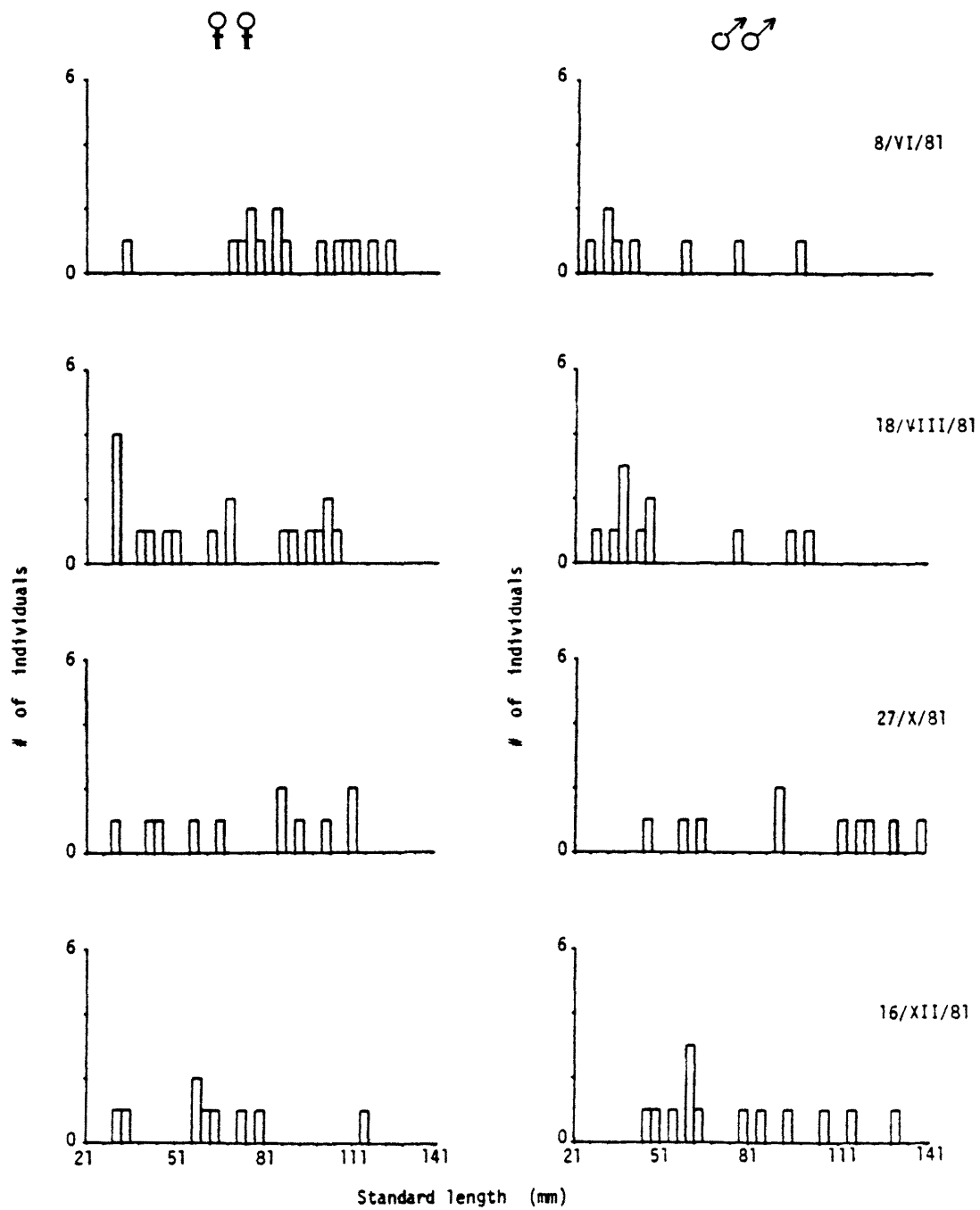


Figure 11.34: Size frequency distribution of *Cichlasoma motaguense* in the R. Yure.

Figura 11.34: Distribución por tamaño de *Cichlasoma motaguense* en el río Yure.

activity in June-July (see below). An alternative explanation is that in June and August the largest size class of males present in the population consisted of individuals about 130mm in length which were not sampled representatively. Later in the year, however, females in this older cohort had also grown out of the size range effectively sampled with the electroshocker, thus restoring the apparent sex ratio (i.e. the ratio within the sample) to near unity. The only method to obtain a truly representative size frequency distribution of C. motaguense in the R. Yure (and in similar rivers) would be by using a fish poison such as rotenone.

Reproduction: There is apparently no published information on the reproductive ecology of C. motaguense with which to compare data collected during the present study. A number of field observations indicate that both parents guard the young and, presumably, the eggs. Breeding coloration is quite distinctive in this species, with females developing yellow/orange patches on the opercula and anterior part of the trunk. This coloration was noticed especially in fish from L. Yure and is further described in Section 11.7.

In the R. Yure, C. motaguense females first become sexually mature at a length of about 80mm. This is illustrated in Fig. 11.35 where female size distribution is shown as a function of ovarian development stage (see p. 5-111, Vol. 1). Yolk accumulation in oocytes begins in females as small as 45mm but stage III ovaries (containing oocytes up to about 0.9mm diameter) were only seen in females 85mm and above. Similarly, stage II males were observed at lengths greater than 60mm, but stage III males only above 90mm.

Analysis of reproductive seasonality is made difficult by the relatively

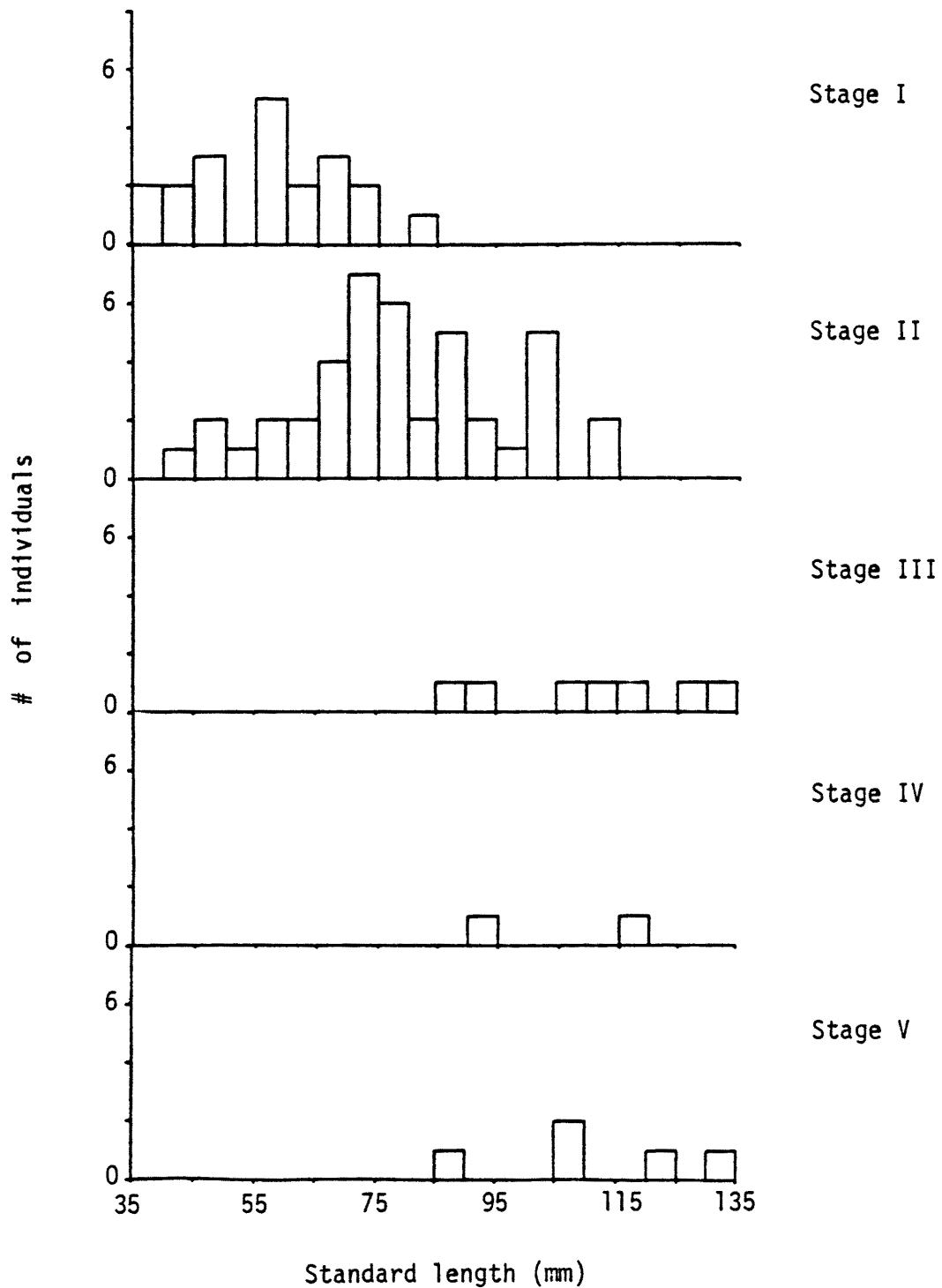


Figure 11.35: Size frequency distributions of female Cichlasoma motaguense at various ovarian development stages.

Figura 11.35: Distribuciones por tamaño de las hembras de Cichlasoma motaguense en varios estadíos de madurez.

Table 11.16: Seasonal variation in the gonosomatic index of C. motaguense
(≥ 70 mm S.L.) R. Yure.

Tabla 11.16: Variación estacional en el índice somático-gonadal de C. motaguense
(≥ 70 mm L.E.) en el río Yure.

<u>Date</u>	<u>♀♀</u>				<u>♂♂</u>			
	<u>Mean</u>	<u>St. Dev.</u>	<u>Range</u>	<u>N</u>	<u>Mean</u>	<u>St. Dev.</u>	<u>Range</u>	<u>N</u>
I-II/81	.39	.31	.1-.78	4	.61	.70	.21-1.11	2
VI/81	1.08	1.65	.16-4.53	13	.06	-	-	1
VIII/81	.82	1.81	.2-5.66	9	.15	.20	.05-.29	3
X/81	.29	0.12	.14-.48	6	.08	.03	.05-.15	7
XII/81	.51	.52	.13-1.11	3	.16	.23	.04-.64	6
I-III/81	1.11	1.07	.15-2.40	4	.11	.09	.04-.26	6

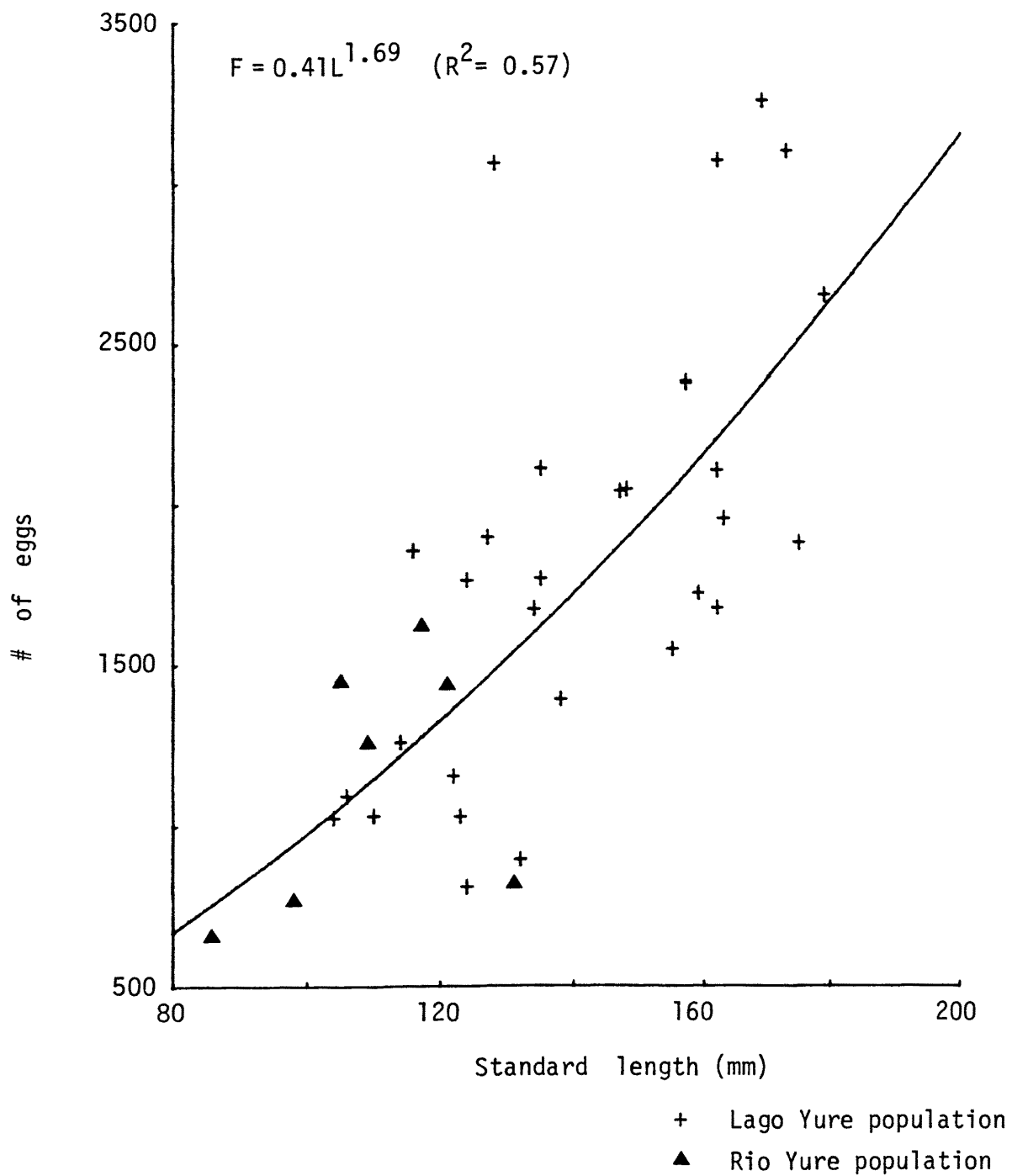


Figure 11.36: Relationship between fecundity and standard length for Cichlasoma motaguense.

Figura 11.36: Relación entre fecundidad y longitud estandar en Cichlasoma motaguense.

low sample sizes, but peak reproduction apparently occurs during the first part of the wet season (June). GSI values (and perhaps population size structure) suggest that there is some reproduction at other times of the year, (Table 11.16). Guapote eggs are usually ovoid when mature, with an average diameter of 1.6-1.8mm and a dry weight of approximately 1.5mg. There was no evidence of any difference in mature egg size between R. Yure females and those from L. Yure. A typical egg size frequency distribution is shown in Fig. 11.48 for a L. Yure female (Section 11.7). Fecundity data from the R. Yure guapote population are compared with those from the L. Yure population in Fig. 11.36. No obvious differences are evident between lotic and lentic populations, and all points have been used to calculate one regression.

Diet: C. motaguense is primarily insectivorous in the R. Yure, but larger size classes become increasingly piscivorous. The percentage of those individuals containing food in which some fish remains were found is as follows:

<u>Length range (mm)</u>	<u>% containing fish</u>
< 50	6
50 - 80	8
> 80	18

Seasonal variation in diet is shown in Fig. 11.37. Plant material was found in only a few fish stomachs, mainly those from the January sample. Fragments of freshwater prawns and Trichoptera larvae were major components of stomach contents in June, although few stomachs in this sample contained food. An examination of intestinal contents indicated that the items most frequently present were filamentous algae and larvae of Odonata, Trichoptera and Ephemeroptera, the latter representing the dominant item in most individuals. Analyses of the August and October samples did not yield detailed information

Figure 11.37: Temporal variation in the diet of Cichlasoma motaguense in the R. Yure at Yure.

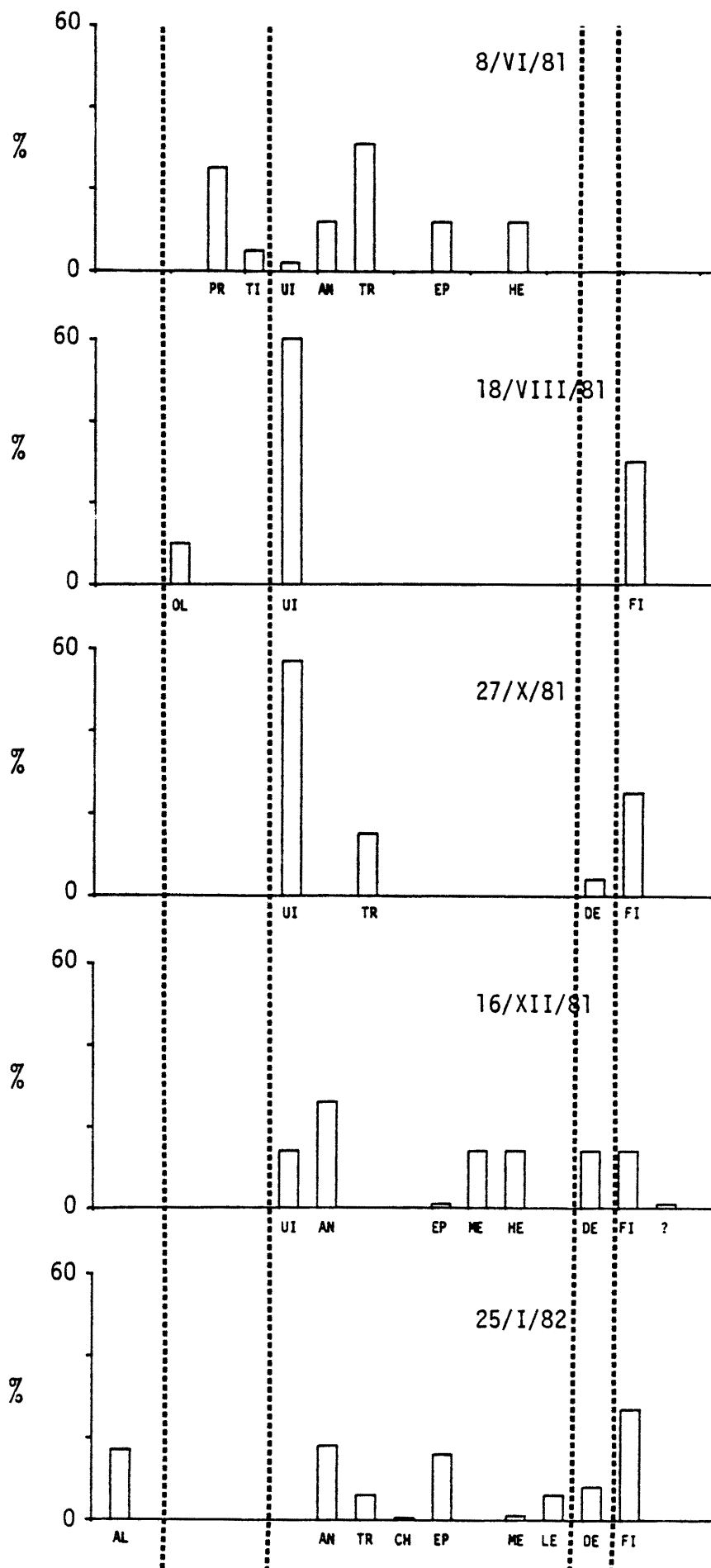
Figura 11.37: Variación temporal en la dieta de Cichlasoma motaguense en el río Yure en Yure.

KEY:

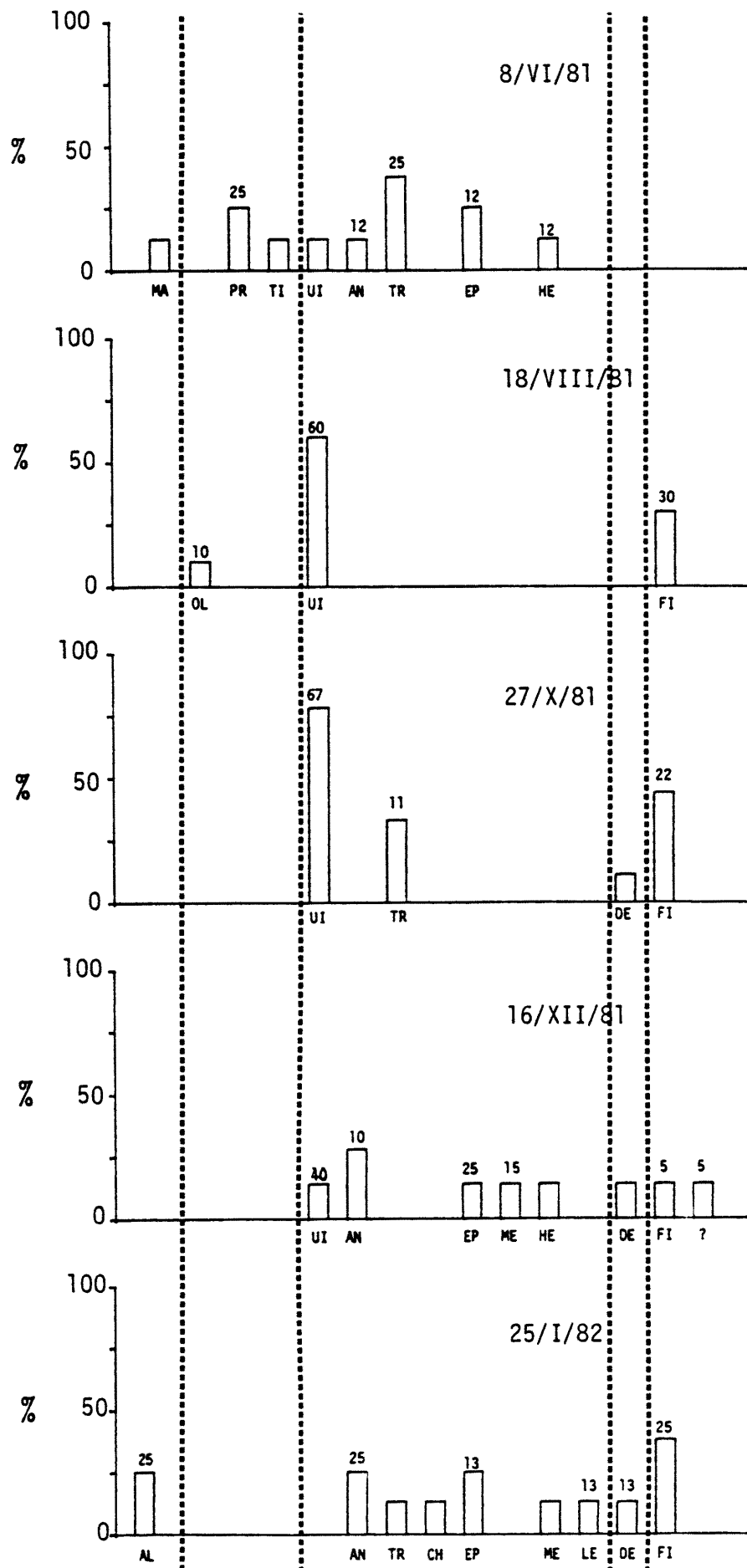
AL: Algae
MA: Macrophyte fragments
OL: Oligochaetes
PR: Prawns
TI: Terrestrial insects
UI: Unidentified insects
AN: Anisoptera lv.
TR: Trichoptera lv.
CH: Chironomidae lv.
EP: Ephemeroptera lv.
ME: Megaloptera lv.
HE: Hemiptera
LE: Lepidoptera lv.
DE: Detritus
FI: Fish
? : Unidentified components

(Numbers over the "frequency" histograms refer to the % dominance of the food item.)

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because stomach contents had been so macerated (by the pharyngeal teeth) that a large proportion had to be catagorized as unidentified insect fragments. These fragments probably represented small, delicate mayfly and stonefly species. Intestinal contents of the October sample included mollusc as well as insect fragments. Anisoptera (mainly Tramea and Leucorrhinia) and Ephemeroptera were important diet components at the beginning of the dry season (Fig. 11.37d and e).

To summarize, there is apparently little seasonal variation in guapote diets in the R. Yure. Aquatic insect larvae usually represent between 60 and 80% by volume of stomach contents, with the remainder being composed primarily of fish remains. Identification of these remains was usually not possible, but ingested scales indicated that poeciliids were the major prey. Although the diet of this cichlid remains fairly constant through the year, it should be noted that a finer resolution of the diet components, particularly the insect larvae, might demonstrate greater seasonal variation in the contribution of specific taxa.

Relative to the L. Yure population, C. motaguense from the R. Yure exhibited low fat accumulations. Fat index values (see P. 5-113, Vol. 1) varied seasonally, with generally higher levels in samples from the wet season (Fig. 11.38). Lower index values in August may have resulted from increased reproductive activity during June and July.

Cichlasoma managuense (Günther) "Guapote tigre"

C. managuense is one of the guapotes common in lower elevation rivers along the Atlantic slope of Central America from Honduras to Costa Rica. It can be readily distinguished from other, closely-related, guapotes by a

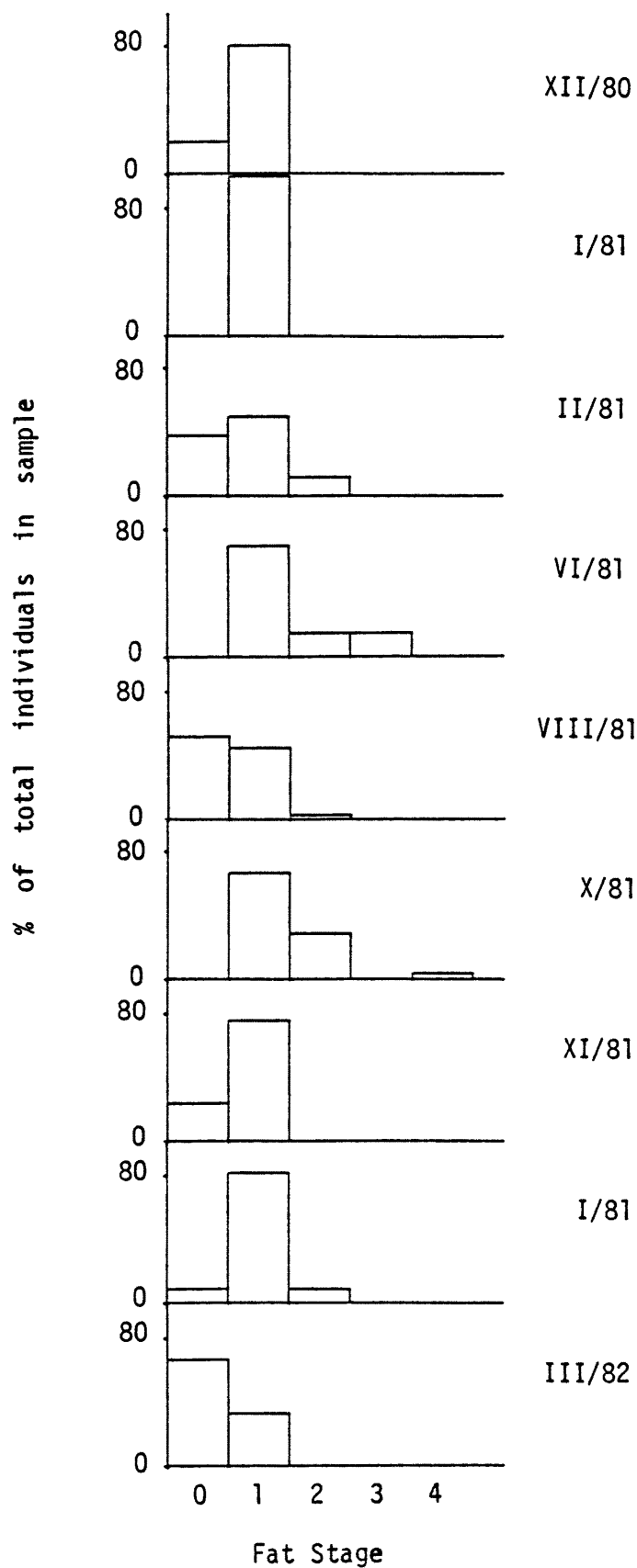


Figure 11.38: Seasonal variation in fat accumulation in Cichlasoma motaguense, R. Yure at Yure.

Figura 11.38: Variación estacional en la acumulación de grasa en Cichlasoma motaguense, río Yure en Yure.

characteristic lobe on the posterior margin of the pre-operculum and a distinctive coloration which includes a striped caudal fin.

During the present study, C. managuense, was recorded only from the lower Humuya river, near the Yure confluence (Table 11.5) and was never abundant. Electroshocking in pools at the side of the main channel caught this species primarily in the wet season (September), suggesting that increased discharge rates acted to confine smaller individuals to these areas.

The length-weight relationship calculated from the present samples (60-214mm S.L.) is:

$$W = (7.90 \times 10^{-5}) L^{2.85}$$

Little information is available on the reproductive ecology of this species. One female (92mm S.L., taken in September) and one male (214mm S.L., taken in February) had maturing gonads. All other individuals were immature. In L. Jiloá, Nicaragua, C. managuense spawns in the late dry season (McKaye 1977).

C. managuense is piscivorous, a habit to which it is presumably well adapted by the dentition characteristic of the Parapetenia taxonomic group of Cichlasoma, in which the median pair of teeth in the upper jaw and the second and third pairs on the lower jaw are large and canine-like. For the 60% of the present sample which contained food in the gut, the diet was composed entirely of fish, mainly the poeciliids Poecilia mexicana and Alfaro huberi. It is likely that the younger stages are insectivorous (in L. Jiloá this species is zooplanktivorous before it becomes piscivorous; McKaye 1977).

Since the preferred habitat of C. managuense apparently consists of backwaters and pools of larger rivers, and lowland lakes, it is likely that it will become an important predatory species in the El Cajón reservoir. It

therefore merits considerable attention in future studies of the El Cajón fishery (see Section 11.3).

11.6.2.8 Ariidae:

Arius melanopus (Günther)

The Ariidae is a cosmopolitan family of catfishes with members in Africa and Asia as well as Central and South America. Many of the species are marine and a number of others are found primarily in coastal regions, inhabiting brackish water and ascending large rivers. There are three species recorded from Honduras (Martin 1972). Two of these, A. assimilis and A. guatemalensis (referred to as Galeichthys assimilis and G. guatemalensis by Regan (1908) were recorded by Martin only from the Atlantic and Pacific coastal regions respectively. He recorded A. melanopus from inland rivers in the Ulúa drainage. Specimens caught during the present study agreed well with the description of A. melanopus given by Regan (1908). This species may be differentiated from the other two Arius species mentioned above by the shape of the palatine teeth. Those of A. melanopus are granular or obtusely conical, whereas the teeth of the other two species are villiform (more pointed).

A. melanopus is distributed from the Atlantic slope of Mexico to Panama. During the present study, samples were recorded only from the R. Humuya (at the Yure confluence and at its confluence with Q. de Chamo; Table 11.5). These fish were collected only by gill netting and only during the dry season (March-April; a third sample, not documented in Table 11.5, was collected from

Plate 8: Arius melanopus, showing mouth-incubated eggs
and juveniles.

Foto 8: Arius melanopus, mostrando los huevos y juveniles
encubados en la boca del macho.

the Humuya in February 1983). Gill nets set in the R. Humuya in September failed to catch any individuals of this species. It is unclear whether this pattern reflects the absence of A. melanopus from these rivers during the wet season, suggesting it is migratory and ascends rivers during the dry season to breed, or simply that wet season sampling was inefficient (see below). The failure to collect this species from the Sulaco drainage was probably a result of infrequent sampling in the main river channel rather than its absence from the area.

A. melanopus was the most common species in the Humuya gill net catches. All fish captured were within the size range 131-194 mm S.L. (Fig. 11.39) Gill net selectivity may have been partially responsible for this restricted size range, but one of the samples was collected with a small explosive charge, using the multi-mesh gill nets primarily as a block net. If smaller individuals had been present, they probably would have been represented in the sample. These findings suggest that A. melanopus is migratory in the Humuya/Ulúa system, moving upstream, perhaps from the delta area, during the dry season to spawn.

The reproductive ecology of Arius is especially interesting. Males incubate eggs and developing young in the mouth, for which behavior the throat and opercular region become greatly expanded. This is a characteristic that is apparently widespread in the Ariidae although not found in other catfish families. It has been described in a number of species, including A. falcarius (Willey 1910, cited by Rosen and Bailey, 1966), Potamarius maculatus (Hubbs and Miller 1960), Bagre marinus (Merriman 1940, cited by Breder and Rosen 1966) and A. guatemalensis (Carr and Giovannoli, 1950). To our knowledge, there is no published description of the reproductive ecology of A.

melanopus.

Mature eggs of A. melanopus are large, measuring approximately 9-10 mm in diameter and weighing about 380mg wet weight. The related species A. guatemalensis apparently produces eggs which are slightly larger still, up to 1.3mm (Carr and Giovannoli 1950). The total number of mature or maturing ovarian eggs averaged 21 in the present samples of A. melanopus. Distributions of egg counts and size ranges are shown in Fig. 11.39 for the March and April samples. No attempt was made to calculate a length-fecundity relationship because of the small size range of females. Size at first maturity in this species is about 135mm or less.

Two sets of data suggest that spawning is relatively synchronous in Arius and that it occurs mainly towards the end of the dry season. First, a larger percentage of females in the March collection contained small eggs (<5mm) than was the case for the April sample (54% vs. 11%) (Fig. 11.39). In ovaries which had a distinct group of maturing or mature eggs, all remaining eggs were less than 2mm in diameter. Second, more males with eggs/young in the mouth were taken in the April sample than in the previous month's collection. This is demonstrated by Table 11.17, which also shows that males incubating eggs or young were not eating. In these individuals, not only does the mouth cavity become enlarged to accommodate the young, but also the oesophagus is closed off -- the obvious reason for this being to prevent to parent from swallowing his offspring. (The lower proportion of non-incubating males and females with empty stomachs in the April sample was probably a result of day-time sampling and the diel feeding pattern of this species).

The mean number of eggs being incubated by males was 15 (range 7-20), and the mean number of incubated juveniles was 8 (range 2-18). These mean values

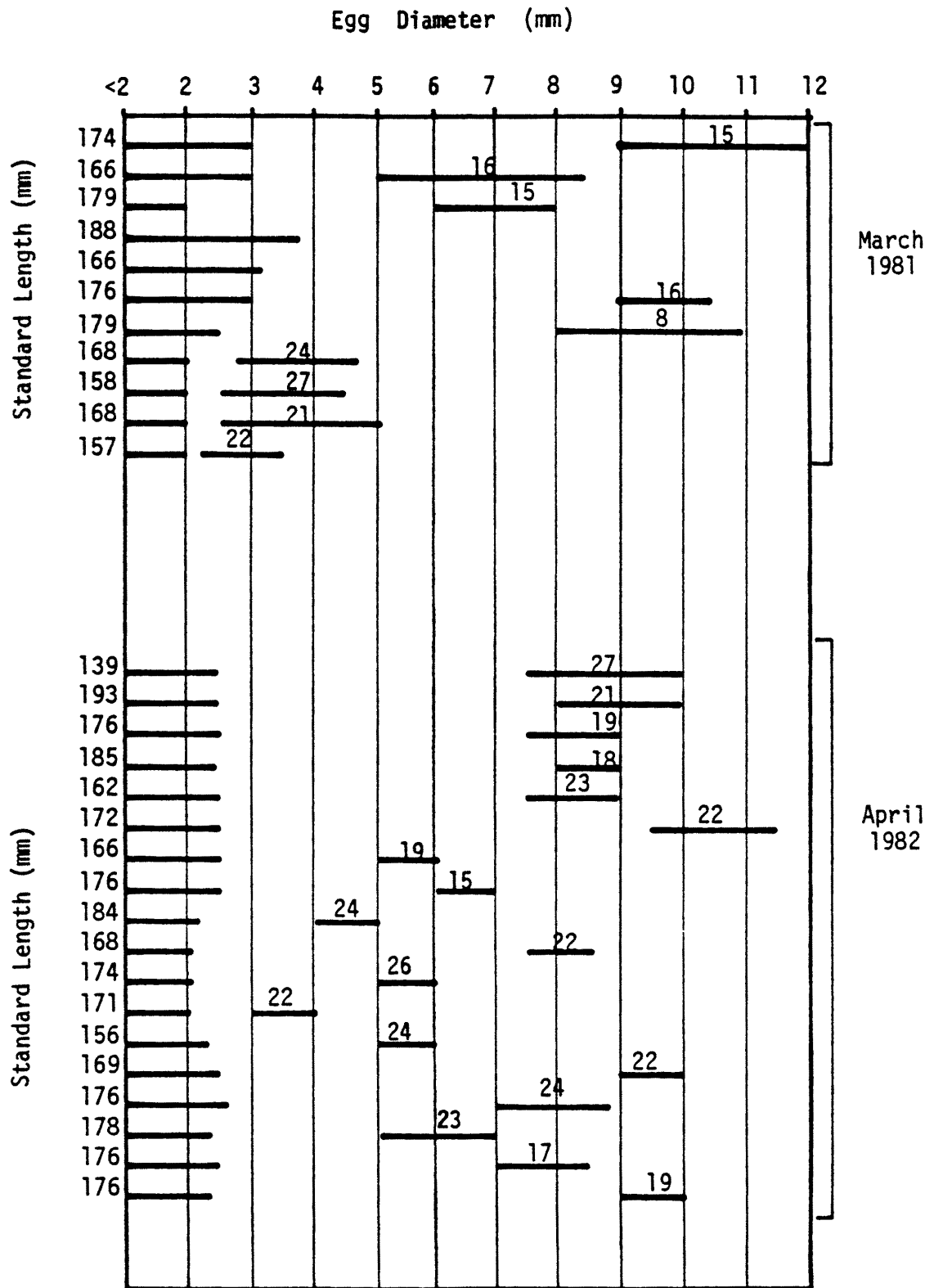


Figure 11.39: Fecundity and egg size in Arius melanopus.

(Bars indicate range of egg diameters, numbers refer to number of eggs)

Figura 11.39: Fecundidad y tamaño de los huevos en Arius melanopus.

(Las líneas representan el rango de tamaños, los números indican el número de huevos)

Table 11.17: Relationship between feeding activity and oral incubation in Arius melanopus males.

Tabla 11.17: Relación entre la actividad alimenticia y la incubación oral de los machos de Arius melanopus.

Sample date	Incubation status	# males with food in stomach	# males without food in stomach
March	eggs in mouth	-	1
	young in mouth	-	-
	mouth empty	4	-
April	eggs in mouth	-	6
	young in mouth	-	10
	mouth empty	7	7

probably have little significance since it is likely that the method of fish collection caused some loss of eggs/young from the males' mouths. The modal diameter of incubated eggs was 10mm. Eggs obtained from males exhibited a range of embryonic development and young were present in the mouth up to a length of 38mm (typical range within a brood = 34-37mm). By this size, the young had exhausted the food supply stored in the yolk sac and were actively feeding either by being temporarily released to forage, as in many of the mouth-brooding African cichlids, or possibly by ingesting food while remaining in the mouth of the male (Merriman 1940, cited by Breder and Rosen 1966). Young Arius were feeding mainly on Ephemeroptera and Diptera larvae and filamentous algae, as shown in Table 11.18 b).

Adult diets were similar to those of juveniles, except that the adults were additionally taking large numbers of Trichoptera (Hydroptilidae and Hydropsychidae) and Anisoptera (Aphylla and Ophiogomphus) larvae. Most of the mayflies in the stomachs were of the family Tricorythidae, and dipteran larvae were represented by the families Chironomidae, Empididae, Simuliidae and Heleidae.

Nothing is known about the amount of time incubating males have to spend without feeding, nor what proportion of energy stored in body tissues is used up during this period. However, analysis of condition factors,

$$K = \frac{W \times 10^5}{L^3}$$

where: K = condition factor; W = weight of fish; L = length of fish; indicates that males with eggs in the mouth were slightly heavier for their length than males with juveniles in the mouth (K = 1.92 [\pm .08, N = 4] and 1.72 [\pm .10, N = 12], respectively). A t-test shows that the difference in the

Table 11.18 a): Food of Arius melanopus adults (R. Humuya, March 1982).

Tabla 11.18a): Alimentación de los adultos de Arius melanopus (río Humuya, marzo de 1982).

<u>Item</u>	<u>Vol. (%)</u>	<u>Freq. (%)</u>
Macrophytes	1	15
Ostracods	<1	24
Diptera lv.	8	100
Ephemeroptera lv.	34	92
Plecoptera lv.	1	15
Trichoptera lv.	17	92
Anisoptera lv.	14	15
Coleoptera lv.	<1	24
Pyralidae lv.	<1	8
Hemiptera lv	<1	15
Uniden. insect frag.	10	54
Sand	15	85
<hr/>		
N analyzed :	17	
N + food :	13	
Length range (mm)	131-193	

Table 11.18 b): Food of mouth-incubated Arius juveniles, R. Humuya, April 1982.

Tabla 11.18 b): Alimentación de juveniles de Arius encubados en la boca (río Humuya, abril de 1982)

<u>Item</u>	<u>Freq. (%)</u>
<u>Fragillaria</u>	64
Ephemeroptera lv.	27
Diptera lv.	36
Ostracods	36
Fish scales	9
Sand	27
<hr/>	
N analyzed :	11
N + food :	11
Length range (mm)	32-37

mean condition factors for these two groups of males is statistically significant ($p < .01$, d.f. = 14). Presumably those individuals with juveniles in the mouth had been without food for a longer period of time than males incubating eggs. Thus the former group had lost more weight than the latter and consequently exhibited lower condition factors.

It is possible that A. melanopus will be one of the species significantly affected by the El Cajón impoundment. An annual survey census could be undertaken relatively easily in the future just downstream of the dam wall and would provide valuable additional information on the reproductive ecology of this species (See Section 11.3).

11.6.2.9 Atherinidae:

Melaniris guatemalensis (Günther)

Atherinids, or silversides, are an important component, of many riverine and especially lacustrine fish communities throughout South, Central and North America. The family, however, is composed primarily of brackish water and marine species. Silversides are typically elongate fish, possessing large eyes.

There has been some confusion with the taxonomy of Central American species of Melaniris. Three "species" reported from Honduras, (M. guatemalensis, M. guila and M. meeki) probably are synonymous and should be placed under M. guatemalensis. Martin (1972) and Miller and Carr (1974) discuss these taxonomy problems, and Bussing (1978) reviews the taxonomy of Central American Melaniris.

M. guatemalensis has been recorded from all major Atlantic and Pacific drainages in Honduras; its range extends as far south as Panama (Martin 1972).

Plate 9: The silverside Melaniris guatemalensis (40-46 mm S.L.)

During the present study it was recorded only twice, on both occasions from the R. Humuya/Yure confluence. It is probably most common in slow-flowing, lower elevation rivers. A few individuals were taken in March 1981 when a pool was sampled with an explosive charge, and relatively large numbers were caught on one night in September 1982 using dip nets and flashlights (Table 11.5). Searching with this method on other occasions failed to locate any individuals. M. guatemalensis taken during this latter collection ranged in length from 46 to 61mm and the male:female ratio was approximately 1:1. Gonads of all individuals were immature, although a few females contained eggs up to 0.4mm diameter, and all GSI's were less than 1.

Silversides typically spawn in shallow water, often amongst vegetation to which the eggs adhere. The related species, M. sardina, which is endemic to the Great Lakes of Nicaragua, spawns during the dry season (Meek 1907). M. guatemalensis in lowland rainforest streams of Costa Rica apparently spawns during the wet season, since ripe females have been observed in September (P. Vaux, unpublished information). In the Costa Rican population, females measuring 48-53mm. S.L. were mature and contained an average of 72 eggs measuring 0.7-0.9mm. It is possible that the large number of Melaniris observed in the R. Humuya/Yure during September represented a post-spawning population, since most oocyte diameters were less than 0.1mm. Nevertheless, the gonads did not appear spent, and no recently spawned eggs were found.

M. guatemalensis is typically insectivorous in rivers. The fish collected in September contained both non-aquatic insects (ants) and aquatic insect larvae (especially Ephemeroptera and Trichoptera), as well as some filamentous algae. The gut of Melaniris is relatively short (about 1/2 of the fish's standard length), a characteristic of insectivorous species.

In lakes, silversides usually feed on zooplankton, typically at dawn and dusk (Moyle 1976, Zaret 1971). They often school in large numbers along the littoral areas of lakes and can significantly influence zooplankton community structure (e.g. M. chagresi in Gatún Lake, Panama; Zaret 1972). M. guatemalensis may well become an important species in the food chain of the El Cajón reservoir -- this is further discussed in Section 11.3.

11.6.2.10 Centropomidae:

Centropomus pectinatus (Poey) "Robalo"

Centropomus is primarily a marine genus, but one which often ascends rivers to considerable distances. Six species were recorded from Honduras by Martin (1972) and there are at least a further two present in the Central American region. The range of most of these species extends from Mexico to central South America (Miller 1966).

The only species that Martin recorded from inland Honduras was C. parallelus (although C. ensiferus was recorded in the R. Coco, some distance from the coast) and was collected from the Ulúa and Chamelecón rivers. The one centropomid caught during the present study was identified to C. pectinatus on the basis of characters described by Regan (1906) and Hildebrand (1925). These include an anal fin with 7 branched rays and 56-65 scales in a longitudinal series. C. pectinatus had been reported by Martin only from the Caribbean coast near Tela.

One specimen of C. pectinatus was taken at the Humuya/Yure confluence in September 1982. It measured 493mm S.L., weighed 2299g and was a female which was clearly spent (GSI = 0.26). The ovaries were flacid and empty, oocytes (60µm diameter) being present only on the ovarian walls. The stomach

Plate 10: Centropomus pectinatus (robalo).

contained one fish, ~65mm in length, probably a cichlid. Approximately 95g of fat were present in the abdominal cavity of this Centropomus.

It seems probable that this (apparently) anadromous species will be excluded from the upper Humuya and Sulaco rivers by the El Cajón dam. Routine sampling below the dam wall in the future will allow valuable information to be collected on its biology (see Section 11.3).

11.6.2.11 Pomadasysidae:

Pomadasys crocro (Cuvier) "Corbinata"

Pomadasys is another genus which, like Centropomus, is primarily marine but also enters rivers and lakes. Two species have been recorded from Honduras, both from rivers in the Yojoa area (Martin 1972). P. crocro can be distinguished from P. boucardi by the maxillary, which extends to below the anterior part of the eye in the former species, but not in the latter (see Regan, 1906, who provides a key to six species).

P. crocro was caught in gill nets set in the R. Humuya (at the Yure confluence and near Q. de Chamo) in March and April 1982 (Table 11.5). The four fish taken ranged in length from 230 to 300mm S.L. (303 - 670 g). An additional specimen was taken in April with a "tapesca" (fishing weir) built across the R. Sulaco, upstream from Salitrón Viejo. This individual measured 330mm S.L. (821g).

All five examples of this species were female and all had small ovaries that were apparently spent. GSI values ranged from 0.33 to 0.71 and oocytes measured 0.02 to 0.08mm in diameter.

Two stomachs contained food. Aquatic insect larvae (Anisoptera, Ephemeroptera and Trichoptera) were the most common items, but fish remains

were noted in one sample. Prawn remains were present in the intestine of one fish.

Apparently very little is known of the reproductive or trophic ecology of Pomadasys. Members of this family (marine forms) usually produce pelagic eggs (Breder and Rosen 1966). It is presumed that it is anadromous in the Ulúa/Humuya system (and that the individuals taken in the present study were post-reproductive fish). If this is so, then it will probably be unable to survive in the El Cajón reservoir without access to the coast.

11.6.2.12 Mugilidae:

Joturus pilchardi (Poey) "Cuyamel"

Although the family Mugilidae (mullets) is primarily marine, two species found in Honduras are freshwater forms. One of these, Agonostomus monticola ("tepemechín") was recorded during the present study only from L. Yure, although it is no doubt present in river systems of the El Cajón area. It will be further discussed in the section dealing with L. Yure (11.7).

The second species in this family is Joturus pilchardi and differs from tepemechín in having incisor-like jaw teeth. It is distributed from Mexico to Panama and, according to Miller (1966), is restricted to swiftly flowing waters. Regan (1906) notes that it is said to "live only in mountain torrents and at the foot of waterfalls". However, during the present study Joturus was recorded only once, from the R. Sulaco (near Salitrón Viejo) where a juvenile (64mm S.L.) was caught with a cast net at the river bank (Table 11.5). Although not much sampling was done in swift, steep gradient, mountain streams, the failure to record this species at any of the other sites routinely sampled, and its apparent absence from L. Yure (Agonostomus is

present in this reservoir and supposedly has similar habitat preferences), suggests that it is rare in the El Cajón area. Martin (1972) recorded Joturus from three sites only, all of which were on lower elevation rivers (R. Chamelecón, R. Lindo and R. Omoa). He also states that local fishermen consider the cuyamel to be catadromous, i.e. it migrates downriver to spawn.

11.6.2.13 Gobiidae:

Awaous taiasica (Lichtenstein) "Guavina"

Of the five "goby" species recorded from Honduras (Martin 1972), only one, Awaous taiasica, was collected from the El Cajón area. This is also the only species of the family which appears to have a largely inland distribution; the other four have been recorded mainly from coastal areas. (The Gobiidae is primarily a marine family).

A. taiasica was collected from the Humuya, Sulaco, Yunque and Yure rivers. In the latter river, it was a fairly persistent member of the community, being taken in low numbers but often representing a substantial component of total biomass (Fig. 11.7). It was found mainly in riffle areas and rapids and its relative abundance may therefore have been underestimated because of problems of capture. The fused pelvic fins, a characteristic of the family, form a type of ventral sucker which probably assists the fish in maintaining its position in fast currents. It is interesting that Carr and Giovannoli (1950) noted that, in the R. Cholucteca, A. taiasica was most common in pools, whereas the related species, Sicydium multipunctatum, inhabited fast-flowing riffle areas. In the R. Yure, where Sicydium is absent, Awaous appears to have taken over the riffle habitat.

The present collections of Awaous included individuals within the length

- Plate 11: Awaous taiasica (guavina), 197 mm S.L.
-- note pelvic fins adapted to form a sucker.
- Foto 11: Awaous taiasica (guavina), 197 mm L.E.
-- notar las aletas pélvicas las cuales están
modificadas para formar una succión.

Table 11.19: Food of Awaous taiasica (Yure, Humuya and Sulaco drainages.)

Tabla 11.19: Alimentación de Awaous taiasica (las cuencas de los ríos Yure, Humuya y Sulaco).

<u>Item</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Filamentous algae	19	-
Macrophyte frag.	5	-
Ostrocods	81	19
Mites	29	-
Molluscs	10	-
Uniden. insect frag.	14	-
Anisoptera lv.	10	-
Trichoptera lv.	33	-
Heleidae lv.	90	-
Chironomidae lv.	86	14
Ephemeroptera lv.	76	48
Hemiptera	10	-
Coleoptera lv.	57	-
Coleoptera ad.	10	-
Detritus	62	33
Sand	24	5
<hr/>		
N analyzed :	21	
N + food :	21	
Length range (mm) :	88-258	

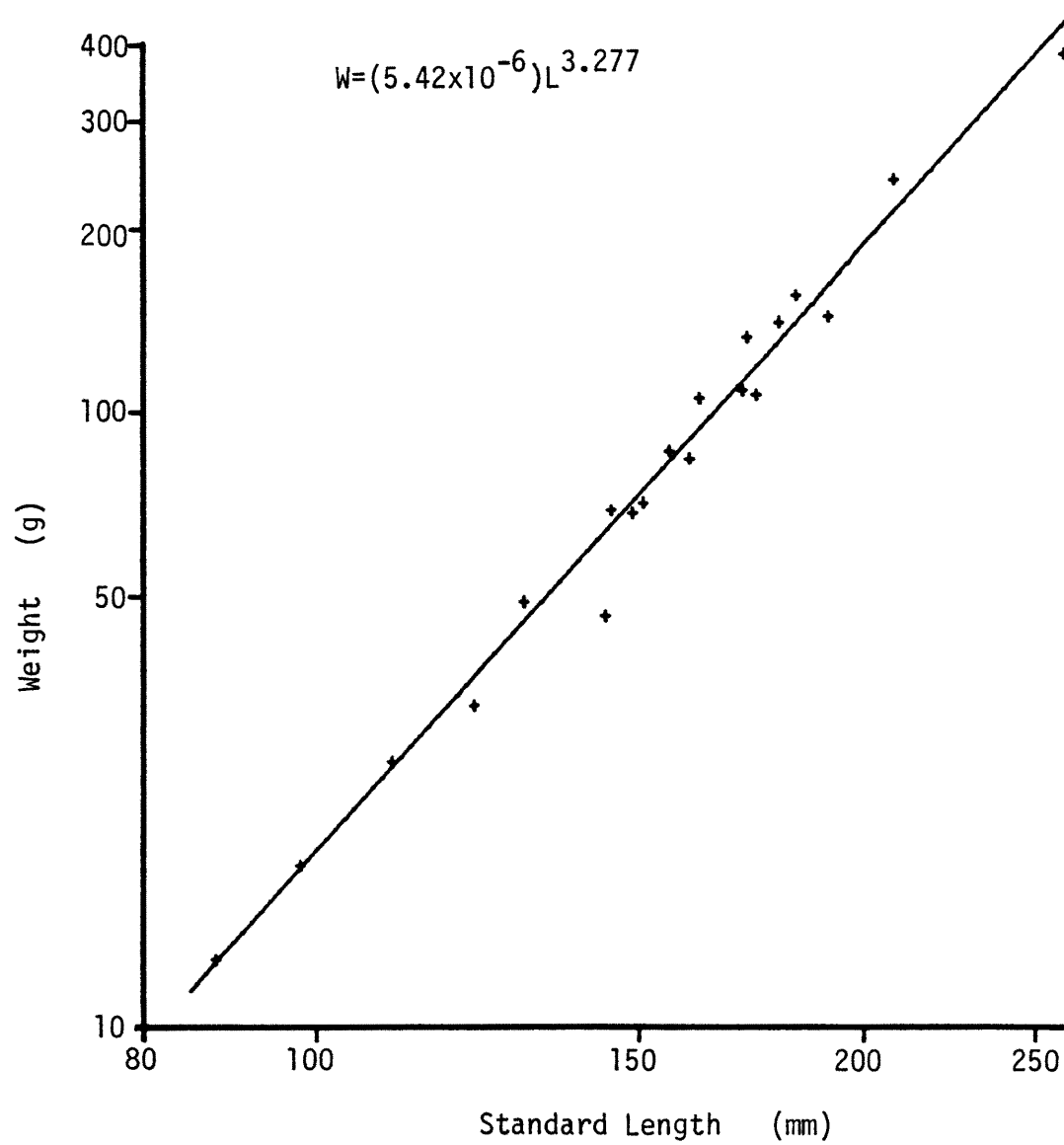


Figure 11.40: Length-weight relationship of Awaous taiasica.

Figura 11.40: Relación longitud-peso de Awaous taiasica.

range 88-25mm. The length-weight relationship is shown in Fig. 11.40. Although samples were collected in both wet and dry seasons (Table 11.5), mature individuals were never found. Oocyte diameters were less than 0.04mm and the gonads were always very small. Therefore, nothing is known of the reproductive ecology of this species.

The diet of Awaous was remarkably consistent between sampling sites and dates. Data from all samples have been combined and are presented in Table 11.19. Dipteran larvae (both Chironomidae and Heleidae) were the most frequently encountered item, but were dominant in only a few individuals. Coleoptera and Ephemeroptera larvae and ostracods were additional common diet components but mayfly larvae were most frequently the dominant item. The presence of ostracods in the diet suggests that Awaous does not feed entirely in riffle areas, since ostracods were presumably more common in pool habitats. Nearly all the guavinas collected during this study had large accumulations of oily, yellow fat in the abdominal cavity.

11.6.3 RIVER FISH COMMUNITIES -- A SYNTHESIS

A wide variety of factors potentially influence not only the composition of river fish communities but also the interactions that occur between the different species. Although a number of studies have looked at the structure and functioning of fish communities in temperate streams (e.g. Angermeier 1982, Horwitz 1978, Mendelson 1975), there have been relatively few studies done on tropical systems (e.g. Moyle and Senanayake, in press; Kramer 1978; Zaret and Rand 1971). While these studies cannot be reviewed here, two points should be emphasized:

- 1) Investigating the often complex inter-specific relationships in a

system, whether this is a river or a lake, is usually essential to understand how that system is functioning. Furthermore, rational management of a system is unlikely to be effective if it is not adequately understood.

2) The rivers and lakes of the El Cajón area represent a valuable resource which can serve as a base for future, more detailed, studies into various aspects of ecosystem functioning.

As is further discussed in other parts of this report (e.g. 11.3), the pre-impoundment Fisheries Program has provided not only insights into certain aspects of the future reservoir fishery, but also a base of biological and ecological information that can be used in the development of the reservoir fishery. In future studies of important reservoir fish species, comparisons with riverine populations will be especially interesting.

While a detailed documentation of the more subtle interactions within riverine fish communities of the El Cajón area will need additional in-depth studies, general characteristics of these communities have been illustrated by the data presented in the previous sections of this report. These patterns are summarized in Figs. 11.41 and 11.42; discussion of the L. Yure fishery in Section 11.7 will provide information allowing a comparison between riverine and lacustrine populations of certain species, which will further contribute to understanding the organization of aquatic systems in the El Cajón area.

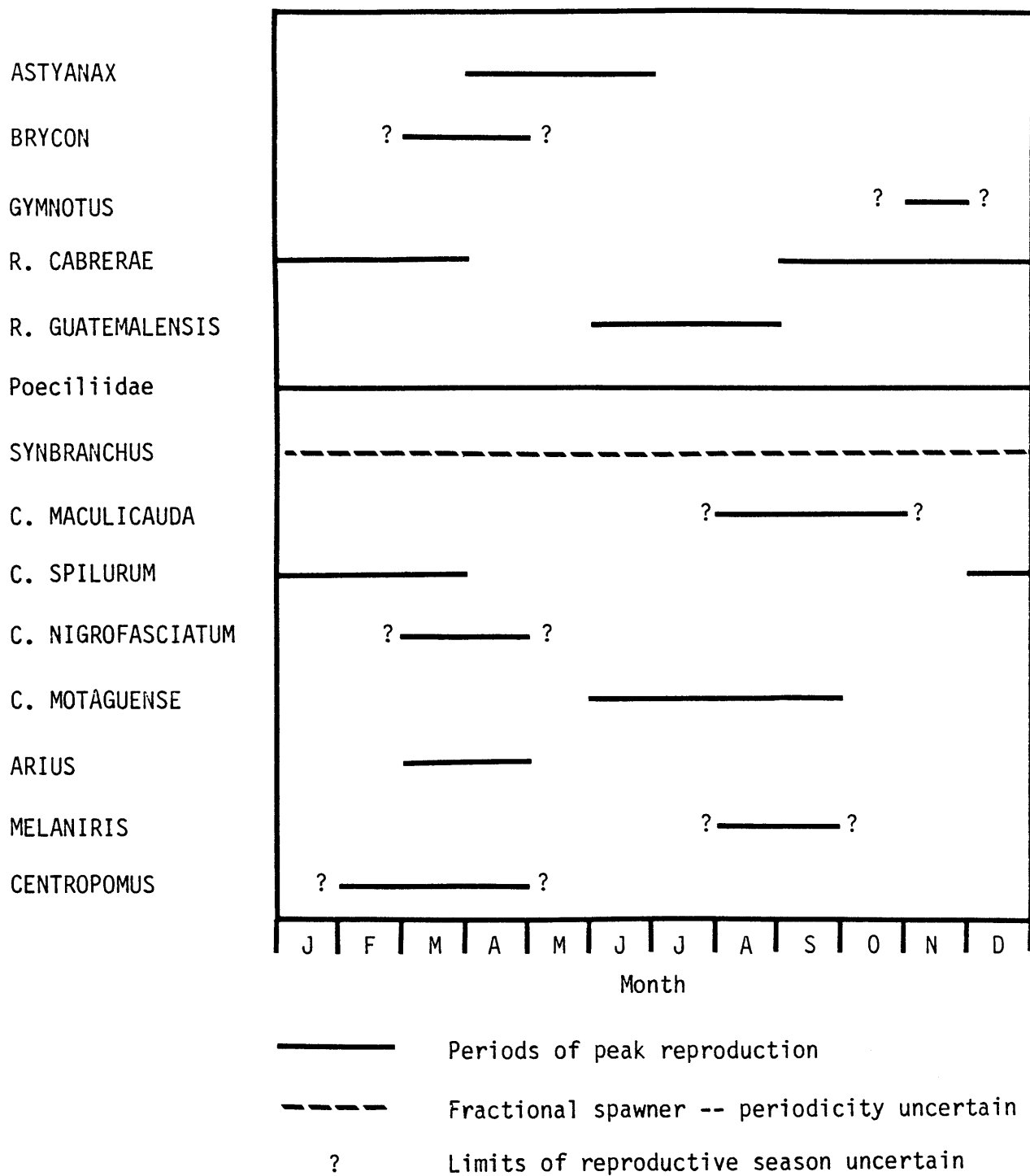
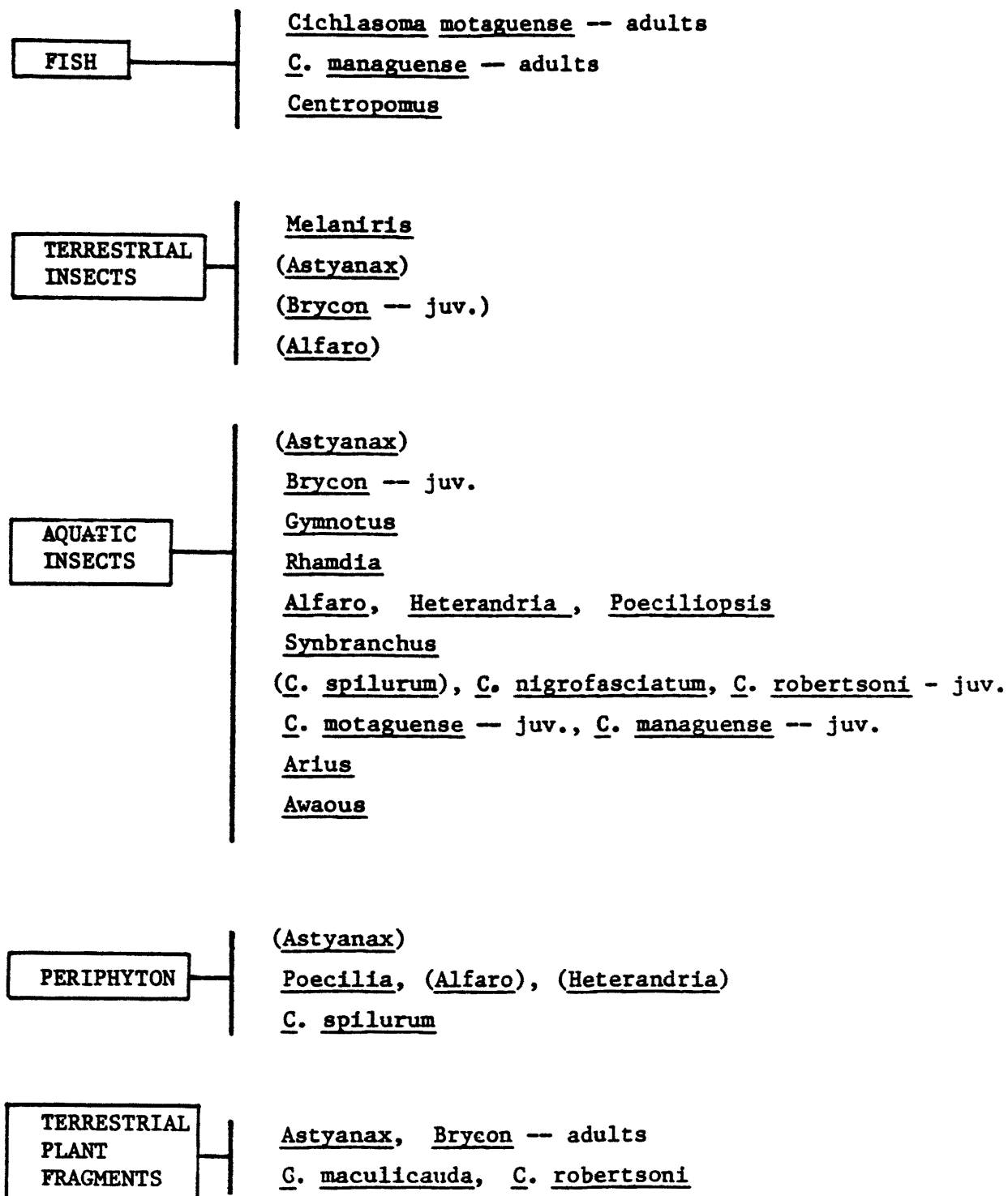


Figure 11.41: Reproductive seasonality in riverine fish communities.

Figura 11.41: Estacionalidad de reproducción en las comunidades de peces riverinas.



() = secondary food item for this species.

N.B. This figure shows major trophic categories only --- most species can feed on a broad range of items.

Figure 11.42: Summary of trophic relationships in riverine fish communities.

Figura 11.42: Resumen de las relaciones tróficas en comunidades de peces riverinas.

11.7.1 INTRODUCTION

Previous sections of this report have summarized the biology and ecology of fish species collected from rivers in the El Cajón watershed. These studies have produced base-line data which will be of major importance in future analyses and management of the El Cajón reservoir fishery.

As was the case in the Limnology Program, L. Yure was used as a partial model to better integrate the riverine fisheries information base into a framework for the El Cajón reservoir. Data collected from the monitoring program on the L. Yure fishery has allowed insights into the effects of impoundment on certain native stream fishes and, additionally, the impact of an exotic predator, the largemouth bass, on the native fish assemblage.

Two obvious limitations of L. Yure as a model for the El Cajón reservoir are:

- 1) Species richness in L. Yure is lower than it will be in L. El Cajón.
- 2) The introduction of largemouth bass into L. Yure tends to confound impoundment-related and predator introduction-related effects on the native fish assemblage. (In this respect, however, it should be noted that bass will probably be sooner or later probably be introduced into the El Cajón reservoir and will likely become an important component of this reservoir's fishery.)

Despite these limitations, the L. Yure study has provided a very useful comparative data-base, which the present section summarizes.

11.7.2 THE LAKE FISHERY: AN OVERVIEW

Five species were frequently collected during the L. Yure monitoring program:

Cichlasoma motaguense ("guapote")

Astyanax fasciatus ("sardina")

Rhamdia cabreræ ("bagre")

R. guatemalensis ("bagre")

Micropterus salmoides ("bass")

The first four of these species are native to the area and at least three are present in the tributaries flowing into L. Yure (see Fig. 11.7 for summary of species composition of the Q. del Cerro community). The fifth species in the list above is the exotic largemouth bass, which is present in L. de Yojoa and was introduced into L. Yure in April 1980 (according to the accounts of local fishermen).

In addition to these five species, two others were infrequently taken from the lake. The gymnotid "eel", Gymnotus cylindricus, was occasionally captured along the reservoir perimeter, with both electroshocker and gill-net sampling. This nocturnal species is probably present in the L. Yure tributaries even though it was not recorded from them during the present study. Although sampling methods used in L. Yure were unlikely to have captured this species very efficiently, it likely represents a rare component of the reservoir fish community. Analyses of the lake samples have been included in the discussion of this species presented in Section 11.6.2.2.

The other species encountered relatively infrequently in L. Yure was the tepemechn (Agonostomus monticola). It was never recorded from the L. Yure tributaries, but more intensive sampling in these streams might have revealed

its presence (see below). The poeciliids Alfaro huberi, Poecilia sphenops, and Heterandria bimaculata are common members of the tributary communities, but were not found in the lake itself from 1980 onwards. In September 1979, some poeciliids (species uncertain) had been observed in the littoral area along the dam wall. Presumably predation pressure from guapote and bass was responsible for the extinction of these small species from the lake (see also Section 11.6.2.5).

The fishery monitoring program revealed distinct shifts in species composition of the reservoir community between 1980 and 1982. Species shifts are commonly observed in new impoundments and are an integral part of the temporal changes in fish production. These changes in species' relative abundance will be discussed in more detail in the following species accounts, but the general trends can be outlined here.

Table 11.20 summarizes average monthly gill-net captures by species in terms of biomass and numbers of fish. All data have been corrected for sampling effort, the catch per unit effort representing the amount of fish captured per 100m² net per 24 hours. As previously discussed in Section 11.5, time restraints and low fish densities meant that sampling effort concentrated on those areas of the reservoir which led to higher catch rates. However, throughout the course of the study, a wide variety of locations within the reservoir was sampled (Fig. 11.4). A major component of the within-month variation in fish catch (standard deviations in Table 11.20) was probably due to between-station variations in fish abundance, but it is not possible to separate this component from the one describing variations in catch between sampling dates at any one station. In Table 11.21, however, total catches have been broken down according to station in order to present an approximate

Table 11.20: a) L. Yure gill net catches: Mean (standard deviation) weight of fish caught per unit effort (g).

Tabla 11.20: a) Capturas por redes agalleras en L. Yure: Promedio (desviación estandard) de pesos de los peces capturados por unidad de esfuerzo.

(a)	Month	# sampling days	CIM	MIS	ASF	RHC	RHG	AGM	Total catch per unit effort
	1980 IX	3	67 (92)	0	0	111 (191)	0	0	177
	X	8	29 (42)	28 (80)	8 (13)	60 (132)	12 (22)	20 (38)	157
	XI	5	123 (132)	0	73 (151)	23 (52)	7 (16)	80 (178)	306
	XII	5	7 (7)	0	1 (1)	18 (19)	8 (19)	41 (92)	76
	1981 I	4	153 (131)	89 (177)	12 (15)	254 (279)	0	0	507
	III	5	345 (229)	0	8 (10)	27 (19)	21 (40)	48 (107)	448
	V	1	454 -	0	0	0	0	0	454
	VII	1	519 -	87 -	0	34 -	63 -	0	704
	VIII	1	0	0	0	0	0	179 -	179
	X	1	56 -	0	2 -	19 -	12 -	0	89
	1982 II	1	28 -	12 -	6 -	0	23 -	0	68
	V	5	155 (77)	206 (207)	35 (41)	6 (13)	66 (109)	73 (162)	540
	VI	4	266 (114)	150 (203)	86 (27)	0	24 (48)	0	525
	VII	4	190 (218)	119 (176)	58 (56)	0	84 (63)	0	450
	IX	3	163 (67)	58 (41)	87 (68)	10 (17)	29 (33)	0	346
	XI	7	166 (90)	78 (114)	199 (196)	0	65 (68)	0	508

CIM- Cichlasoma motaguense

MIS- Micropterus salmoides

ASF- Astyanax fasciatus

RHC- Rhamdia cabreræ

RHG- Rhamdia guatemalensis

AGM- Agonostomus monticola

Table 11.20: b) L. Yure gill net catches: Mean (standard deviation) number of fish caught per unit effort.

Tabla 11.20: b) Capturas por redes agalleras en L. Yure: Promedio (desviación estándar) de número de peces capturados por unidad de esfuerzo.

Month	# sampling days	CIM	MIS	ASF	RHC	RHG	AGM	Total catch per unit effort
1980 IX	3	1.7 (0.8)	0	0	1.2 (2.1)	0	0	2.9
X	8	1.2 (1.2)	0.1 (0.2)	0.4 (0.4)	0.6 (1.1)	0.2 (0.3)	0.1 (0.2)	2.6
XI	5	1.3 (1.7)	0	7.7 (15.9)	0.3 (0.8)	0.2 (0.4)	0.1 (0.3)	9.6
XII	5	0.5 (0.4)	0	0.1 (0.2)	0.3 (0.3)	0.1 (0.2)	0.1 (0.3)	1.1
1981 I	4	1.9 (0.6)	0.1 (0.2)	0.8 (0.9)	3.1 (3.5)	0	0	5.9
III	5	2.5 (2.0)	0	0.5 (0.7)	0.4 (0.3)	0.1 (0.2)	0.1 (0.3)	3.6
V	1	5.8 -	0	0	0	0	0	5.8
VII	1	10.1 -	0.2 -	0	0.4 -	0.4 -	0	11.1
VIII	1	0	0	0	0	0	0.2 -	0.2
X	1	0.8 -	0	0.2 -	0.2 -	0.2 -	0	1.4
1982 II	1	0.2 -	0.6 -	0.8 -	0	0.2 -	0	1.8
V	5	1.4 (0.6)	0.4 (0.3)	3.9 (4.3)	0.04 (0.1)	0.4 (0.6)	0.1 (0.3)	6.2
VI	4	1.6 (1.0)	1.3 (0.8)	10.4 (3.6)	0	0.2 (0.3)	0	13.5
VII	4	1.2 (1.2)	2.1 (2.2)	6.4 (6.0)	0	0.6 (0.3)	0	10.3
IX	3	0.7 (0.1)	1.3 (0.2)	9.6 (5.1)	0.1 (0.1)	0.1 (0.1)	0	11.8
XI	7	1.3 (1.1)	1.0 (1.0)	14.4 (9.4)	0	0.4 (0.4)	0	17.1

Table 11.21: Catch per unit effort (g/100 m² net/24 hrs) of gill net sets at various stations in Lago Yure.

Tabla 11.21: Capturas por unidad de esfuerzo (g/100 m² de red/24 h) de redes agalleras en varias estaciones en el lago Yure.

Station (see Fig. 11.4)	Mean	Std. Dev.	# Occasions Fished
1	462	315	6
2-4	377	300	19
5-6	382	242	4
7	68	151	5
8-9	167	139	2
10	303	440	9
11	336	303	3
12-13	402	569	2
14	734	393	2
15	243	---	1
16	322	221	7
17	376	402	3
18	36	52	2
19	466	427	2
20	200	228	3
21	18	27	3
22	0	---	1
23	265	---	1
24	247	272	2

Figure 11.43: Species composition of the L. Yure fish community, gill net and electroshocker samples, 1980 and 1982.

Figura 11.43: Composición de especies de la comunidad de peces del lago Yure, muestras tomadas con electroshock y redes agalleras en 1980 y 1982.

KEY:



Characidae

ASF: Astyanax fasciatus



Cichlidae

CIM: Cichlasoma motaguense



Pimelodidae

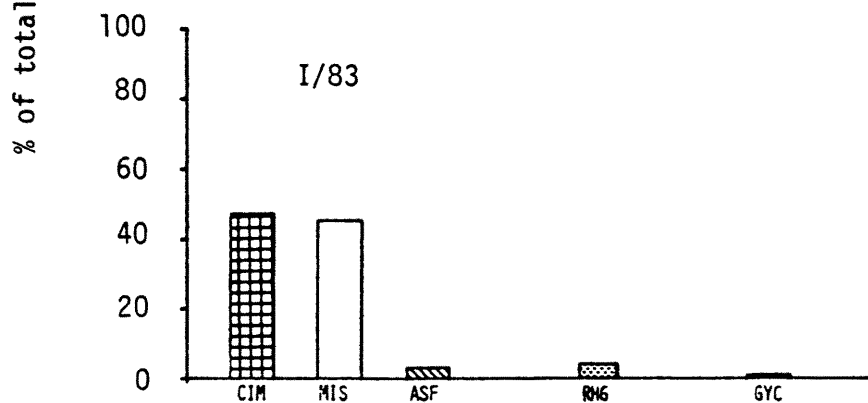
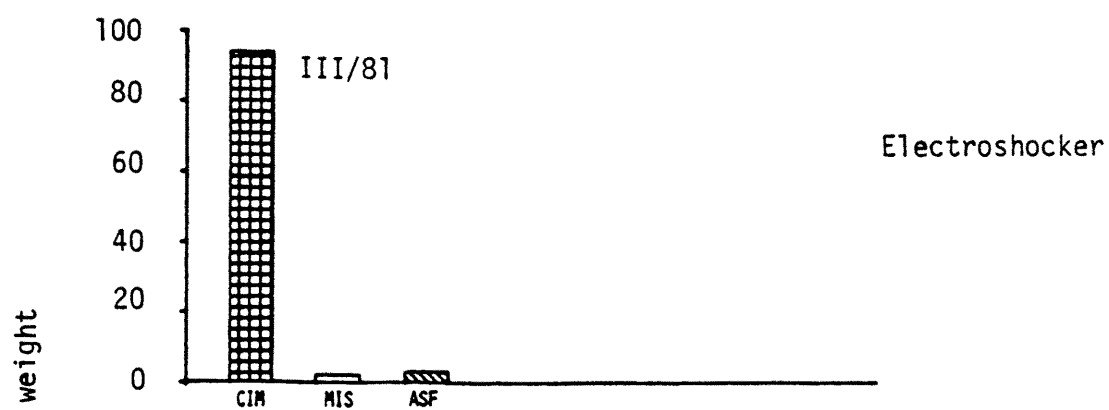
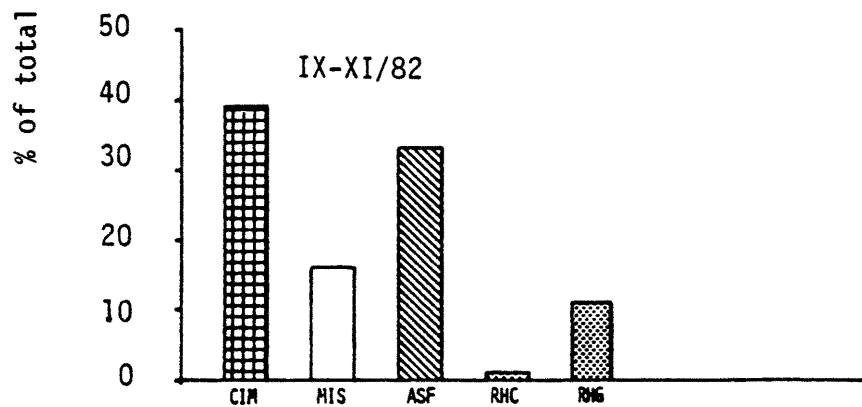
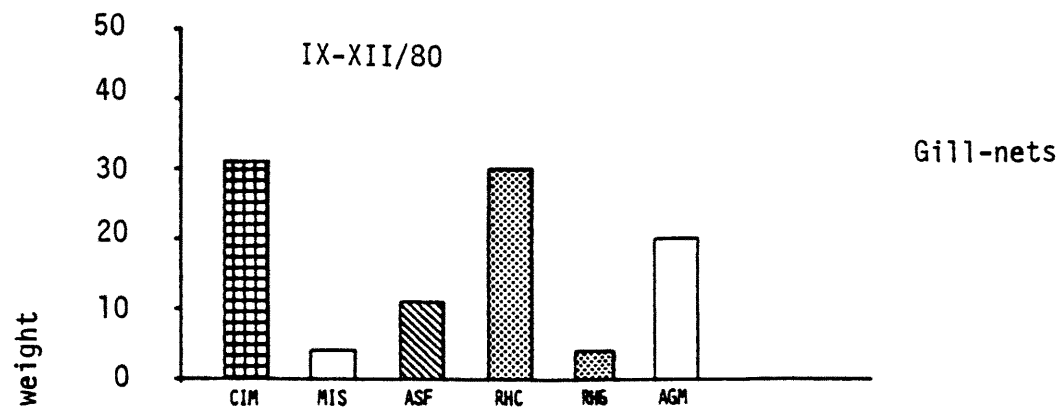
RHC: Rhamdia cabreræ

RHG: R. guatemalensis



GYC: Gymnotus cylindricus

MIS: Micropterus salmoides



description of spatial variation in gill net captures in this reservoir.

Throughout this study, capture rates were relatively low, often less than one individual of each species per 100 m² net (Table 11.20). Average total weight of fish per unit effort varied from 68 to 704 g/100m², with an overall mean of 344g/100m². Catch rates were more consistently high during 1982 than in the previous two years, mainly as a result of increased sardina and bass catches.

Three major trends emerge from the catch data presented in Table 11.20:

- 1) Between 1980 and 1982, there was a shift in the relative abundance of the two catfish species. Rhamdia cabreræ, the dominant catfish in upper elevation streams (eg. Fig. 11.7), was initially the more abundant of the two species in the lake. By 1982, it was being infrequently caught and, instead, R. guatemalensis was common in the net catches.

- 2) Bass (Micropterus salmoides) was more common in gill net catches during 1982 than in the previous two years. Increases in catch rates probably reflected an actual increase in the reservoir's bass population.

- 3) Sardinas (Astyanax fasciatus) were a much more important component of gill net catches in 1982 than in 1980 and 1981. While this increase in catch rate may in part have reflected a population increase, it is more likely that it was the result of a change in feeding behavior when Daphnia became the dominant zooplankton species in the lake.

These major changes in the L. Yure fish community are summarized in Fig. 11.43 which shows the percentage composition (by weight) of gill net catches in 1980 and 1982.

The species composition of electroshocker-caught samples from the perimeter of the lake likewise shows the increase in the relative abundance of bass (Fig. 11.43). Electroshocking in 1980 captured primarily young guapote, whereas in 1983 (and in 1982- see Appendix 2) the catch was split almost evenly between guapote and bass. The electroshocker did not sample sardinas efficiently (they are a fast swimming species which eludes capture) and so their representation in these perimeter samples should not be taken as a measure of their actual abundance.

Fishermen-caught (hook and line) samples were routinely analyzed from October 1981 to September 1982. The relative abundance of bass and guapote in these samples is shown in Table 11.22. These data underestimate the contribution of bass because the smallest size classes were often returned to the lake and thus not registered. However, the trend demonstrated by the changing bass:guapote ratio is similar to the patterns observed with other sampling gears. Temporal changes in the L. Yure fish community will be further discussed in the following sections.

11.7.3 SPECIES ACCOUNTS

With the exception of Micropterus and Agonostomus, the ecology and biology of riverine populations of species recorded from L. Yure have previously been discussed (Sections 11.6.2.1, 11.6.2.3 and 11.6.2.7). The present section contains additional information dealing with the lacustrine populations of these species.

Astyanax fasciatus "Sardina"

The gill net capture rate of Sardinas increased approximately ten-fold

Table 11.22: Frequency of guapote (C. motaguense) and bass (M. salmoides) in fishermen-caught samples from L. Yure. *

Tabla 11.22: Frecuencia de guapote (C. motaguense) y bass (M. salmoides) en las muestras tomadas por pescadores en el L. Yure. *

<u>Month</u>	<u>Bass (%)</u>	<u>Guapote (%)</u>	<u>N</u>
X '81	4	96	50
XI	25	75	59
XII	37	63	27
IV '82	68	32	22
V	58	42	33
VI	60	40	40
VII	28	72	32
VIII	71	29	35
IX	77	23	31

* Most of the hook and line fishing was done along the perimeter of the reservoir. Bass and guapote represented over 95% of the catch but Rhamdia were taken occasionally.

between 1981 and 1982. Before May 1982, an average of 1.5 fish were being caught per unit effort. After May, the catch rose to an average of 10.2 individuals per unit effort. This sudden change almost certainly reflected a shift in the feeding mode of sardinas resulting from the appearance in the zooplankton community of the cladoceran Daphnia pulex. Before the appearance of Daphnia, sardinas were mainly benthic feeders (see below). Because of this feeding behavior they were not susceptible to gill-netting. After the appearance of Daphnia, sardinas switched to a planktivorous feeding mode utilizing the pelagic zone to an increased degree and thus becoming much more susceptible to gill-netting.

Before May 1982, adequate samples of Astyanax were difficult to obtain from the lake and appreciable gill net catches were made on only one occasion (November 1980; Table 11.20, Appendix 2). On this date, nets were set across a small bay into which a perennial stream discharges (Station 17, Fig. 11.4). The high catch on this occasion may have represented a migration of sardinas into this stream since the catch at the same station on the following night was extremely low. After May 1982, catch rates increased but gill-net selectivity (see Appendix 1) still presented a potential problem for obtaining truly representative samples. Younger age classes, especially, were largely absent from the gill-net samples.

Size frequency distributions from two sets of samples are shown in Fig. 11.44. They clearly illustrate the male:female size differences that have previously been discussed for riverine populations (see Fig. 11.8). Note that the apparently bimodal population size structure in November 1980 does not necessarily represent two distinct cohorts since the two size groups were captured with different gears. Population size structure on additional

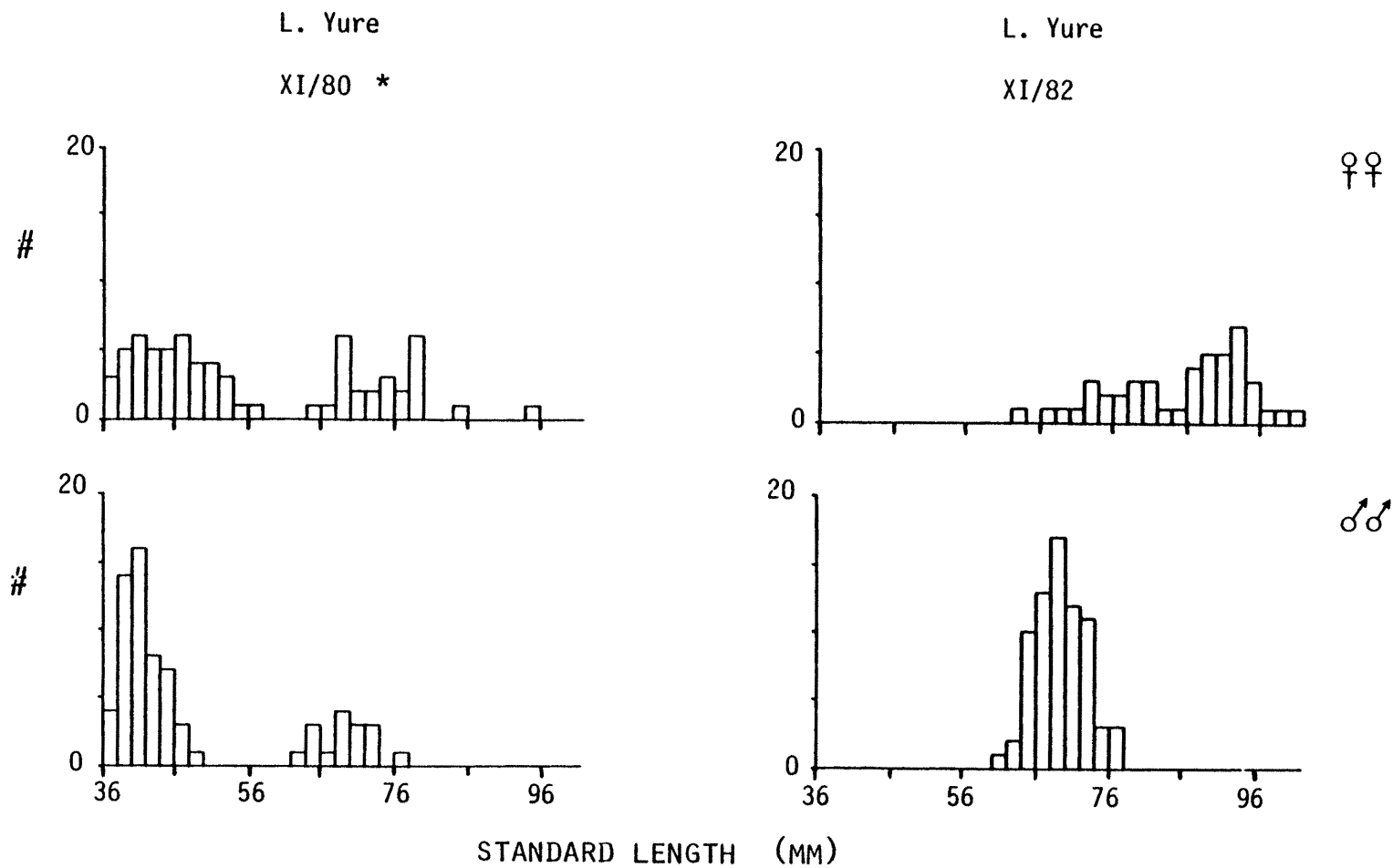


Figure 11.44: Size frequency distributions of *Astyanax fasciatus* in L. Yure.

Figura 11.44: Distribución por tamaño de *Astyanax fasciatus* en el lago Yure.

(* Smaller size group caught with electroshocker; larger size group caught with gill nets)

sampling dates can be inferred from the GSI/standard length scatter diagrams of Fig. 11.45. The smaller size classes in February and March 1981 were captured with an electroshocker and do not appear in the later samples which were collected with gill nets. The maximum length of males was usually about 74mm, whereas females were taken at lengths of up to 100mm.

In this lake population of Astyanax, size at first reproduction appears to be about 40mm (Fig. 11.45). Mature individuals were taken in most months of the year but reproductive activity is apparently broadly bimodal since fewer mature individuals were encountered in July and February. Mean GSI values for 13 sets of samples from L. Yure are shown in Table 11.23. Sardina eggs are a clear golden-yellow when mature and measure 0.8-1.0mm in diameter. Egg dry weights measured on L. Yure samples were approximately 0.10-0.12mg. The fecundity-female length relationship is shown in Fig. 11.11. A linear relationship accounts for a higher percentage of total variance than does a power curve:

$$F = -8042 + 142 L \quad (R^2 = 0.67)$$

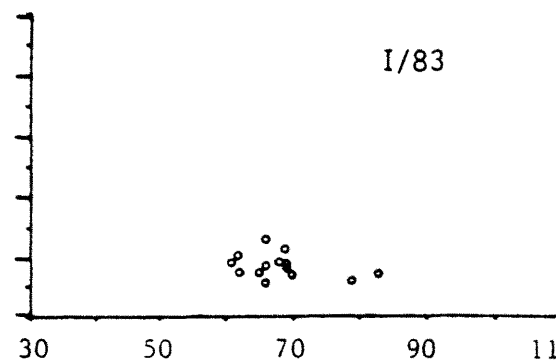
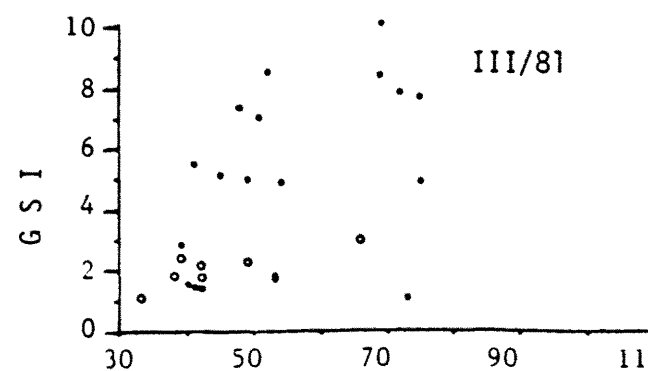
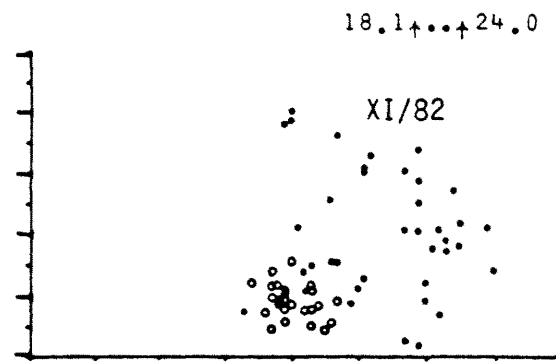
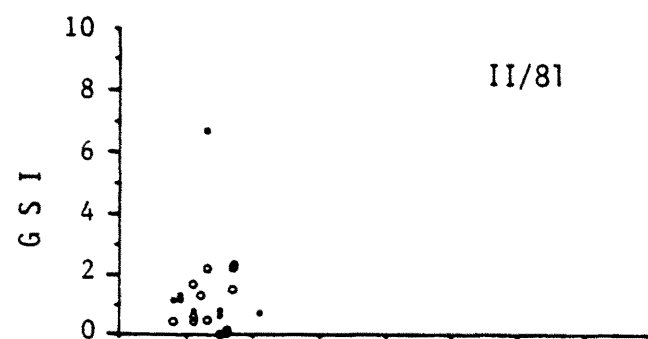
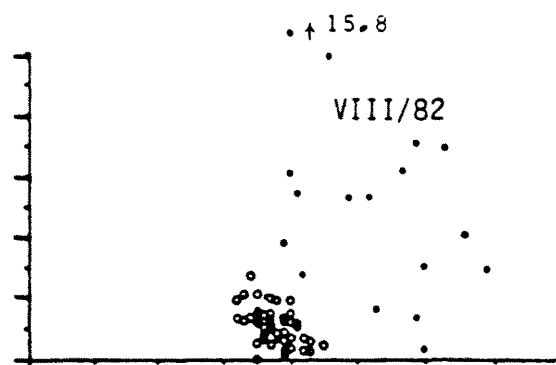
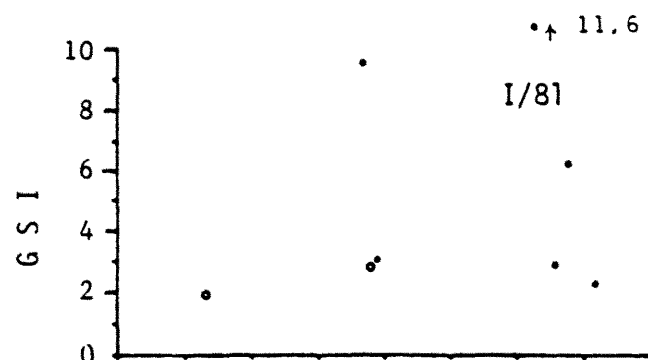
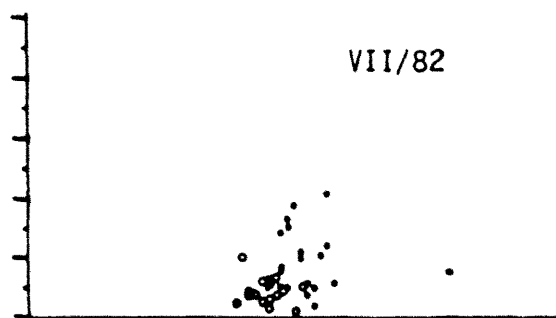
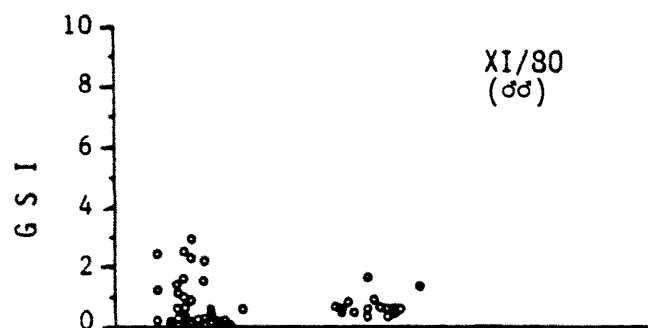
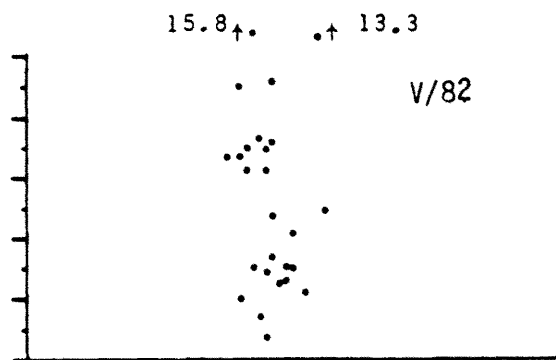
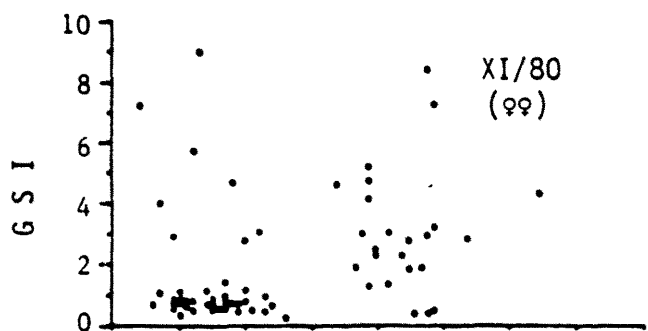
$$F = 0.0006 L^{3.48} \quad (R^2 = 0.53)$$

where F = fecundity and L = standard length (mm).

The true relationship is probably described by a power function (c.f. Bagenal 1978). The fecundity of L. Yure females was approximately 1/2 that of females from the R. Yure, as shown by the two regressions in Fig. 11.11. This considerable difference between lentic and lotic sardina populations may be related to reduced seasonality of reproduction in the lacustrine population. Sardinas in L. Yure may be repeat spawners producing two or more batches of eggs per year but with each group containing fewer eggs than the hypothesized single batch produced by the R. Yure population. The population dynamics of

Figure 11.45: Seasonal variation in the gonosomatic index of Astyanax fasciatus in L. Yure.

Figura 11.45: Variación estacional en el índice somático-gonadal de Astyanax fasciatus en el lago Yure.



STANDARD LENGTH (mm)

STANDARD LENGTH (mm)

● = females 11-213 ○ = males

Table 11.23: Seasonal variation in the gonosomatic index of Astyanax fasciatus, L. Yure.

Tabla 11.23: Variación estacional en el índice somático-gonadal de Astyanax fasciatus, L. Yure.

<u>Date</u>		<u>Mean</u>	<u>St. Dev.</u>	<u>Range</u>	<u>N</u>
5/XI/80	♀	3.14	2.01	0.46-8.55	24
	♂	0.71	0.35	0.36-1.66	16
11/XI/80	♀	1.57	1.90	0.33-5.86	44
	♂	0.57	0.75	0.05-2.97	53
9/I/81	♀	5.87	4.00	2.29-11.60	6
	♂	2.40	0.63	1.96-2.85	2
12/II/81	♀	1.74	1.94	0.65-6.75	9
	♂	0.95	0.82	0.04-2.25	12
18/III/81	♀	4.22	2.53	1.45-8.59	13
	♂	2.06	0.50	1.11-2.58	7
19/III/81	♀	6.03	3.07	1.11-8.44	5
	♂	3.00	-	-	1
18-21/V/82	♀	5.51	3.67	0.27-15.39	28
23-26/VI/82	♀	4.05	3.45	1.30-11.03	7
	♂	1.61	0.29	1.22-2.14	8
13-15/VII/82	♀	1.94	1.06	0.44-4.18	20
	♂	0.88	0.43	0.27-2.02	17
1-2/IX/82	♀	4.94	3.66	0.37-15.85	18
	♂	1.21	0.60	0.22-4.17	43
26/XI/82	♀	5.32	5.44	0.39-24.04	22

Astyanax deserve more investigation in the future, especially since this species represents an important food resource for bass in L. Yure and potentially for other predator fish species in L. El Cajón.

In R. Yure, Astyanax is omnivorous, eating both plant material and insects. This was also the typical diet of sardinas in L. Yure before May 1982, as is shown in Fig. 11.46 a-b). Macrophyte fragments, detritus, chironomids, Hemiptera and other insect fragments were major items in sardina diets at this time. In L. Yure, a small species of cyclopoid copepod (Tropocyclops prasinus) and the cladoceran Moina micrura were the dominant components of the zooplankton community before May 1982 (Fig 7.29, p. 7-276, Vol. 1). Both were almost totally ignored by Astyanax. At the end of May, however, zooplankton community structure changed drastically with the appearance of the large cladoceran Daphnia pulex. Daphnia is presumably much more "noticable" to, and/or more easily captured by sardinas than Moina and Tropocyclops since the fish abruptly switched to eating it almost exclusively (Fig. 11.46 d). Later on in the year, when Daphnia became less abundant (Fig. 7.27, p. 7-273, Vol. I) sardina stomachs contained a lower proportion of this cladoceran (Fig. 11.46 e). Other zooplankton species, including Chaoborus, were rarely found in sardina stomachs. The dominance of aquatic insect larvae in the diet of sardinas collected in November 1982 (Fig. 11.46 f) resulted largely from their capture near the mouth of Q. Tepemechfn where insect drift was entering the lake.

Astyanax is primarily a littoral species. Echosounder surveys of the pelagic zone of L. Yure repeatedly failed to locate any schools of fish, but it probably does represent the major consumer of zooplankton in L. Yure and plays a central role in the trophic network of this reservoir. Gill raker

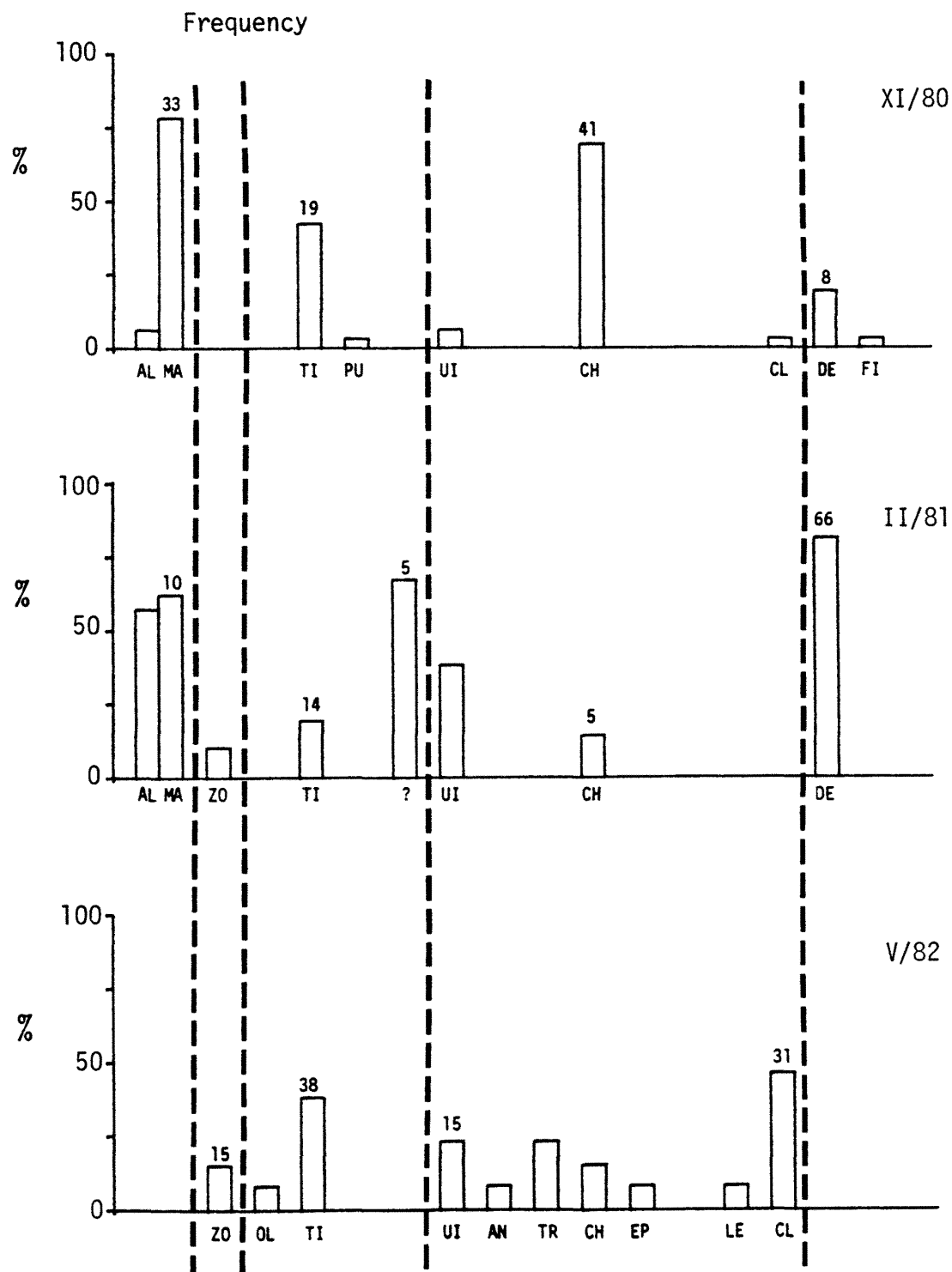


Figure 11.46: Food of Astyanax fasciatus in L. Yure.

Figura 11.46: Alimentación de Astyanax fasciatus en el río Yure.

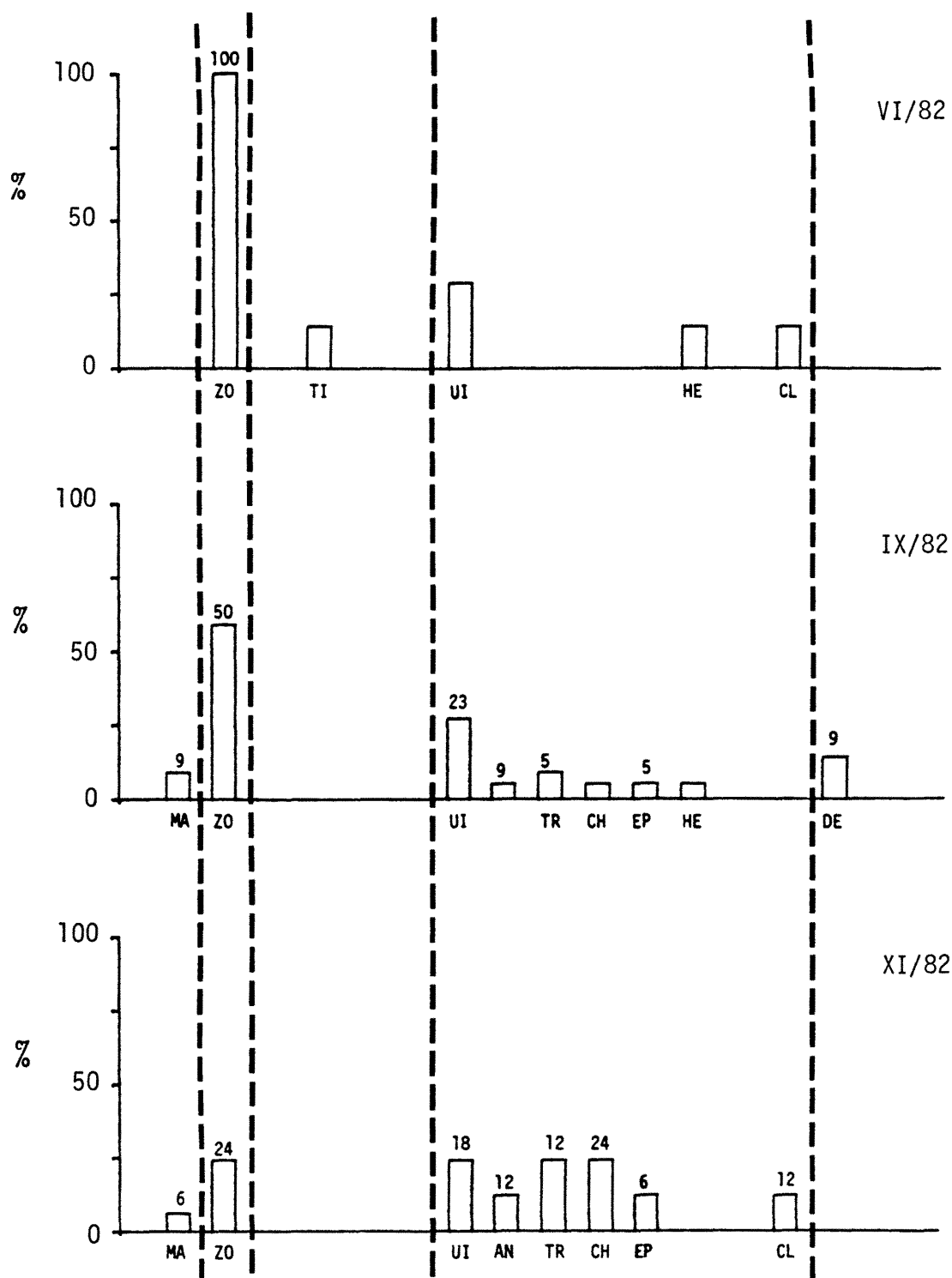


Figure 11.46 (cont.)

KEY:

AL: Algae
 MA: Macrophyte fragments
 ZO: Zooplankton
 OL: Oligochaetes
 TI: Terrestrial insects
 PU: Unidentified pupae
 AN: Anisoptera lv.

TR: Trichoptera lv.
 CH: Chironomidae lv.
 EP: Ephemeroptera lv.
 LE: Lepidoptera lv.
 CL: Coleoptera lv.
 DE: Detritus
 FI: Fish

structure suggests that sardinas are not true filter feeders but instead capture zooplankton prey individually. In L. Nicaragua, an endemic planktivorous species of Astyanax (A. nasutus) has a slightly higher gill-raker count than the littoral A. fasciatus (Bussing 1976), presumably enabling it to better capture and/or retain zooplankton. The extent to which Astyanax is able to effectively utilize the pelagic "niche" of L. El Cajón will be an important factor in determining the overall trophic efficiency of this reservoir (see further section 11.3).

Rhamdia cabreræ, R. guatemalensis "Bagre"

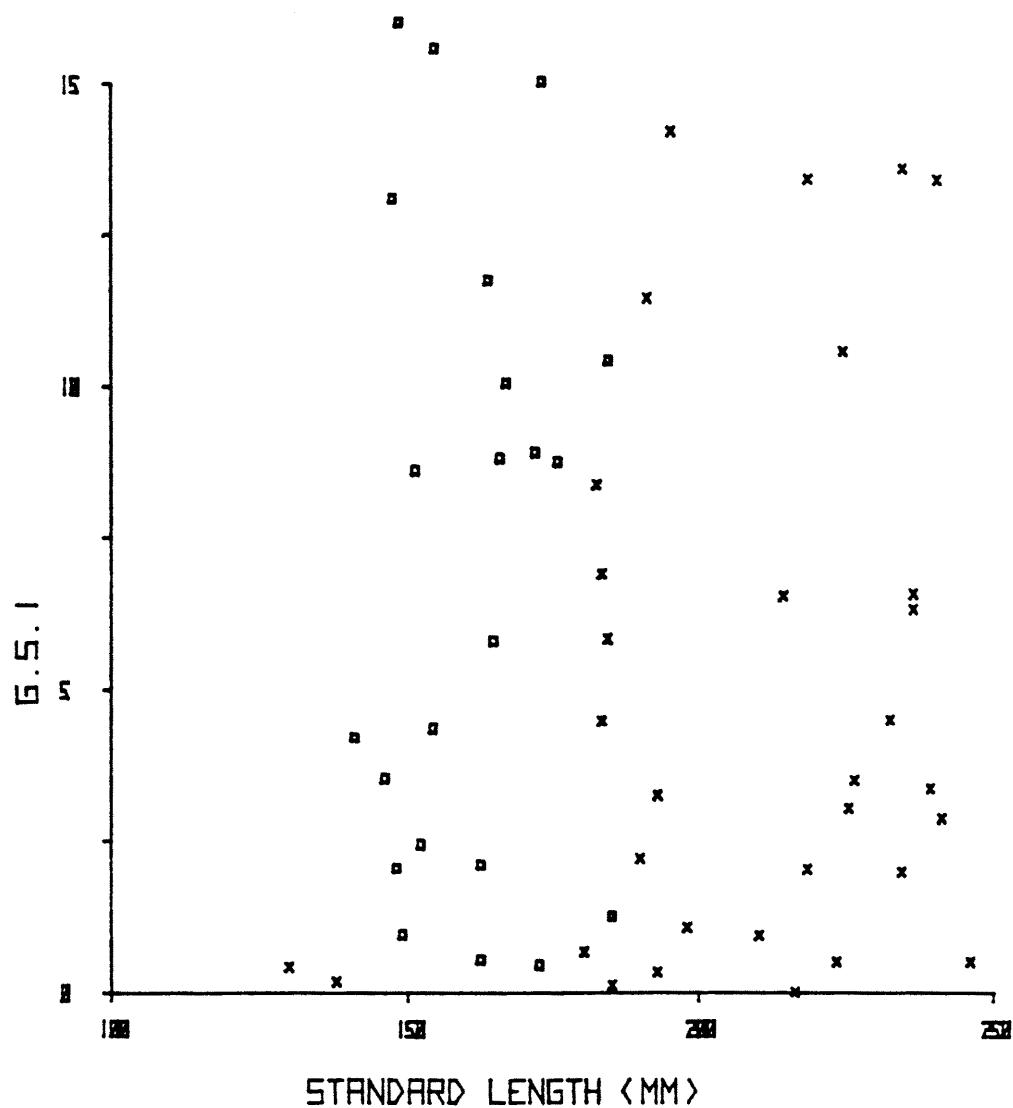
These two species of catfish represented an average of approximately 35% by weight of total gill net catches in 1980 and about 15% in 1982. The average catch of both Rhamdia species per unit effort, however, remained fairly constant throughout the fishery monitoring program, even though within-month and between-station variance (standard deviations in Table 11.20) was relatively high. Although the total Rhamdia catch was similar throughout the study, the relative proportion of the two species changed markedly. In 1980, R. cabreræ was the dominant catfish, although R. guatemalensis was also being taken in moderate numbers. During 1981, neither species was clearly dominant, but in 1982, gill nets caught primarily R. guatemalensis and only occasionally R. cabreræ. This switch in the relative (and absolute) abundance of the two species is interesting since R. guatemalensis is the catfish more characteristic of larger, lower-gradient rivers, whereas R. cabreræ is relatively more abundant in upper elevation streams (see Fig. 11.7 and Section 11.6.2.3). R. guatemalensis was not recorded from the tributary streams entering L. Yure, but presumably must have been present in this part

of the R. Yure before impoundment. Although the reason for the increase in abundance of R. guatemalensis in L. Yure is unclear, it presumably relates to the greater fecundity of this species relative to R. cabreræ and to the transition from lotic to lentic conditions (see below).

Rhamdia were most frequently captured in gill nets near the mouths of inflowing streams (especially Q. Tepemechn). Electroshocking around the perimeter of the reservoir caught few catfish (Appendix 2). Gill net catches were apparently strongly biased towards larger size classes as can be inferred from the plot of standard lengths in Fig. 11.47. Males of both species were similar in size (\bar{x} = 169mm and 166mm S.L. for R. cabreræ and R. guatemalensis respectively), however female R. guatemalensis were larger than female R. cabreræ (207mm vs. 162mm).

Although the virtual absence of smaller size classes from the gill net catches may in part have been related to gill net selectivity, it is likely that it also reflected an actual low abundance of smaller fish in the lake. As mentioned above, perimeter electroshocking caught very few Rhamdia, even at night, which further suggests their low abundance. While the electroshocker was unable to sample at depths greater than about 1.5m, deeper gill net sets rarely took any Rhamdia.

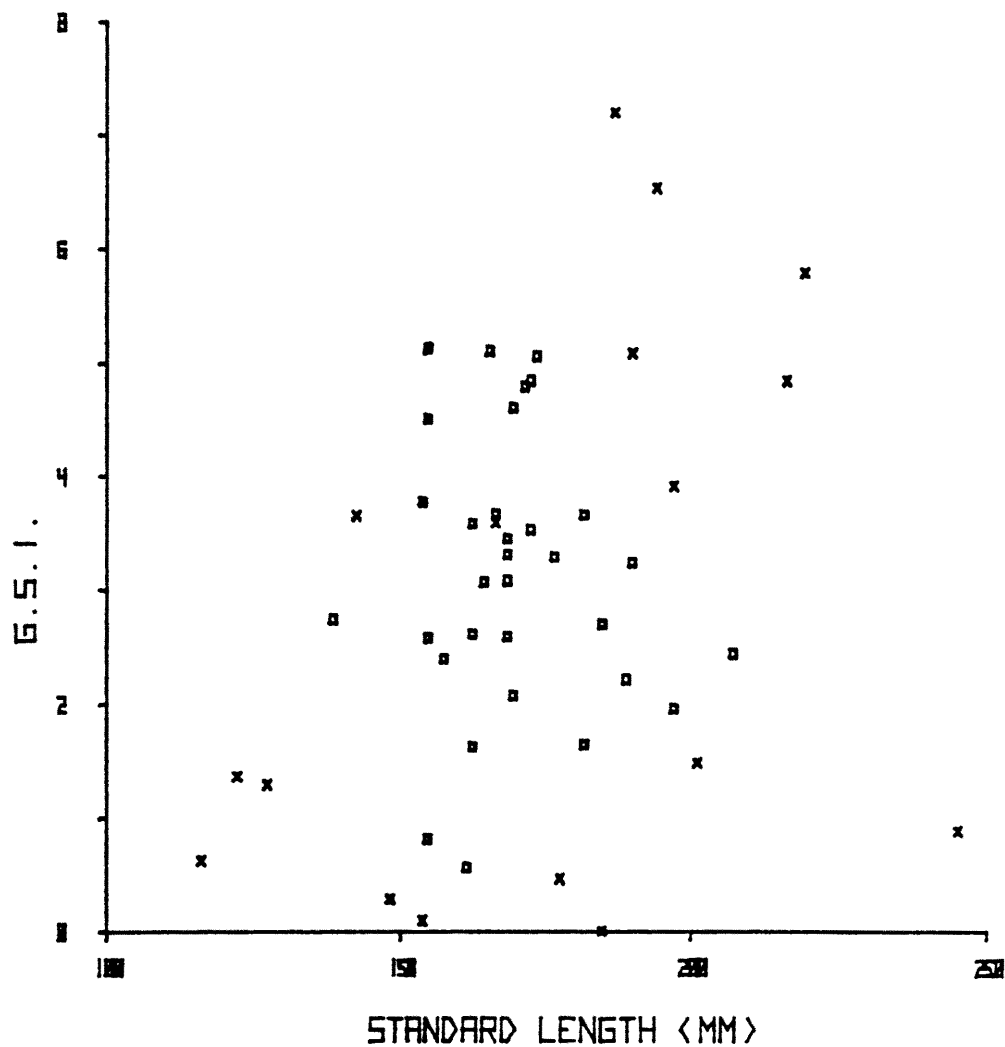
A high proportion of the Rhamdia sampled with gill-nets had mature or maturing gonads, strongly indicating that reproductive behavior increased their susceptibility to gill-netting. The GSI values for all Rhamdia taken from L. Yure are shown in Fig. 11.47 and illustrate the high proportion of mature individuals in the samples. Since Rhamdia were caught most frequently near stream mouths, it may be that these species were exhibiting migratory movements associated with reproduction. Stomach analyses suggested that most



□ R. cabrerai
 × R. guatemalensis

Figure 11.47 a: Relationship between gonosomatic index and standard length in Rhamdia spp. females, L. Yure, 1980-1982.

Figura 11.47 a: Relación entre el índice somático-gonadal y la longitud estandar en las hembras de Rhamdia spp. en el lago Yure, 1980-1982.



□ R. cabrerai
 × R. guatemalensis

Figure 11.47b: Relationship between gonosomatic index and standard length in *Rhamdia* spp. males, L. Yure, 1980-1982.

Figura 11.47b: Relación entre el índice somático-gonadal en los machos de *Rhamdia* spp. en el lago Yure, 1980-1982.

Rhamdia had been actively feeding in or close to the streams (see below). Since there was a shift during this study from dominance by R. cabreræ to dominance by R. guatemalensis, the time series obtained from each species is insufficient to allow an adequate documentation of reproductive seasonality. Nevertheless, peak reproduction in R. cabreræ apparently was occurring between December and March, whereas the highest proportions of mature R. guatemalensis were observed from May to July. These patterns of reproductive seasonality are similar to those observed in riverine populations of Rhamdia (Section 11.6.2.3). Seasonal variations in fat index values for R. guatemalensis in L. Yure also paralleled those for the riverine populations, with highest fat accumulation observed in samples collected in November. Low index values observed during May-July correlate well with the peak in reproductive activity occurring at that time (Table 11.24).

As previously mentioned, R. cabreræ females were smaller than those of R. guatemalensis. While it is unclear if the smallest mature individuals in these samples represented the size at first maturity in the L. Yure populations, the size difference between the two species is consistent with observations from riverine populations which showed that R. cabreræ matures at a smaller size than R. guatemalensis.

Egg size and fecundity differ significantly between the two species. As illustrated in Fig. 11.48, R. cabreræ produces eggs which are 1.2-1.6mm in diameter when mature. Females of the size frequently encountered in L. Yure contain from about 1000 to over 5000 eggs (Fig. 11.18). In contrast, mature R. guatemalensis exhibit approximately the same "investment" in gonadal tissue (similar GSI values, see Fig. 11.47) as R. cabreræ, but produce many more, smaller eggs measuring approximately 0.8-1.0mm in diameter (Fig. 11.48) at

Table 11.24: Temporal variation of the fat accumulation index in R. guatemalensis (L. Yure).*

Tabla 11.24: Variación temporal en el índice de acumulación de grasa en R. guatemalensis (L. Yure).*

<u>Month (1982)</u>	<u>Fat Index Value</u>					
	<u>0</u>	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>
V-VII	0	1	10	4	2	0
VIII-IX	0	0	1	7	0	1
XI	0	1	2	1	6	9

* Data refer to number of individuals at each index value.

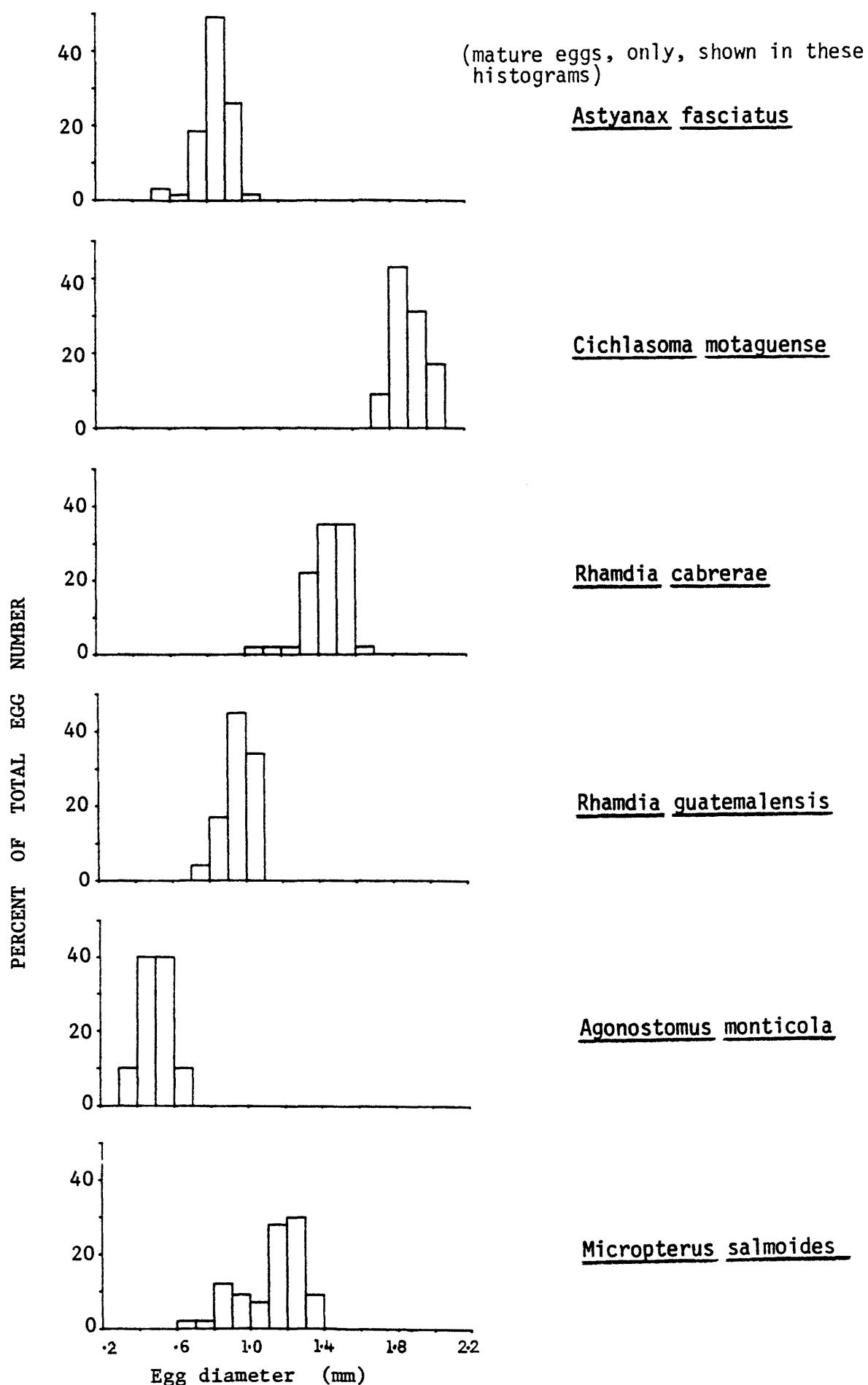


Figure 11.48: Egg size frequency distributions for six species in L. Yure.

Figura 11;48: Distribuciones por tamaño de los huevos de seis especies en el lago Yure.

maturity. Egg counts from L Yure females varied widely but were often within the range of 20,000-60,000 (Fig. 11.49). Eggs of R. cabreræ are therefore about 4X larger, by volume, than those of R. guatemalensis. Presumably newly hatched larvae of R. cabreræ are also significantly larger than those of R. guatemalensis; this may be an important factor influencing the distribution of the two species. R. guatemalensis may be excluded from higher gradient streams because of an inability of its small larvae to survive at elevated water velocities (recall from the discussion above that this species spawns mainly in the wet season when river discharges are higher). In lower elevation streams and in lakes, where high current velocity is less of a problem, the higher fecundity of R. guatemalensis is presumably a factor which results in its dominance relative to R. cabreræ. Because of the likely importance of Rhamdia in the El Cajón reservoir, and because of the species shifts observed in L. Yure, additional effort needs to be focused on the ecology of the juvenile stages of these catfish (see Section 11.3).

Rhamdia are nocturnal feeders; electroshocker-caught samples taken in the late afternoon contained little or no food in their stomachs whereas fish captured in gill nets were generally full. Table 11.25 provides a comparative summary of the diets of both Rhamdia species in L. Yure. No obvious seasonal differences in diets were noted, therefore data from various sampling dates have been pooled. As previously described for riverine populations (Section 11.6.2.3), Rhamdia is almost exclusively insectivorous. The amount and diversity of insects observed in L. Yure Rhamdia stomachs was often striking. Not only were stomachs usually full, but they frequently contained a very high number of insect taxa, both of which observations contrasted strongly with the scarcity of benthic invertebrates noted in samples taken from the lake

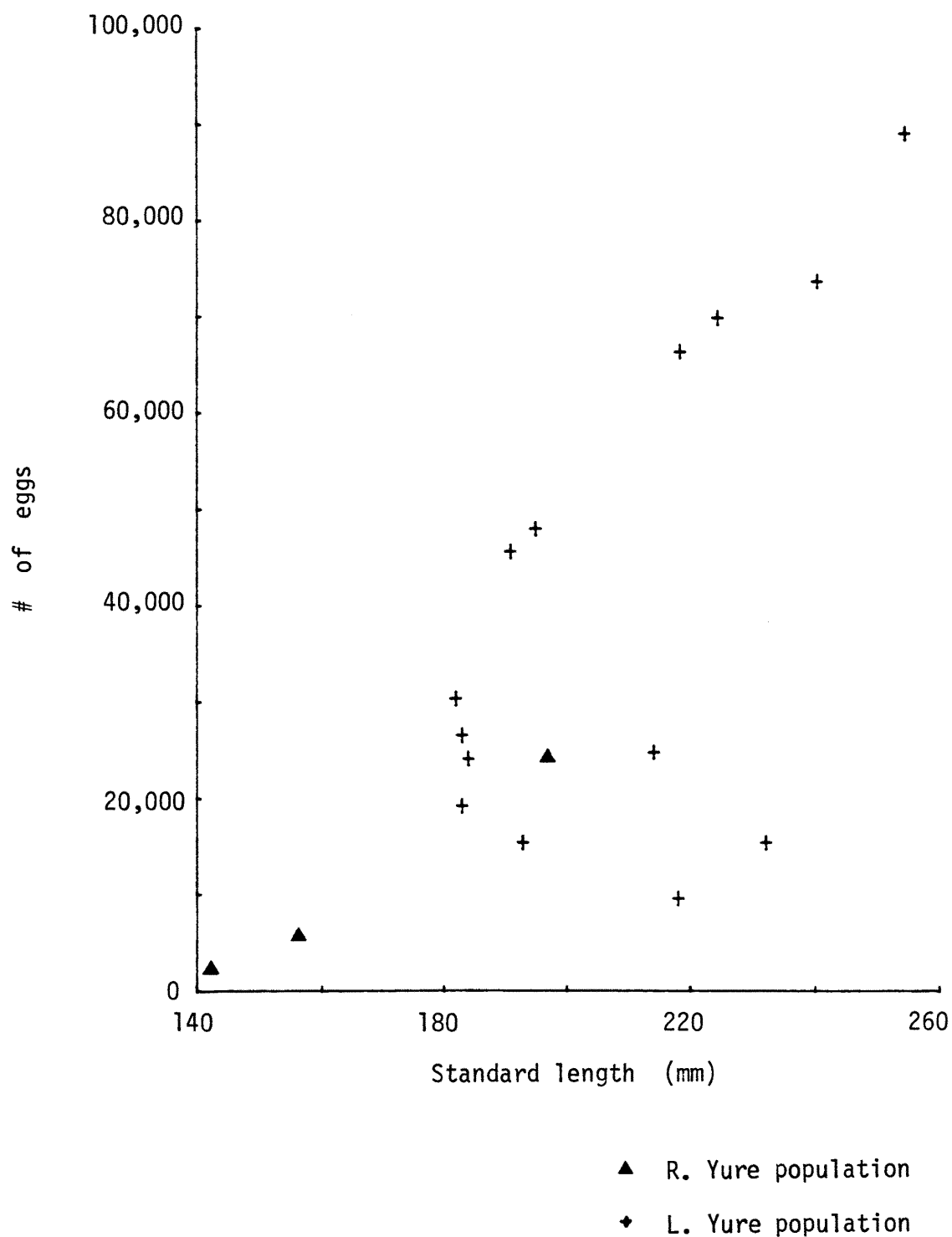


Figure 11.49: Relationship between fecundity and standard length of *Rhamdia guatemalensis*.

Figura 11.49: Relación entre fecundidad y longitud estandar en *Rhamdia guatemalensis*.

sediments. For example, R. cabreræ taken in September 1980 contained especially large numbers of dipteran larvae (Eristalis, Limonia, Simulium, Chironomidae), as well as Trichoptera (Leptonema, Smicridea), Odonata (Siphonuridae), Ephemeroptera, Plecoptera and Megaloptera (Corydalis). At this time, benthic samples from various sites in the reservoir yielded only a few small chironomid larvae. More abundant invertebrate populations were only observed in 1982 when benthic plants became increasingly widespread. It therefore would seem likely that stream invertebrates represented the major food resource for Rhamdia, at least during the first few years after the reservoir's formation. Later, as indicated by the stomach analyses of R. guatemalensis, lacustrine benthic invertebrate populations became increasingly important (especially the Anisoptera genus Idiataphe).

Table 11.25 shows that the diets of Rhamdia species overlapped considerably (i.e. both species were eating similar items). Earthworms were usually a major food item in those samples taken shortly after a heavy storm, when the lake level had risen and flooded littoral vegetation. Various taxa of insect larvae were the most frequently encountered major items in Rhamdia stomachs, however. The overall similarity in the diets of these two catfish species suggests that competition may have been occurring between them and may represent a further reason for the species shifts observed between 1980 and 1982.

Cichlasoma motaguense ("Guapote")

Population Structure: C. motaguense is the only cichlid species present in L. Yure and the tributary streams. The absence of other cichlids from the

Table 11.25: Food of Rhamdia spp. in L. Yure.Tabla 11.25: Alimentación de Rhamdia spp. en el L. Yure.

<u>Item</u>	<u>R. cabreræ</u>		<u>R. guatemalensis</u>	
	<u>Vol. %</u>	<u>Freq. %</u>	<u>Vol. %</u>	<u>Freq. %</u>
Algae/Macrophytes	0.1	7	<0.1	8
Cladocera	0.2	21	0.1	4
<u>Chaoborus</u>	1.4	21	-	-
Turbellaria	0.2	7	-	-
Oligochaetes	32.9	21	57.0	27
Ostracods	<0.1	7	-	-
Leeches	-	-	<0.1	4
Molluscs	<0.1	7	-	-
Uniden. insect frag.	16.6	43	2.3	8
Hemiptera	1.0	21	0.4	8
Anisoptera lv.	2.6	14	19.5	62
Trichoptera lv.	4.3	43	2.8	46
Diptera lv.	12.9	43	2.0	27
Ephemeroptera lv.	3.5	71	<0.1	12
Lepidoptera lv.	0.6	36	-	-
Megaloptera lv.	18.1	36	0.6	4
Coleoptera lv.	1.2	43	0.3	23
Coleoptera ad.	0.1	14	-	-
Non-aquatic insects	-	-	1.2	4
Fish remains	-	-	9.4	4
Detritus/silt	0.6	7	3.4	27
Unidentified component	3.7	14	1.0	4

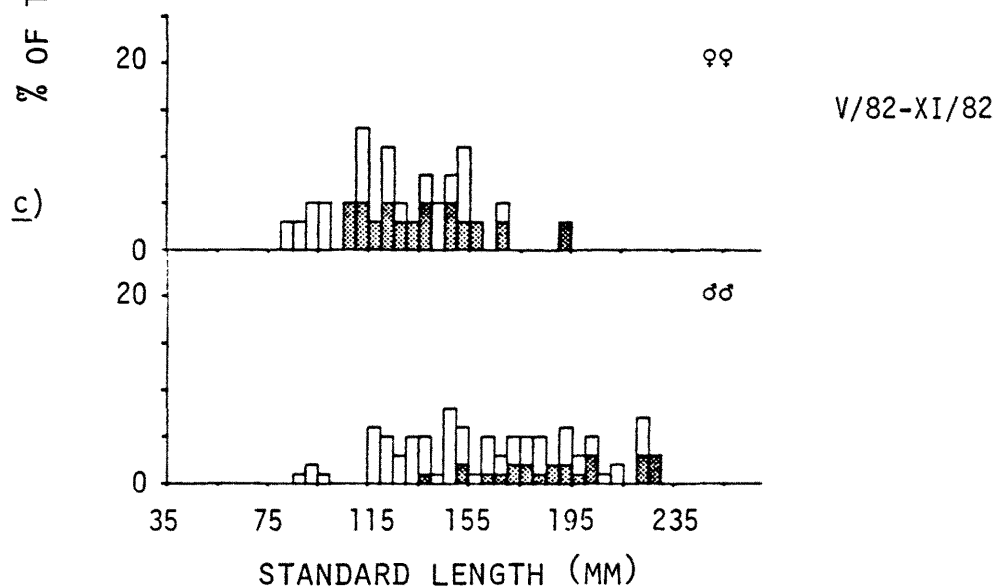
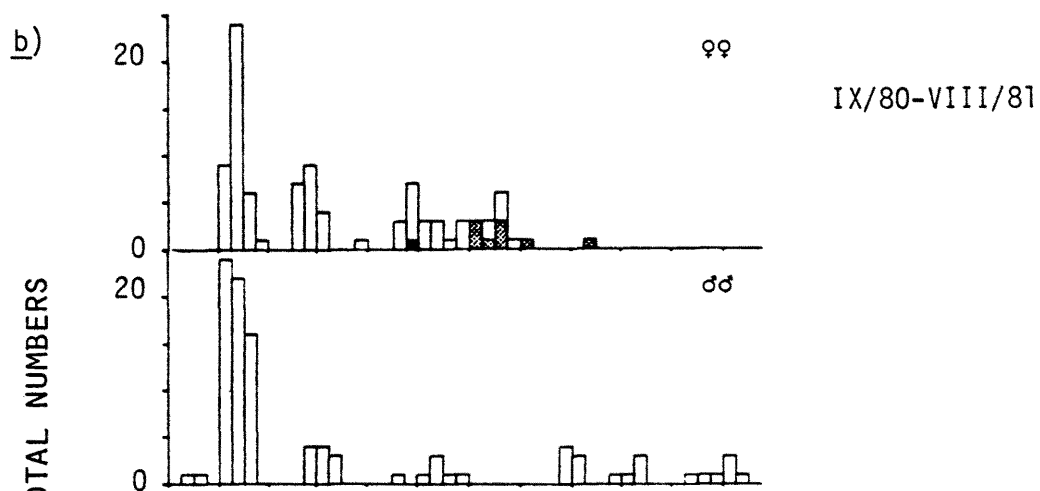
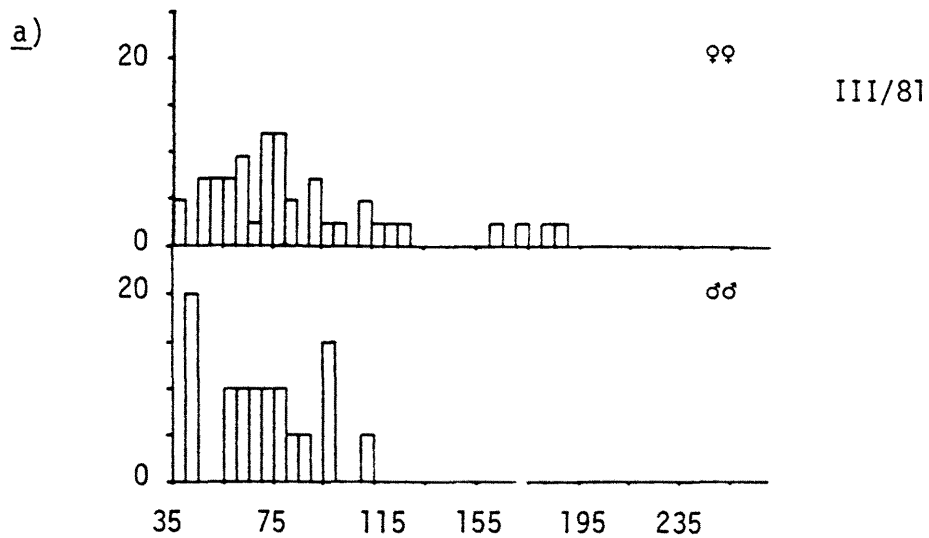
reservoir reflects their absence from the area before impoundment and not an inability to survive in the newly created lake environment. Guapote were often the major component in terms of numbers and, especially, biomass of the gill net catches from L. Yure. Although monthly mean catches varied considerably, especially in 1980 (Table 11.20), guapote represented an overall average of between 30 and 40% of total biomass throughout the fishery monitoring project (Fig. 11.43). Unlike the patterns seen with the other four major species in L. Yure, guapote exhibited no marked changes in abundance (catch per unit effort) between 1980 and 1982. Electroshocker sampling of the reservoir perimeter in 1980 caught primarily guapote but in 1981 and 1982, this form of sampling captured fewer cichlids per unit effort (time spent electroshocking) and these represented a lower percentage of total biomass (Fig. 11.43).

A typical size frequency distribution of a perimeter electroshocker sample is shown in Fig. 11.50a, and resembles some of the distributions observed in the R. Yure population (Fig. 11.34). Although the larger individuals in the perimeter sample were females, gill net samples from L. Yure clearly show that males grow to a larger size than females (see below). There is no sign of any clear cohort structure to the reservoir guapote population, a finding which would be expected from the pattern of reproductive seasonality in this population (see below). In 1980 and the first part of 1981, gill net sets captured primarily small guapote (<80mm). Subsequently, larger individuals became increasingly common in the catches and throughout 1982 the small size classes were almost never taken (Appendix 2). This change in the size structure of guapote samples is illustrated in Fig. 11.50b and c which shows size frequency distributions of fish captured in 1980-81 and 1982.

Figure 11.50: Size frequency distributions of Cichlasoma motaguense samples from L. Yure, taken with a) electroshocker and b) gill nets.

Figura 11.50: Distribuciones por tamaño de muestras de Cichlasoma motaguense tomadas con a) electroshock y b) redes agalleras en el lago Yure.

(Shaded areas refer to percentage of mature individuals --- see text for further description. Males in b) not classified for maturity stages.)



The reason for the absence of small guapote from the 1982 gill net samples is unclear (they were still being taken in electroshocker sampling around the perimeter of the reservoir, Fig. 11.43). Two possible explanations are: 1) a decrease in the abundance of small guapote in the lake, and 2) a change in the behavior of these fish such that they became less susceptible to gill-netting. Such a behavioral change may have resulted from the increase in the lake's predator (bass) population, leading to guapote increasingly avoiding areas which provided little shelter.

The size frequency distributions in Fig. 11.50 clearly illustrate the male:female size difference. The largest female taken during the entire study measured 200mm S.L. whereas males were recorded up to length of 260mm S.L. The length/weight relationship for guapote is shown in Fig. 11.33. Male:female ratios for the reservoir guapote samples varied widely. For example, in the perimeter sample illustrated in Fig. 11.50a, the ratio was 0.5:1.0. For gill net samples, the male:female ratio was 1.1:1.0 in 1980/81 and 2.3:1.0 in 1982. The reason for these differences is unclear.

Reproduction: Female guapote in L. Yure first mature at a length of approximately 100mm (Fig. 11.50). Males mature at a larger size (about 135mm). Breeding coloration is distinctive in both sexes. Females develop a large black blotch on the operculum and the throat area becomes a deep yellow/orange color. The dark markings on the side of the fish also become more accentuated at this time. Males, in contrast, lose their typical series of lateral markings and develop a mottled green/black color. In addition, the dorsal surface of the head develops a characteristic hump, which is especially noticeable in individuals larger than 200mm. This change in the shape of the antero-dorsal surface of the male is commonly observed in several Cichlasoma

species. Males retain their distinctive breeding coloration for a while after reproduction has occurred. The presence of this coloration was used to characterize the proportion of mature males, as shown in Fig. 11.50. Females however, were classified as mature on the basis of oocyte diameters and the cichlid maturity index summarized in Vol. 1 (p. 5-111). Individuals at stage 4 or 5 were deemed mature. Mature guapote were taken throughout the year, but peak reproduction occurred from May to July. Reproductive seasonality is therefore similar in lacustrine and riverine guapote populations but breeding appears to occur over a more extended period of time in the lentic environment.

As previously mentioned in Section 11.6.2.7, guapote produce the relatively large eggs characteristic of Cichlasoma (Fig. 11.48). Mature eggs are usually ovoid and have an average diameter of about 1.8-2.0mm. Females in the 130-160mm length range typically contain 1500-2500 eggs (Fig. 11.36).

During 1980 and 1981 the most common diet components were chironomid larvae and "zooplankton" (Table 11.26). The latter item consisted primarily of benthic cyclopoid copepods, chydorids and Simocephalus, and rarely included true components of the zooplankton. Stomach contents often contained a large proportion of silt. This observation and the fact that fat index values were generally 0 or 1 suggest that the guapote population was significantly food limited at this time. Filamentous algae and ants were also being ingested but rarely were dominant diet components. Larger guapote were occasionally predaceous on other fish, primarily sardinas.

The amount of food available in the L. Yure system had apparently increased significantly by 1982. Fat accumulation in guapote was on the average higher in this year than in previous years (modal value was 3), and a

Table 11.26: Food of C. motaguense (guapote) in L. Yure (electroshocker-caught samples).

Tabla 11.26: Alimentación de C. motaguense (guapote) en el L. Yure (muestras tomadas por electroshock).

<u>Item</u>	III/81		XI/82	
	<u>Freq. (%)</u>	<u>Dom. (%)</u>	<u>Freq. (%)</u>	<u>Dom. (%)</u>
Algae	36	4	57	29
Zooplankton *	71	32	71	36
Ostracods	4	-	-	-
Mites	18	-	-	-
Molluscs	-	-	43	14
Uniden. pupae	4	-	-	-
Uniden. insect frag.	11	7	29	14
Chironomidae lv.	82	11	14	7
Zygoptera lv.	-	-	7	-
Ephemeroptera lv.	-	-	7	-
Coleoptera ad.	-	-	7	-
Non-aquatic insects	7	7	-	-
Detritus/silt	46	39	-	-
Fish remains	14	-	-	-
<hr/>				
N analyzed :	32		14	
N + food :	28		14	
Length range (mm)	32-197		53-114	

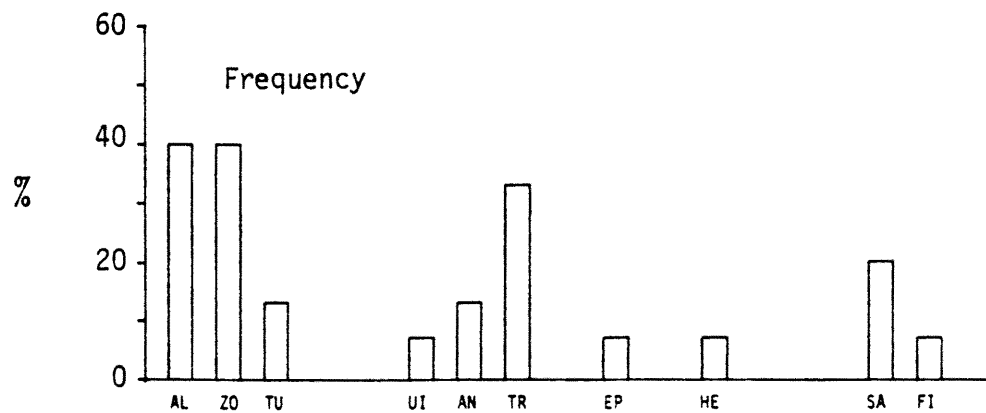
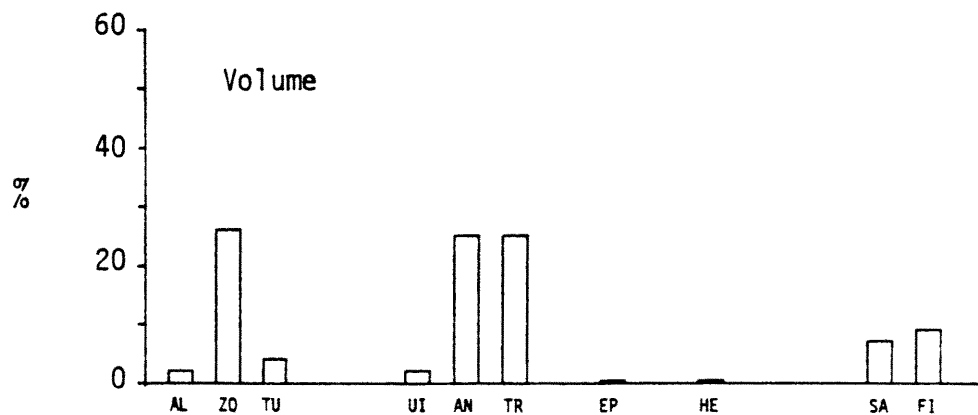
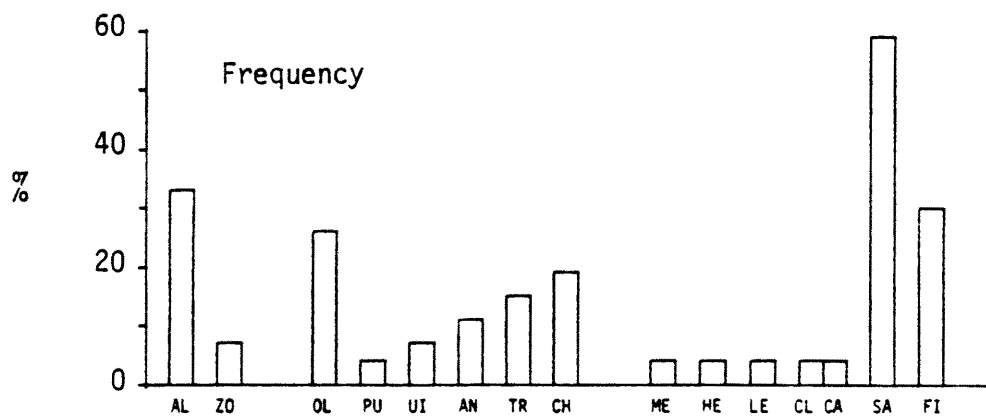
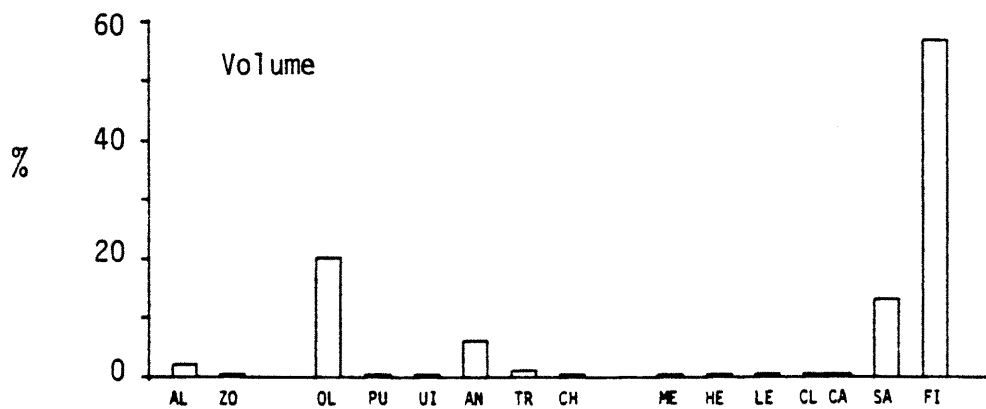
* See text for further description.

Figure 11.51: Food of gill-net caught Cichlasoma motaguense in L. Yure.

Figura 11.51: Alimentación de Cichlasoma motaguense tomado por redes agalleras en el lago Yure.

KEY:

AL: Algae
ZO: Zooplankton
TU: Turbellaria
OL: Oligochaetes
PU: Unidentified pupae
UI: Unidentified insects
AN: Anisoptera lv.
TR: Trichoptera lv.
CH: Chironomidae lv.
EP: Ephemeroptera lv.
ME: Megaloptera lv.
HE: Hemiptera
LE: Lepidoptera lv.
CL: Coleoptera lv. CA: Coleoptera ad.
SA: Sand
FI: Fish



wider variety of food items was encountered in the stomachs. An electroshocker-caught sample taken in November 1982 (Table 11.26) can be compared to the similarly collected sample from 1981 discussed above. Daphnia was dominant in the diet of many smaller guapote in 1982, but filamentous algae (Desmidium and Spirogyra) were also being ingested. Chironomids were relatively less important than they had been previously. Stomach contents from gill net samples were quite varied, but no obvious seasonal patterns were evident. Earthworms were frequently being eaten after rising water levels flooded surrounding land, as was similarly observed for Rhamdia spp. (Fig. 11.51). Zooplankton became a major food item after Daphnia appeared in the lake in May 1982, but it can be noted that guapote diets did not shift as quickly nor as exclusively to Daphnia as was the case for younger bass and sardinas. Anisoptera (Leucorrhinia and, especially, Idiataphe) and Trichoptera larvae (mainly Oecetis) were often major components of guapote diets in 1982, reflecting the increased abundance of benthic invertebrates in the lake as aquatic vegetation developed in the littoral zone. Large size classes became increasingly piscivorous, with sardinas representing the major prey item but with small bass and apparently small guapote also being taken.

Age and Growth: A total of 183 guapote, ranging in size from 44 to 176mm S.L. were tagged and re-released into L. Yure in July and August 1981. At least 13 of these were subsequently recaptured by fishermen, but only 9 were returned for analysis. These returned guapote were recaptured between July 1981 and May 1982; the lengths of these fish when originally tagged ranged from 53 to 158mm. Growth rates, as estimated from the difference between final and original standard lengths, varied greatly, from 1.36mm/month to 8.00mm/month,

with a mean of 3.86mm/month. There was no correlation between growth rate and either fish size or the length of time that had elapsed between tagging and recapture. Although the observed variation in growth rates may have reflected inherent between-individual variation, it may also have been partially an artifact of tagging itself since this process has been shown to reduce growth rates in some species (e.g. Bagenal and Tesch 1978). The present data set includes two anomalously low growth rates (1.36 and 1.59mm/month). If these are omitted from consideration, the average rate becomes 4.54mm/month which, if growth is assumed to be linear over the course of a year, is equivalent to 55mm/year.

Scales were also examined in an attempt to estimate growth rates of guapote. Analysis of an annual series of samples indicated growth checks are formed around February and March, although there appears to be significant variation between individuals in the time of formation. This timing agrees reasonably well with a hypothesized increase in growth rates as water temperatures in L. Yure rise in February/March (see Figs. 7.7 and 7.8, pp. 7-192 and 7-196, Vol. 1). (Note that growth checks were identified in guapote scales principally as regions of "cutting over" and therefore represent resumptions of higher growth rates, rather than the start of periods of slow growth; see Fig. 11.54).

The body-length/scale-radius relationship for guapote is shown in Fig. 11.52. The regression line passes through the origin and there is a change in its slope at a scale radius of approximately 3.5mm (equivalent to a standard length of 108mm). This happens to correspond approximately to the age at first maturity in L. Yure, but the two are not necessarily causally related. Growth checks or annuli on many scales were not clear, especially in the

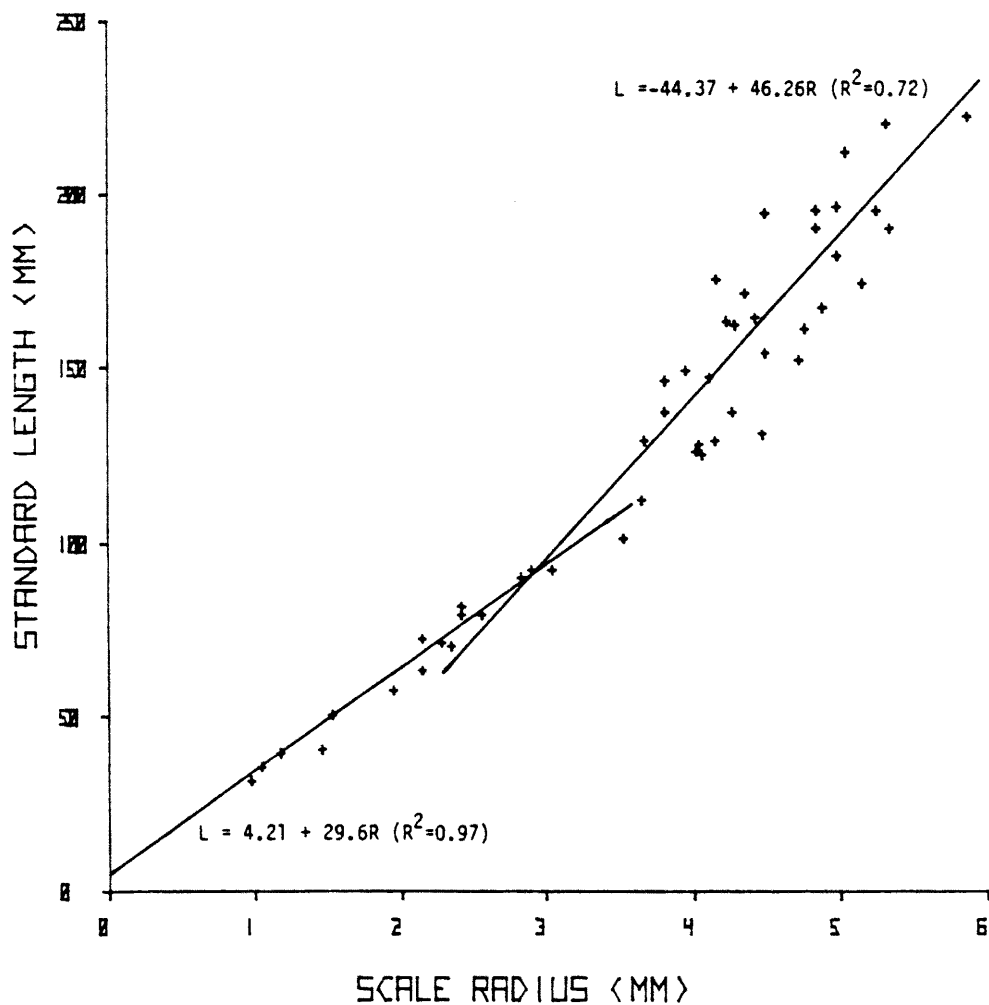


Figure 11.52: Relationship between standard length and scale radius for Cichlasoma motaguense.

Figura 11.52: Relación entre longitud estandar y el radio de las escamas en Cichlasoma motaguense.

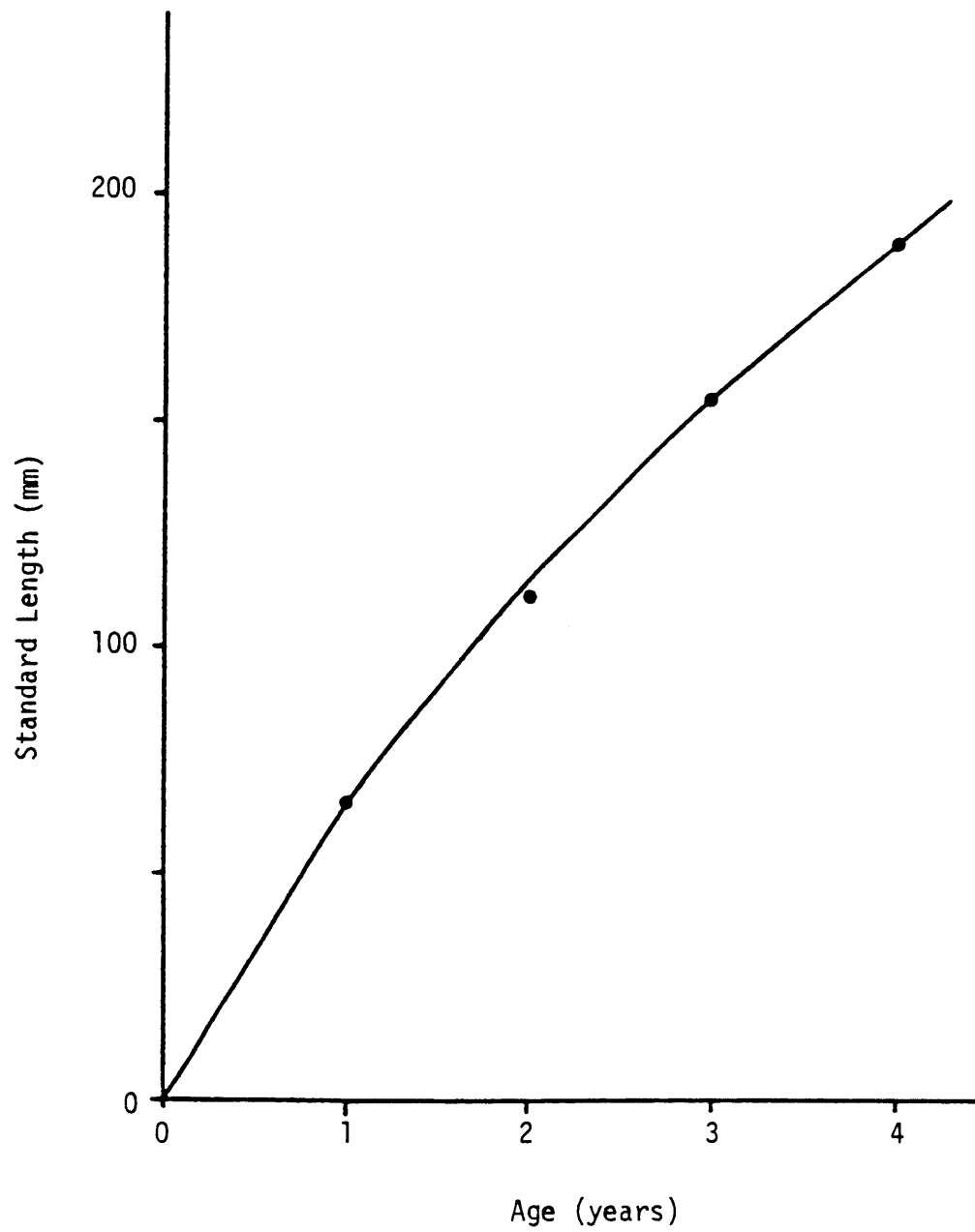


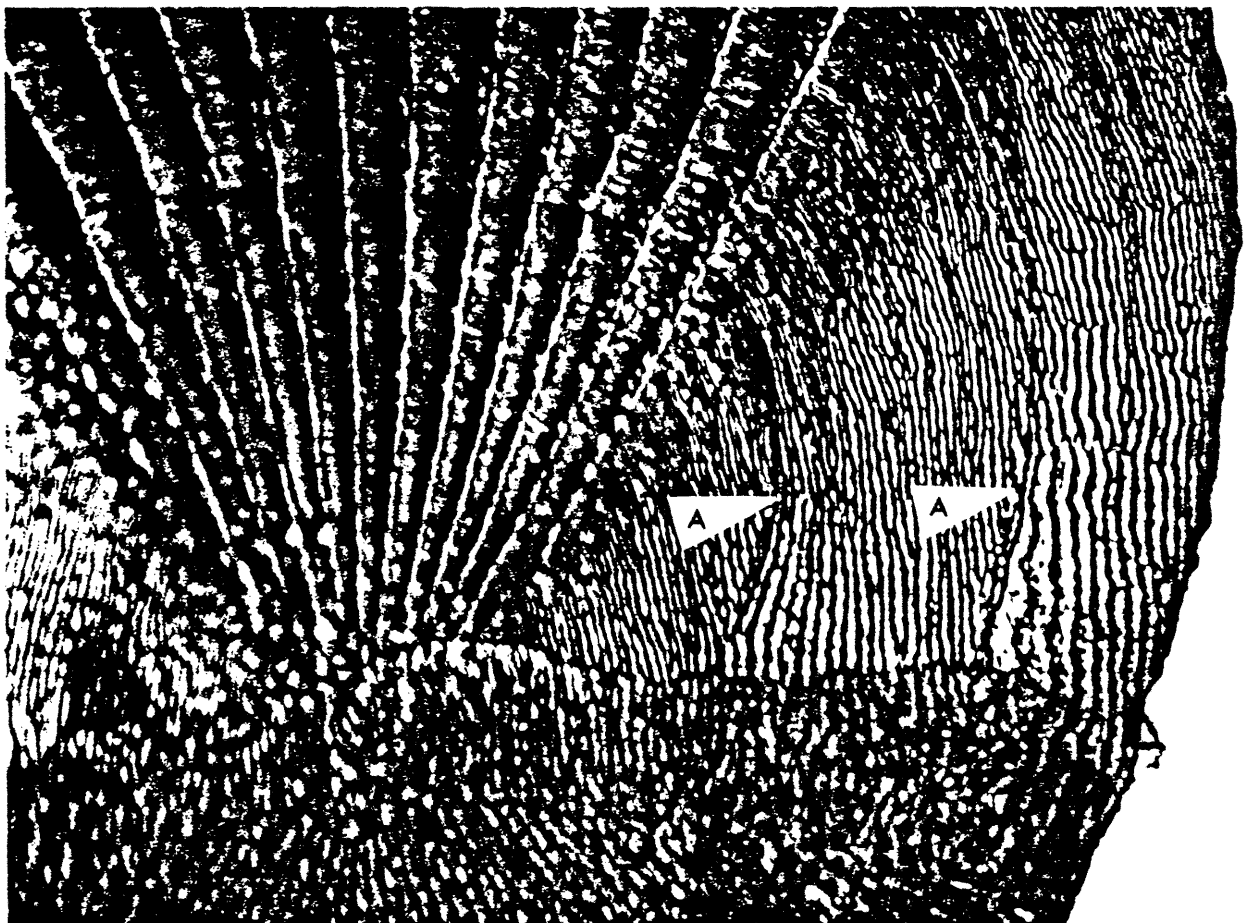
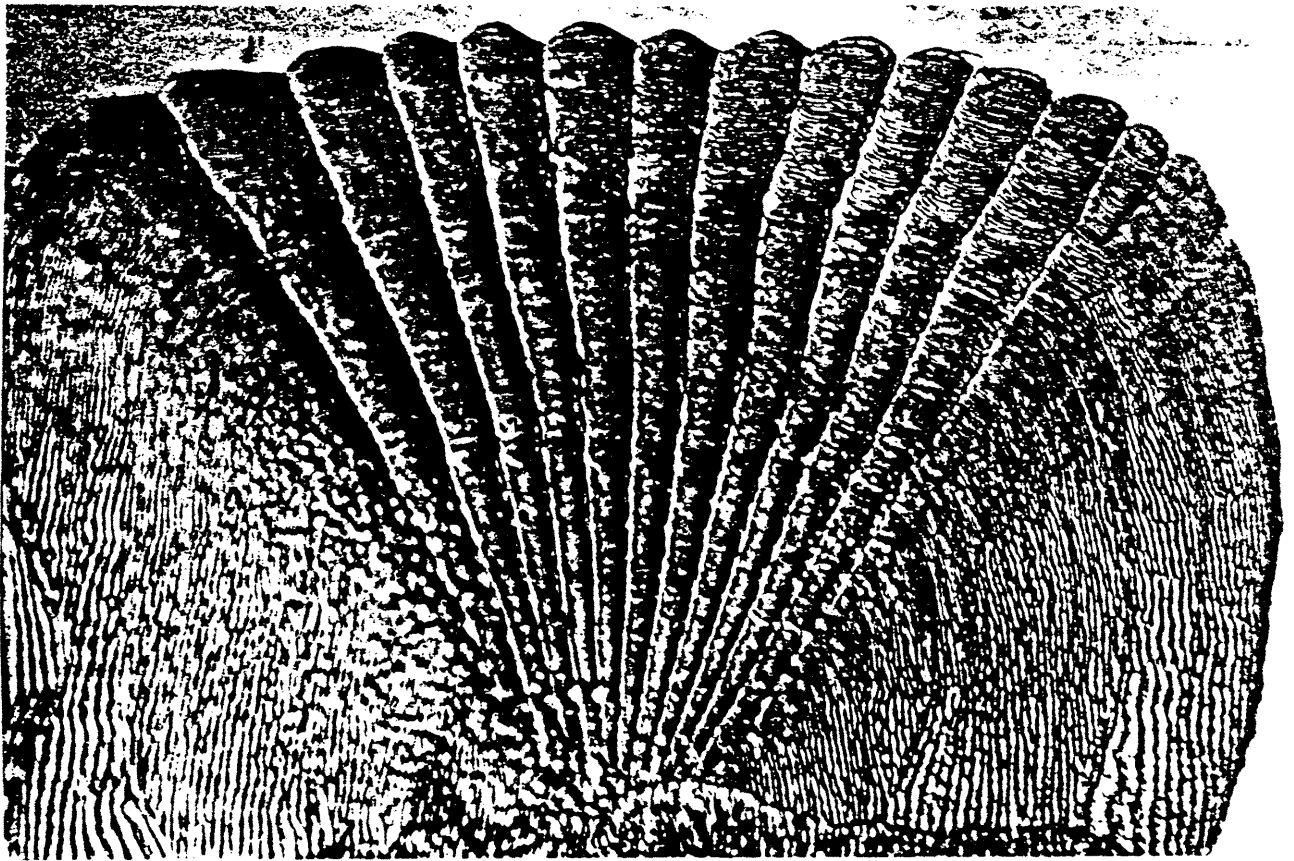
Figure 11.53: Growth of Cichlasoma motaguense in L. Yure.

Figura 11.53: Crecimiento de Cichlasoma motaguense en el lago Yure.

Figure 11.54: Scales of Cichlasoma motaguense illustrating annual growth checks.

Figura 11.54: Escamas de Cichlasoma motaguense ilustrando marcas anuales de crecimiento.

(Lower photograph is an enlarged section of the scale shown in the upper photograph. Scale taken from a female C. motaguense captured in July 1982, measuring 132mm S.L., weighing 92.3g and having an ovarian maturity stage of V.)



A = annulus

larger size classes of guapote. However, growth rates could be estimated by back calculation of fish length at ages corresponding to scale annuli (as discussed in Section 11.5). The resultant growth curve is shown in Fig. 11.53. No obvious difference between male and female growth rates was noted and thus the curve in Fig. 11.53 is applied to both sexes. Guapote in L. Yure reach a length of approximately 60mm in their first year and about 190mm by their fourth year. These growth rates agree well with the estimates made from the tagging experiments. Females therefore mature in their second year and apparently few individuals were surviving beyond their third year. Males, on the other hand, can live for at least four or five years, as the size distributions in Fig. 11.50b and c indicate.

Estimation of age and growth rates will play an important part in understanding and managing the El Cajón fishery and should be further investigated in post-impoundment studies (see Section 11.3).

Agonostomus monticola ("Tepemechín")

A. monticola is one of two fresh-water species in the family Mugilidae that are found in Honduran rivers (the other is Joturus pilchardi; see section 11.6.2.12). Although tepemechín were never collected in river samples, 11 adults were captured by gill netting in L. Yure near the mouths of inflowing streams (Appendix 2, Table 20); nine of these were females. Table 11.27 provides a summary of these samples.

Mature females were captured in May, August and November and were at the ripe/running stage. Tepemechín taken in December and March were immature. This species appears to be a wet season spawner, but more samples are needed to better document reproductive seasonality. In the West Indies, pelagic

Table 11.27: Size distribution and reproductive condition of Agonostomus monticola (tepemechín) in L. Yure.

Tabla 11.27: Distribución de tamaños y condición reproductiva de Agonostomus monticola (tepemechín) en el L. Yure.

<u>Date of capture</u>	<u>Standard Length (mm)</u>	<u>Weight (g)</u>	<u>Sex</u>	<u>GSI</u>	<u># eggs*</u>	<u>Largest egg size class (mm)</u>
2/X/80	193	147	♀	0.33	-	0.07
11/XI/80	294	520	♀	24.20	3,170,323	0.20-0.50
	303	600	♀	26.22	3,827,120	0.40-0.50
12/XII/80	273	400	♂	0.70	-	-
	202	178	♂	0.39	-	-
4/III/81	205	186	♀	0.22	-	0.07
	279	484	♀	0.53	-	0.07
18/VIII/81	310	900	♀	18.11	4,892,401	0.40
21/X/82	262	414	♀	0.40	-	0.08
	308	691	♀	0.71	-	0.08
	297	724	♀	3.46	944,721	0.30-0.40

* Means of 3 sub-sample counts; coefficients of variation for these means were between 5 and 10%.

larvae of A. monticola are found between September and December (Breder and Rosen 1966). Carr and Giovannoli (1950) note that tepemechín are very strong swimmers and are frequently found in torrents and in pools at the base of waterfalls. These observations and the fact that young individuals were never captured in L. Yure suggest that adults move downstream for reproduction or, alternatively, that the present samples represented infrequent incursions into the reservoir from the streams. Tepemechín were less frequently captured in 1982 than in 1981.

The fecundity of tepemechín is very high; females often contain several million eggs, measuring 0.4-0.5mm in diameter (Fig. 11.48). Presumably this species is a complete spawner releasing all its eggs in one spawning.

Three fish contained food in the stomach. In each case sardina (Astyanax fasciatus) remains were the dominant component, with filamentous algae and insect fragments, including Trichoptera, chironomid, Ephemeroptera and Hemiptera larvae also present in the guts. Tepemechín caught in May contained especially high fat accumulations.

Micropterus salmoides

The largemouth bass is native to the eastern part of North America, but in the last 100 years has been introduced into the western United States and many other countries throughout the world (Carlander 1977, Moyle 1976). It is one of the most important freshwater game fish in the United States and it was for this sports fishery potential that it was introduced into L. de Yojoa in 1954 (Ostmark 1964, Cruz 1979b). Because of its economic importance, there have been many studies on the biology and ecology of largemouth bass (e.g. Carlander 1977). The following brief summary of bass life history is based

largely on North American studies and is included here to serve as a context for the data collected from L. Yure.

Preferred habitat for largemouth bass is warm, relatively clear water, with abundant aquatic vegetation. The optimum temperature for growth is about 27°C (Robbins and MacCrimmon 1974) and the minimum oxygen requirement is 1.5-2.0 ppm (Moyle 1976). Adult bass are typically solitary predators but fish less than about 100mm S.L. feed mainly on zooplankton and aquatic insect larvae. Diets can vary considerably between years, apparently not always in relation to prey abundance (Lewis et al. 1961). Spawning first occurs at lengths of between about 180 and 210mm, usually in the bass's second or third spring. Males build nests and spawning will often continue until June, when temperatures reach 24°C (Moyle 1976). Nests are built at depths often less than 1m, but water level changes in reservoirs may result in active nests being as deep as 5m (Miller and Kramer 1971). Growth rates of largemouth bass are extremely variable and depend on genetic stock, temperature and food availability, amongst other things. They can grow to (total) lengths of from 50 to 200mm in their first year and reach 200-410mm by their fourth year. Maximum size and age appear to be about 760mm and 16 years respectively (Moyle 1976).

Since its introduction into L. de Yojoa in 1954, the largemouth bass population of this lake has been the subject of one major study (Cruz 1979a). Using fishermen-caught samples and identifying peaks in size-frequency distributions, Cruz estimated that bass in this lake grow to a length of approximately 180mm in their first year and reach 380mm by their fifth year. He suggested that growth rates in 1978 were lower than those in 1958, possibly because of the larger amount of food available soon after their introduction

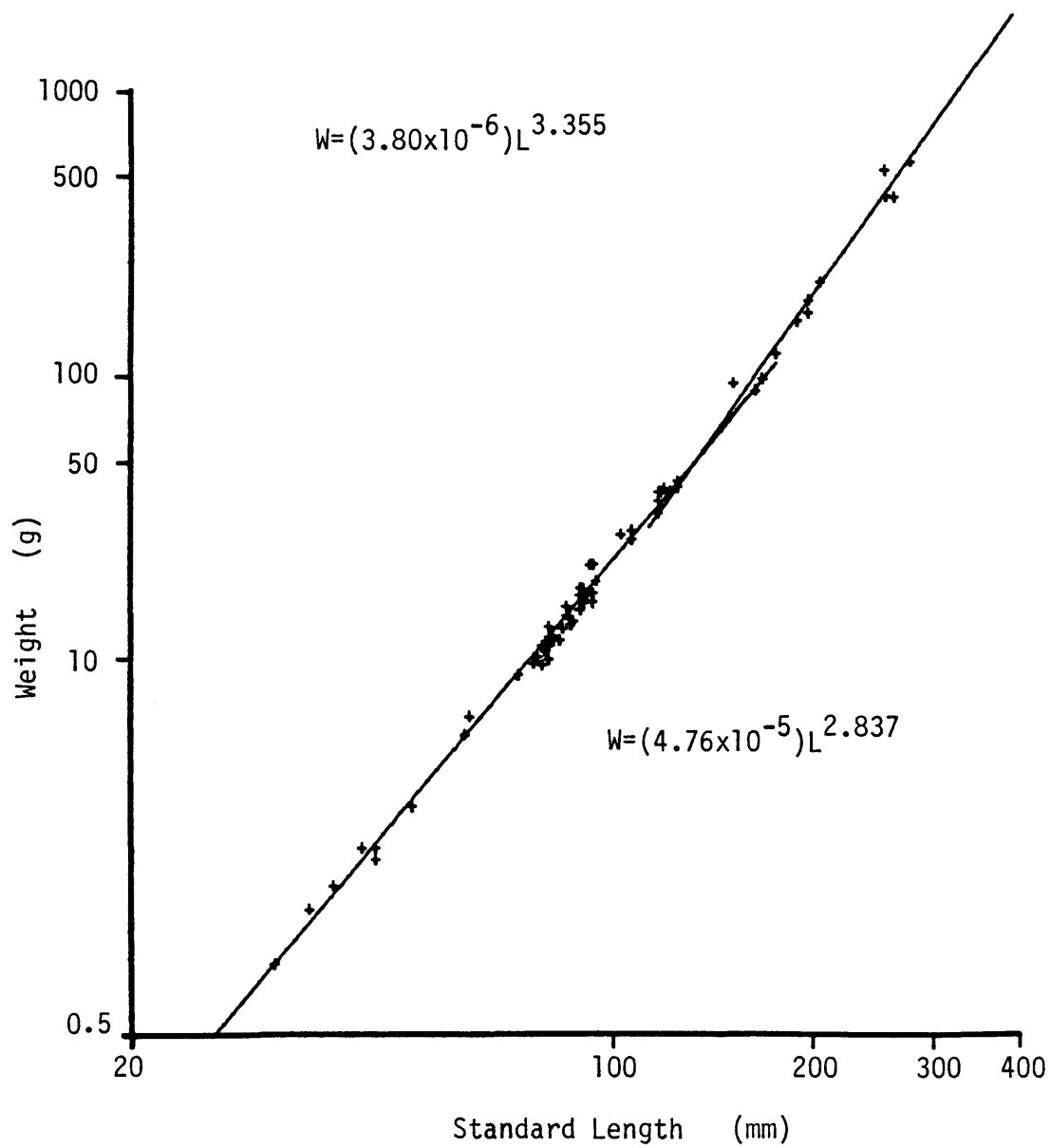


Figure 11.55: Length-weight relationship of Micropterus salmoides.

Figura 11.55: Relación longitud-peso de Micropterus salmoides.

into the lake. However, condition factors for the 1978 population were higher than those for the 1958 population. Analysis of temporal trends in GSI's indicated that reproduction is seasonal in L. de Yojoa, with peak reproductive activity occurring from March to May. The three major food items of the Yojoa bass population in 1978 were Anisoptera larvae, adult Odonata and small bass.

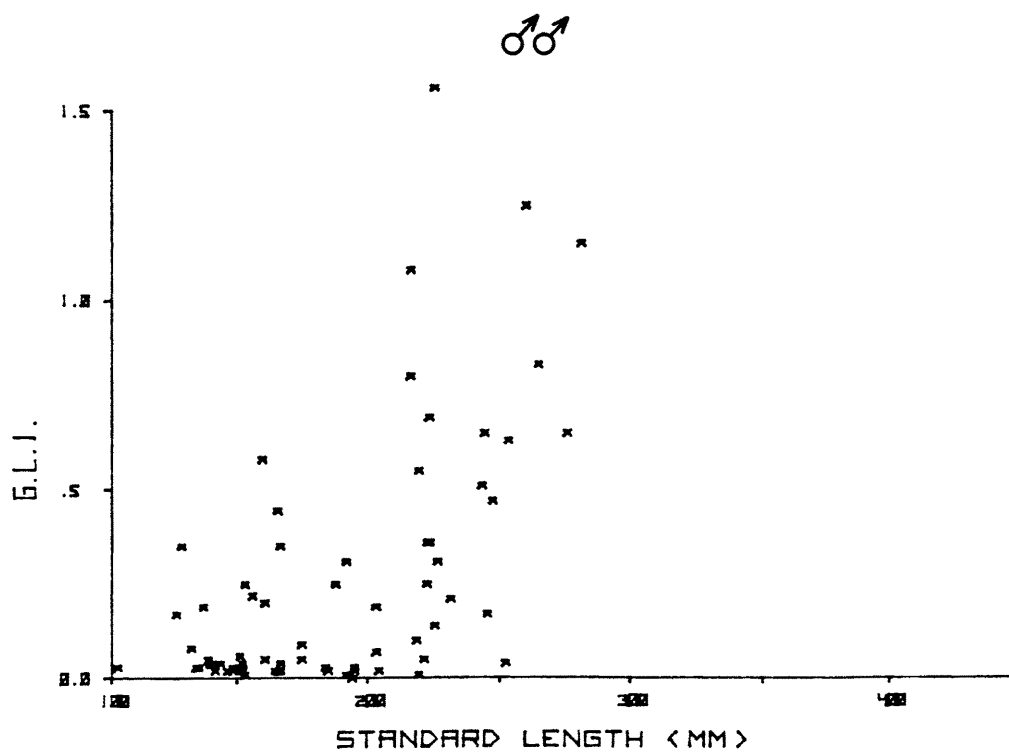
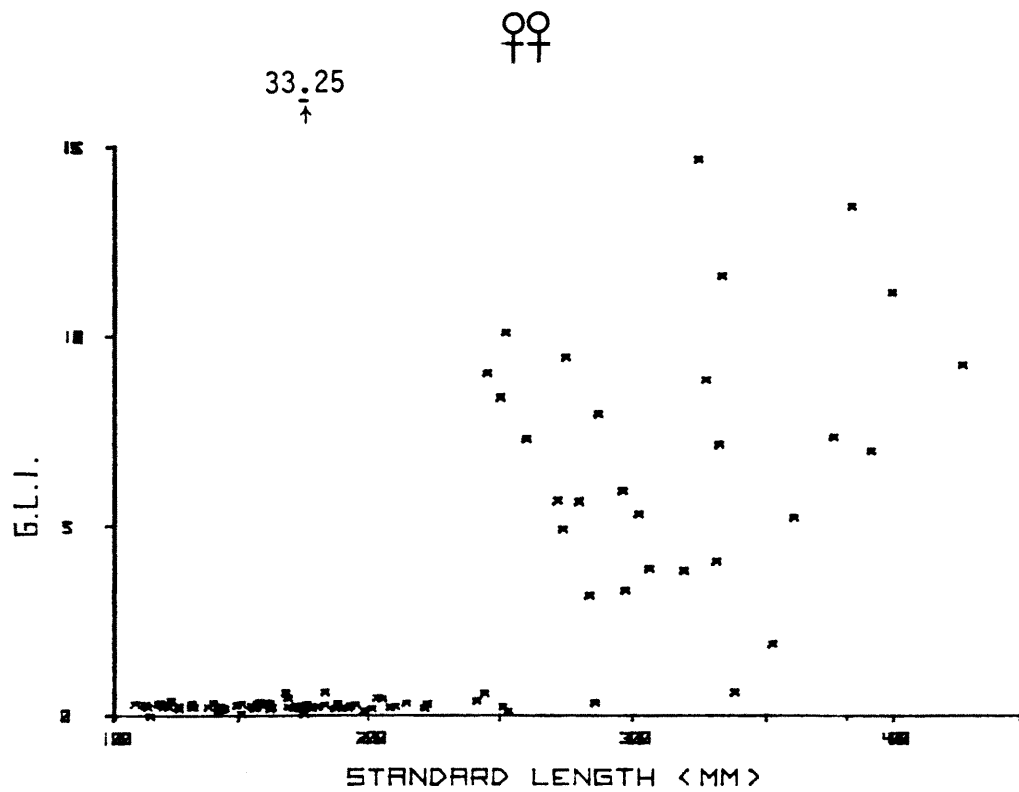
According to accounts of local fishermen, bass were introduced into L. Yure from L. de Yojoa in 1980. During 1980 and 1981, gill net sets in L. Yure captured few individuals, all of them adult (Table 11.21, Appendix 2). Electroshocker sampling of the lake perimeter caught relatively few juveniles, as previously discussed in Section 11.7.1 (Fig. 11.43). Catch rates increased considerably in 1982 (Table 11.21, Fig. 11.43). This increase, like that for sardinas, may have resulted in part from the appearance of Daphnia and the consequent greater exposure of bass to gill netting. However, catch rates had started to increase before Daphnia became the dominant zooplankter and so probably represented a real increase in the bass population.

The size frequency distribution of gill-netted and fisherman-caught bass can be inferred from the data in Fig. 11.56. The largest fish taken were usually females, as was the case for the Yojoa bass population (Cruz 1979a). In the June-July 1982 samples, for example, the largest male taken measured 245mm whereas all fish from 250 to 425 mm were females. The length-weight relationship for L. Yure bass is shown in Fig. 11.55.

A plot of a gonad maturity index, GLI, (similar to GSI -- see Section 11.5) against standard length (Fig. 11.56) indicates that most L. Yure females reach first maturity at a length of about 240mm S.L. With the exception of one individual, smaller females showed virtually no gonad maturation (oocytes measured < 0.1mm). Size at first reproduction was not mentioned by

Figure 11.56: Relationship between gonadal-length index and standard length in bass (Micropterus salmoides), L. Yure, 1980-1982.

Figura 11.56: Relación entre el índice longitud-gonadal y longitud estandar en el bass (Micropterus salmoides) en el lago Yure, 1980-1982.



Cruz (1979) for the Yojoa population, but the value of 240mm just noted is greater than is seen in many N. American bass populations (Moyle 1976). If the one mature female measuring less than 240mm (175mm, Fig. 11.56) represents the true lower size class of mature bass in L. Yure, it is unclear why more mature individuals in this size range were not captured. Mature eggs measure 1.2-1.5mm in diameter (Fig. 11.48) and have a dry weight of approximately 8mg. The number of eggs per female increases with female size as shown in Fig. 11.57. More data from larger bass size classes are obviously needed to be able to calculate an adequate fecundity-length relationship, but the data in Fig. 11.57 are described by the following relationship:

$$F = 0.04 L^{2.28}, \quad (R^2 = .39)$$

where F = fecundity and L = standard length.

These fecundity data are similar to others published for a number of N. American largemouth bass populations, but higher (for a given female size) than the data given by Cruz (1979a) for the Yojoa population. A comparative study of the reproductive ecology of Yojoa and Yure bass populations could play a valuable part in future fisheries management plans for L. de Yojoa, especially in view of differences in the morphology of the two lakes.

Mature females were taken in L. Yure during both dry and wet seasons. Highest capture rates of the larger size classes occurred from May to July and the lowest from February to April (sampling effort was also lower at this time, however). Adult bass would be expected to be most susceptible to capture by gill nets during the spawning period since at this time they are present mainly in the littoral zone. The fact that most gill-netted fish were mature supports this reasoning. The greatest proportion of spent females was encountered during July - September. The present data, although insufficient

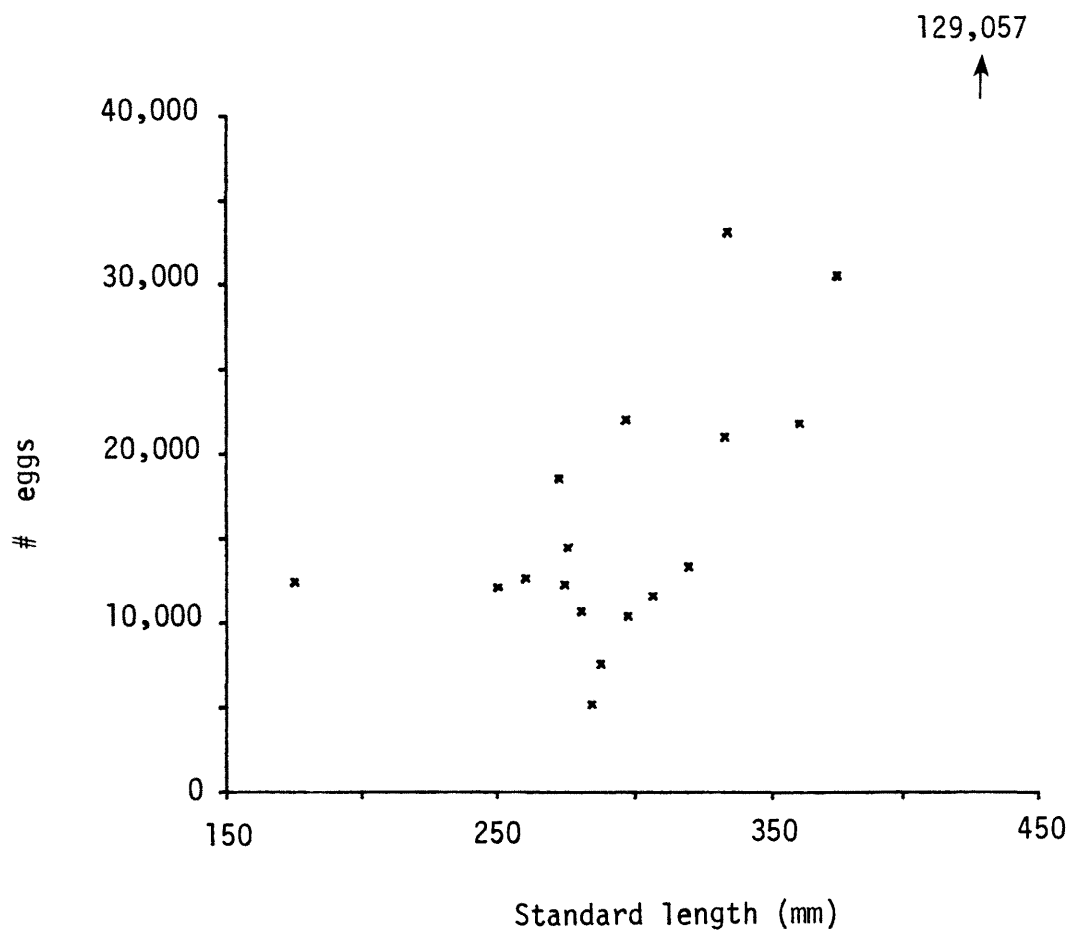


Figure 11.57: Relationship between fecundity and standard length in bass (*Micropterus salmoides*) in L. Yure.

Figura 11.57: Relación entre la fecundidad y la longitud estandar del bass (*Micropterus salmoides*) en el lago Yure.

to allow any definitive statement, suggest that peak reproduction occurs at the beginning of the wet season (April-June) while some individuals spawn between October and February. It is unclear whether some females reproduce more than once a year or whether dry season (October-February) spawners represent individuals which did not reproduce during the first part of the year.

These results from L. Yure differ from those obtained by Cruz (1979a) in his study of the L. de Yojoa bass population. The latter exhibited a clear peak in reproductive activity (as measured by mean GSI values) during February-April. While taking into account that the trend observed in L. de Yojoa may have been influenced by shifts in the location of greatest fishing activity (pelagic/littoral zone), it seems likely that the bass populations of the two lakes show some real differences in reproductive seasonalities.

The feeding habits of bass in L. Yure are summarized in Table 11.28. Most size classes included some fish in their diet, but bass larger than about 200mm were primarily piscivorous. The principal prey species was Astyanax but guapotes (Cichlasoma motaguense) and bass juveniles were also being taken. Before the appearance of Daphnia in the zooplankton community, smaller size classes were feeding mainly on non-aquatic insects (ants especially) and Anisoptera larvae. After May 1982, when Daphnia was the dominant zooplankter, fish smaller than 150 mm were primarily zooplanktivorous. They were taking Daphnia almost exclusively; other components of the zooplankton assemblage were rarely seen in bass stomachs. Anisoptera larvae (primarily the libellulid Idiataphe) continued to represent a major component of bass diets, especially in the medium size classes. The trophic ecology of Yure and Yojoa largemouth bass is similar since Cruz (1979) has shown that Anisoptera larvae

Table 11.28: Food of largemouth bass in L. Yure; a) April-May 1982, b) June-November 1982. †

Tabla 11.28: Alimentación del bass en el L. Yure; a) abril-mayo 1982, b) junio-noviembre 1982.†

(a)

April-May 1982

	Bass Size Class (mm)				
<u>Item</u>	<u>101-150</u>	<u>151-200</u>	<u>201-250</u>	<u>251-300</u>	<u>301-350</u>
Algae	1.6	0.6	-	-	-
Uniden. Insect frag.	12.7	5.9	-	-	-
Anisoptera lv.	18.1	12.1	-	10.0	-
Trichoptera lv.	-	11.8	-	-	-
Chironomidae lv.	-	-	-	-	-
Ephemeroptera lv.	-	-	-	-	-
Hemiptera	-	-	-	-	-
Non-aquatic insects	14.2	11.4	-	-	-
Zooplankton	-	0.6	-	-	-
Fish	53.3	57.5	100.0	90.0	100.0
# fish analyzed :	7	17	2	8	1

† Data represent average volume of food item as a percentage of total food volume.

Table 11.28 (b)

June-November 1982

Item	Bass Size Class (mm)															
	0-50		51-100		101-150		151-200		201-250		251-300		301-350		351-450	
	G/N*	F/M*	G/N	F/M	G/N	F/M	G/N	F/M	G/N	F/M	G/N	F/M	G/N	F/M	G/N	F/M
Algae	-	-	-	-	-	-	0.5	4.9	-	-	-	6.6	-	-	-	-
Uniden. insect frag.	6.2	-	0.2	-	-	-	14.2	-	-	-	-	-	-	-	-	-
Anisoptera lv.	-	-	-	-	-	3.7	-	14.4	-	12.5	-	-	-	-	-	-
Trichoptera lv.	1.9	-	2.6	-	-	<0.1	-	6.4	-	2.9	-	-	-	-	-	-
Chironomidae lv.	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-
Ephemeroptera lv.	-	-	0.6	-	5.3	-	-	0.1	-	-	-	-	-	-	-	-
Hemiptera	12.5	-	-	-	5.0	-	28.1	-	-	4.9	-	-	-	-	-	-
Non-aquatic insects	-	-	-	-	-	-	-	-	-	-	-	20.0	-	-	-	-
Zooplankton	78.1	-	84.1	-	71.7	79.5	14.6	26.4	46.0	12.5	-	-	-	-	-	-
Fish	-	-	10.7	-	15.3	9.0	42.6	53.2	54.0	50.0	100.0	73.4	-	100.0	100.0	100.0
# fish analyzed :	8	-	42	-	21	24	7	18	1	8	3	5	-	2	1	2

† Data represent average volume of food item as a percentage of total food volume.

* G/N = samples caught in gill nets

F/M = samples caught by fishermen with hook and line.

Table 11.29: Fat index values in juvenile and adult largemouth bass, L. Yure.

Tabla 11.29: Valores del índice de grasa en juveniles y adultos de bass en el L. Yure.

<u>Date</u>	< 200mm bass			> 200mm bass		
	<u>Fat index</u>		<u># of observations</u>	<u>Fat index</u>		<u># of observations</u>
	Mean	St. Dev.		Mean	St. Dev.	
X-XII/81	-	-	-	6.5	1.2	11
II/82	0.7	0.6	3	-	-	-
IV-V/82	1.9	1.2	35	6.1	1.9	15
VI-VII/82	3.5	1.3	42	5.5	2.2	22
VIII-IX/82	2.6	1.4	46	5.4	2.0	15
XI/82-1/83	2.9	1.1	53	7.0	6.0	3

are a major diet component in the latter population.

Condition factors were calculated for the L. Yure samples, but no significant seasonal variations were noted. However, a trend in mean values of the composite fat index was evident (see p. 5-113, Vol. 1, for a description of this index). Fish smaller than 200mm S.L. showed considerably greater fat accumulation after May 1982 than before, whereas adults showed a slight decrease in mean fat levels between June and September (Table 11.29). An obvious possible explanation for these trends is that the increased food supply to juvenile bass, represented by the high Daphnia densities after May 1982, led to increased fat reserves. Adult bass did not rely so heavily on zooplankton and thus were less affected by Daphnia. However, reduced food intake resulting from increased reproductive activity led to lower fat index levels during the June to September period following peak spawning in L. Yure.

11.7.4 PROGNOSIS

By the end of 1982, the L. Yure fish community probably still had not yet reached a "stability" phase following impoundment. Changes in community structure and function, such as those as described in the previous sections and in Fig. 11.58, will continue to occur in this reservoir. Monitoring future changes in this fishery will continue to provide useful information on the impacts of impoundment on native fish assemblages and a comparison of the trends observed in L. Yure with those that will be observed in L. El Cajón will generate an increased predictive capability for future impoundment projects in Honduras.

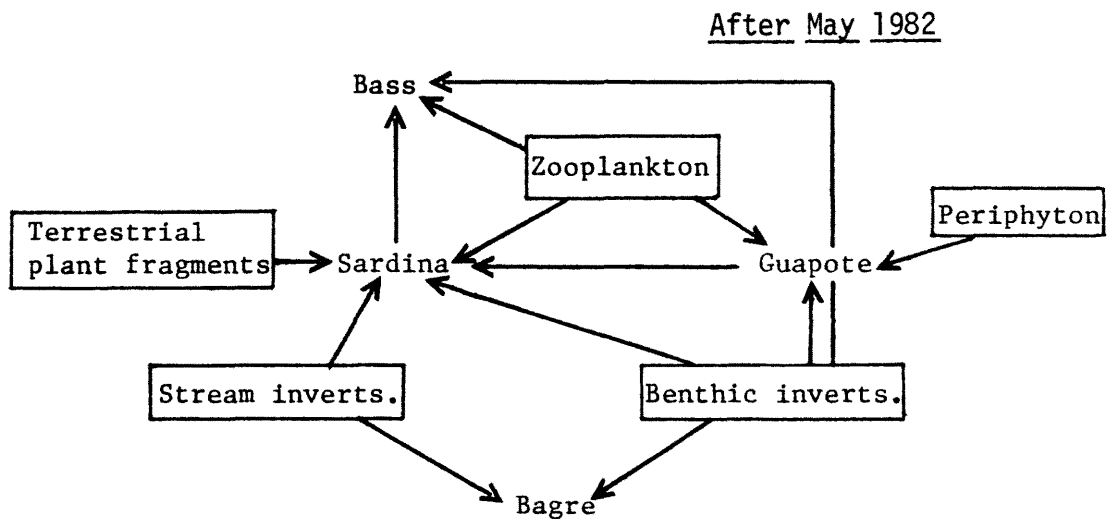
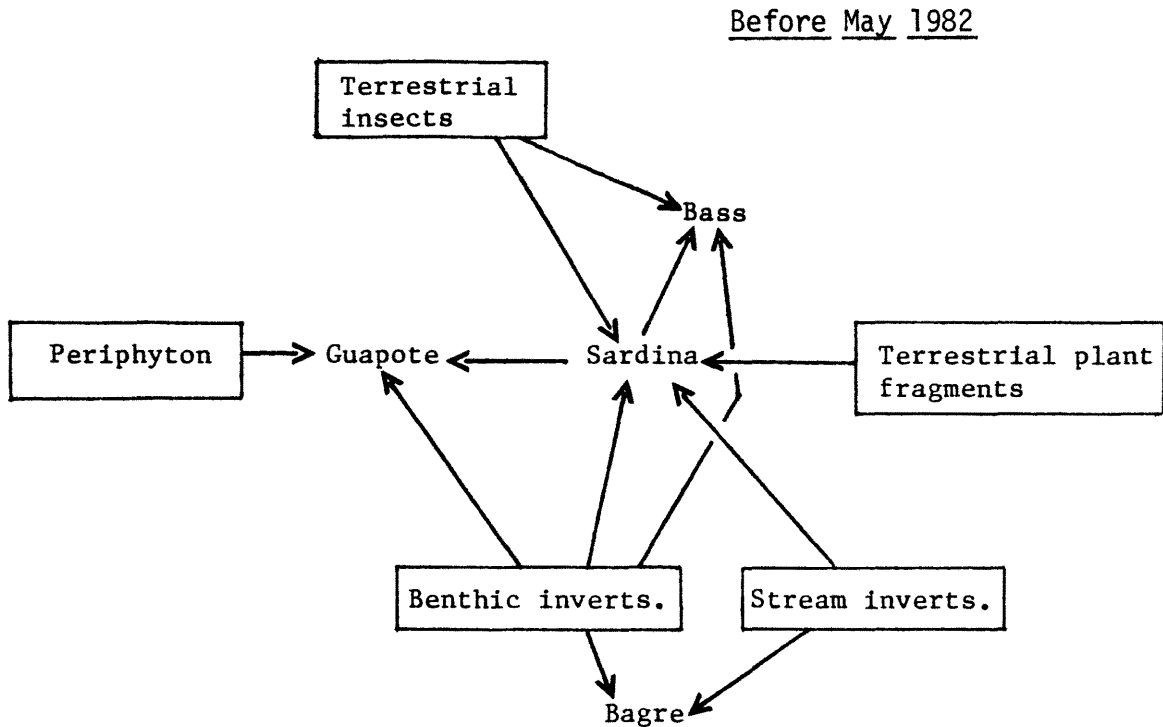


Figure 11.58: Summary of the trophic interactions in L. Yure before and after the appearance of Daphnia.

Figura 11.58: Resumen de las interacciones tróficas en el lago Yure antes y después de la aparición de Daphnia.

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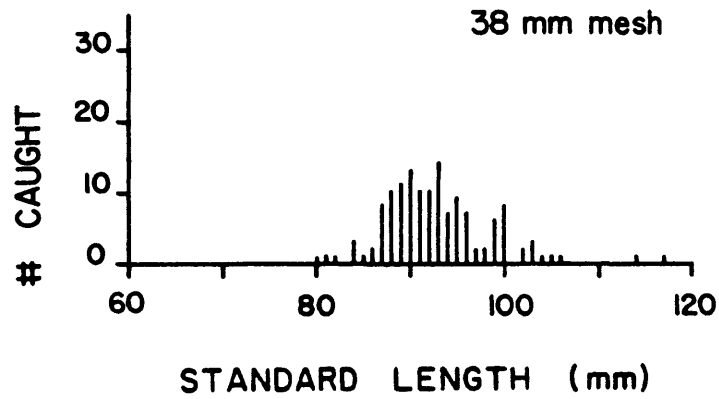
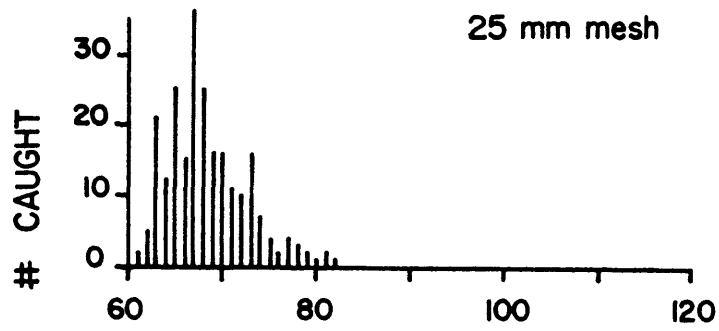
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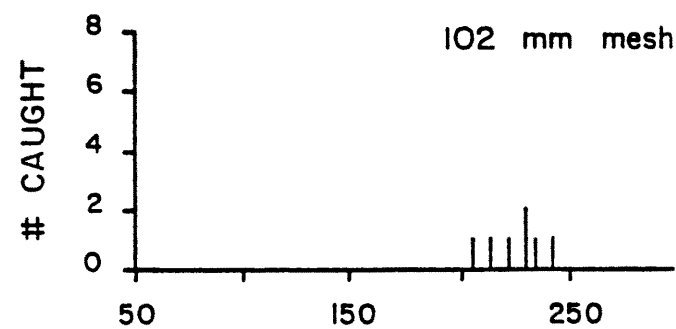
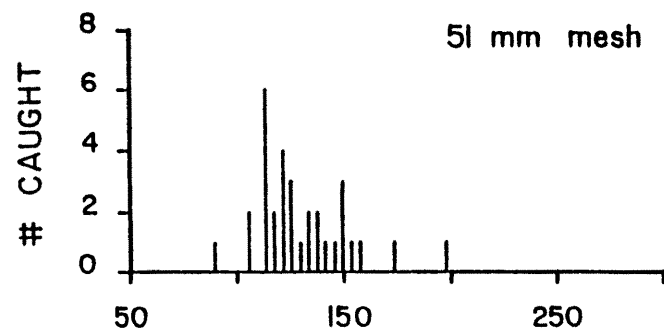
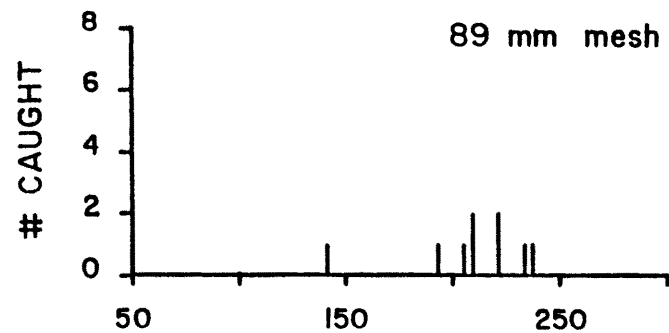
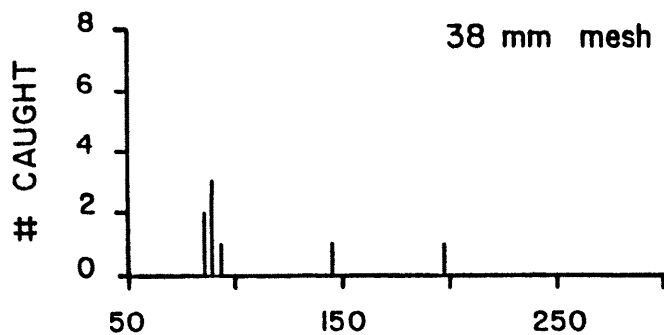
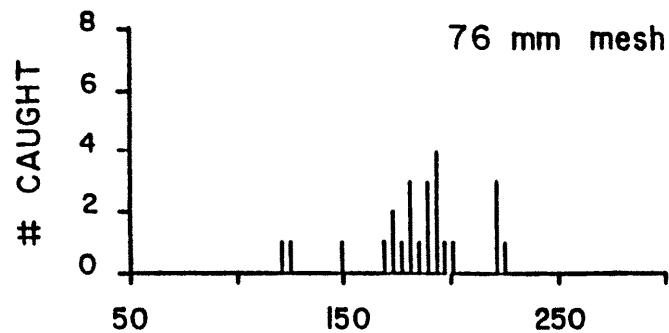
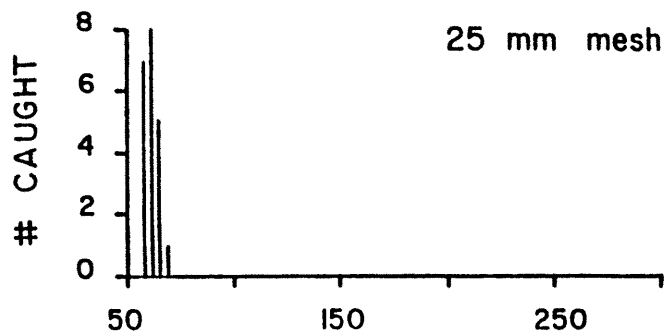
Appendix 1: Gill net selectivity for five species
of fish in L. Yure.

(See section 11.5 for further explanation)

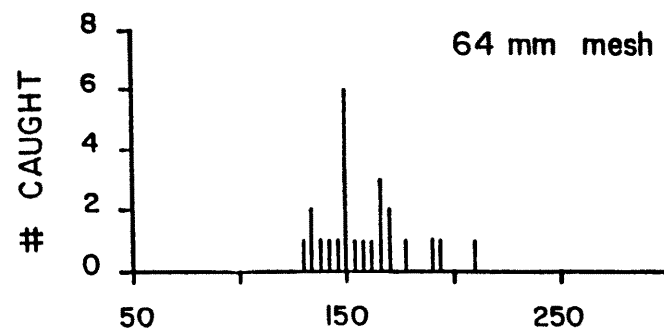
Astyanax



Cichlasoma motaguense

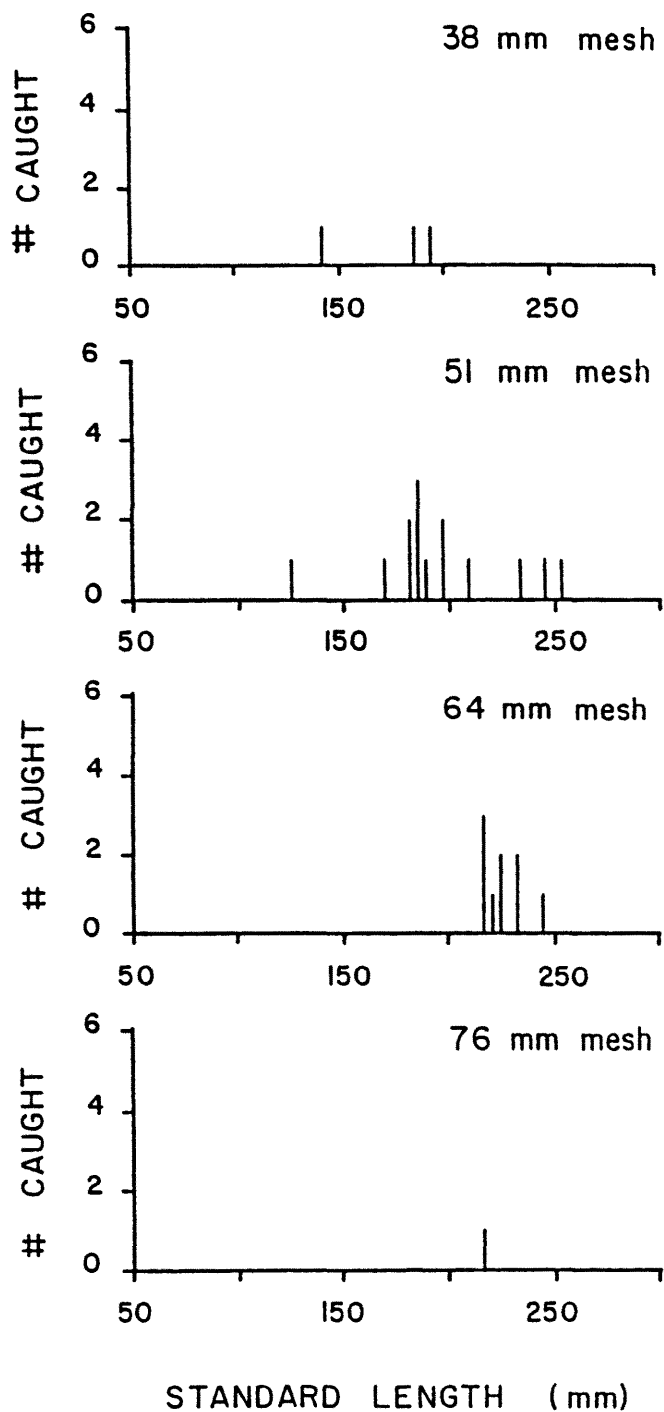


STANDARD LENGTH (mm)

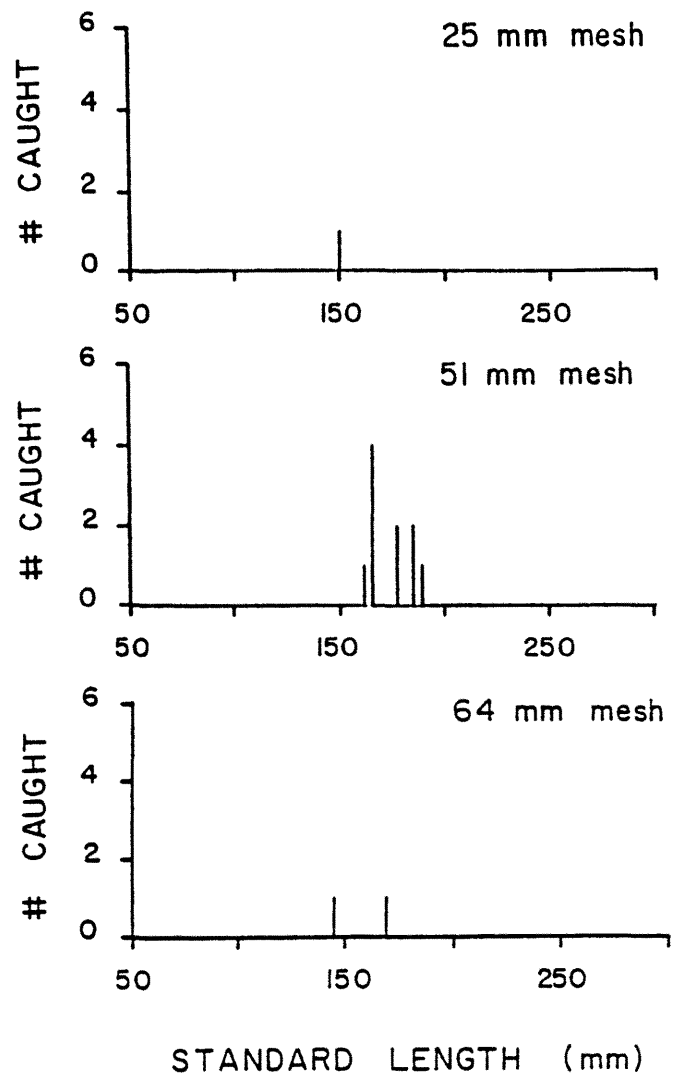


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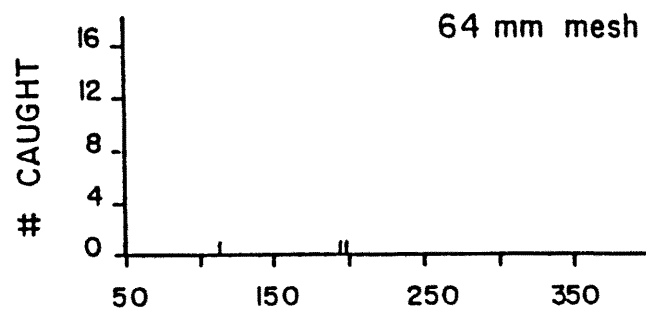
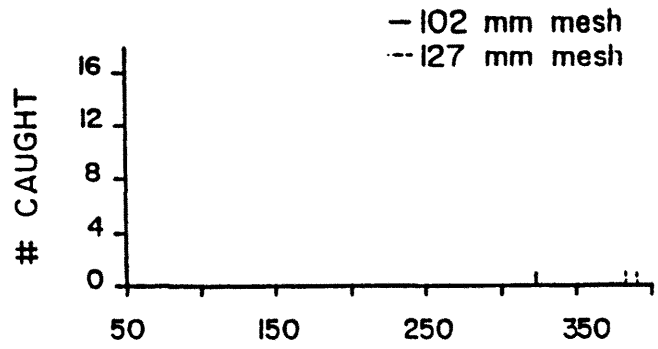
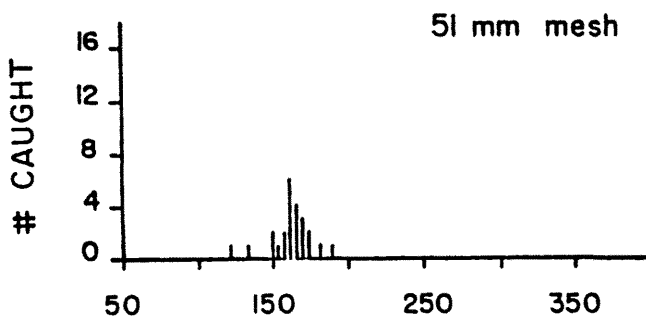
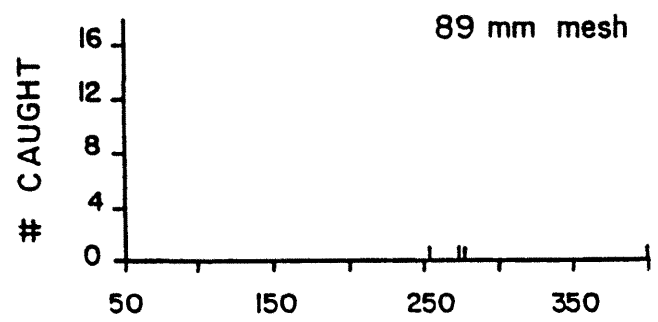
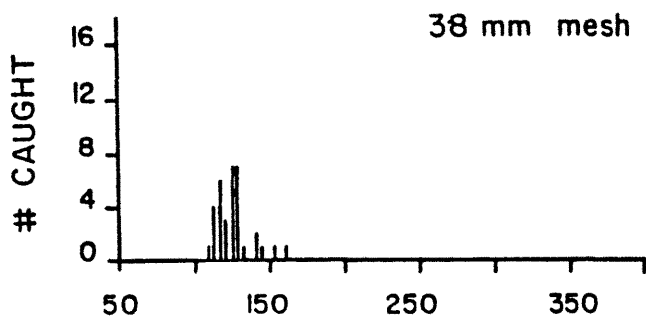
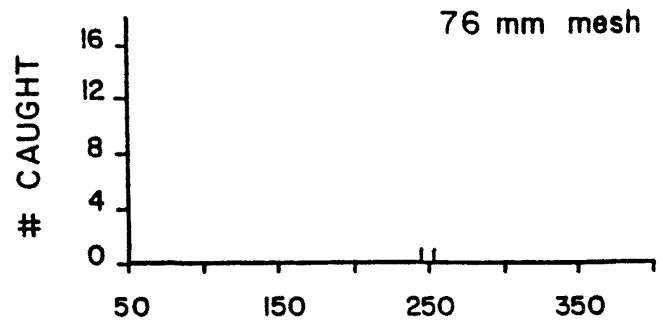
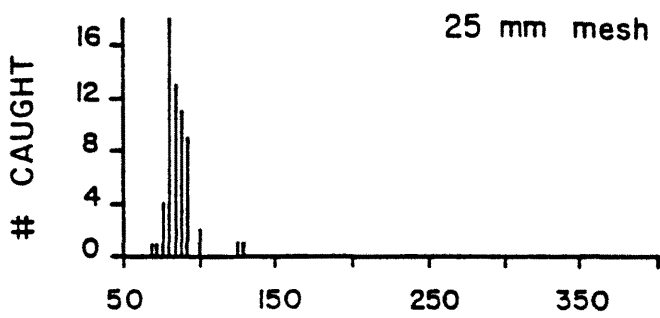
Rhamdia guatemalensis



Rhamdia cabrerae



Micropterus salmoides



STANDARD LENGTH (mm)

STANDARD LENGTH (mm)

Appendix 2: Summary of fish captures in L. Yure.

Gill nets

Date	3/IX/80	18/IX/80	(night) 30/IX/80	(day) 30/IX/80	(night) 1/X/80	(day) 1/X/80	2/X/80	(night) 7/X/80	(day) 7/X/80	8/X/80	10/X/80
<u>Species</u>											
CIM #	2	4	2	2		6	3	1	3	6	
Wt	16	35	360	20		60	267	12	27	118	
LR	60-61	58-68	159-197	59-61		61-67	58-193	78	63-64	58-104	
MIS #											
Wt											
LR											
ASF #						2	1		1		2
Wt						20	10		10		17
LR						66-69	64		85		63-66
RHC #			5	3	1		7				
Wt			430	299	98		833				
LR			161-178	165-185	176		175-207				
RHG #								1			2
Wt								105			104
LR								188			180
AGM #							1				
Wt							147				
LR							193				
# nets set	4	3	3	3	3	3	3	3	3	3	3
m ² nets	220	165	220	220	220	220	220	220	220	220	220

CIM: Cichlasoma motaguense

ASF: Astyanax fasciatus

RHG: Rhamdia guatemalensis

MIS: Micropterus salmoides

RHC: Rhamdia cabrerae

AGM: Agonostomus monticola

GYC: Gymnotus cylindricus

Gill nets

Date	13/X/80 ----->				16/X/80	17/X/80	5/XI/80	7/XI/80	11/XI/80	----->	12/XI/80	----->
<hr/>												
<u>Species</u>												
CIM	#	1					12	1		1		2
	Wt	30					364	10		550		240
	LR	105					60-196	64		258		65-195
MIS	#					1						
	Wt					375						
	LR					252						
ASF	#					1	42	1		1	2	
	Wt					62	398	10		9	18	
	LR					65	62-85	73		62	64-72	
RHC	#	1					2					
	Wt	70					134					
	LR	155					155-160					
RHG	#						1					
	Wt						42					
	LR						138					
AGM	#					1				2		
	Wt					260				1120		
	LR					240				294-303		
<hr/>												
# nets set	1	1	2	4	2	2	3	2	2	2	2	
m2 nets	61	55	165	281	165	116	171	116	165	165	116	
<hr/>												

Gill nets

Date	14/XI/80	----->	3/XII/80	----->	11/XII/80	12/XII/80	----->	18/XII/80	19/XII/80
<u>Species</u>									
CIM #	1	1	1	1	2	2			1
Wt	9	25	10	37	15	32			8
LR	56	95	59	88	56-61	61-88			60
MIS #									
Wt									
LR									
ASF #		2				1			
Wt		21				7			
LR		70-71				64			
RHC #				1	2				1
Wt				56	122				78
LR				149	147-163				163
RHG #									1
Wt									118
LR									193
AGH #						2			
Wt						578			
LR						202-273			
# nets set	2	2	3	1	4	1	3	4	4
m ² nets	165	116	220	61	281	61	220	281	281

Gill nets

Date	7/I/81	8/I/81	9/I/81	28/I/81	----->	3/III/81	4/III/81	19/III/81	20/III/81	21/III/81
<u>Species</u>										
CIM #	7	5	3	6		1	14	7	14	3
Wt	930	477	191	117		719	2014	681	1436	536
LR	58-260	62-196	91-176	57-127		257	64-201	59-241	56-223	143-217
MIS #				1						
Wt				995						
LR				324						
ASF #		1	6		2	1		6	1	
Wt		21	96		20	7		56	77	
LR		98	70-105		73-76	67		66-75	77	
RHC #		12	21		2	2	1	1	2	
Wt		1137	1606		111	139	70	74	136	
LR		148-172	154-192		146-171	157-161	162	166	148-170	
RHG #								1		1
Wt								41		320
LR								127		236
AGM #							2			
Wt							670			
LR							279			
# nets set	4	4	4	1	3	4	4	5	5	5
m ² nets	281	281	281	110	171	281	281	352	352	352

Gill nets

Date	22/V/81	9/VII/81	18/VIII/81	14/X/81	5/II/82	7/V/82	18/V/82	19/V/82	20/V/82	21/V/82
<u>Species</u>										
CIM #	29	51		4	1	10	5	3	8	9
Wt	2290	2614		280	139	1274	1087	393	444	705
LR	57-259	58-191		84-162	150	58-226	134-220	115-170	89-148	95-150
MIS #		1			3	3	4	1	3	
Wt		442			58	1925	2361	289	615	
LR		245			89-101	272-327	274-319	231	86-284	
ASF #				1	4	2	7	6	31	52
Wt				8	32	16	56	48	251	500
LR				66	61-77	68-69	60-72	63-74	60-74	58-109
RHC #		2		1						1
Wt		173		95						141
LR		162-172		175						191
RHG #		2		1	1		1		2	7
Wt		319		62	116		117		248	1299
LR		201-216		139	187		194		183-191	183-245
AGM #			1							3
Wt			900							1829
LR			310							262-308
# nets set	7	7	7	7	7	7	7	7	7	7
m2 nets	504	504	504	504	504	504	504	504	504	504

Gill nets

Date	23/VI/82	24/VI/82	25/VI/82	26/VI/82	13/VII/82	14/VII/82	----->	15/VII/82	16/VII/82
<u>Species</u>									
CIM #	3	5	9	14	2	1		6	14
Wt	756	1181	1296	2128	114	60		1280	2370
LR	172-205	124-225	106-197	114-225	114-115	119		106-233	115-228
MIS #	8	2	5	11	10			6	26
Wt	2273	132	152	456	1910			112	372
LR	77-306	125-163	80-91	82-175	79-275			81-117	57-119
ASF #	44	45	41	79	38	1		72	18
Wt	360	391	345	631	333	7		660	161
LR	62-74	62-75	60-91	61-78	63-79	70		63-93	67-72
RHC #									
Wt									
LR									
RHG #	3				1	2		5	3
Wt	480				132	247		859	449
LR	190-240				195	185-217		180-234	180-236
AGM #									
Wt									
LR									
# nets set	7	7	7	7	7	3	4	7	7
m ² nets	504	504	504	504	504	231	273	504	504

Gill nets

Date	31/VIII/82	----->	1/IX/82	2/IX/82	17/XI/82	18/XI/82	----->	19/XI/82
<u>Species</u>								
CIM	#	1	2	4	3	3	1	6
	Wt	426	563	1042	430	702	541	1618
	LR	223	172-222	149-205	114-169	135-192	238	122-235
MIS	#		8	6	6	16	2	5
	Wt		523	227	123	377	91	212
	LR		80-244	85-169	82-115	74-130	119-128	91-175
ASF	#		27	41	77	42	5	73
	Wt		221	431	790	406	53	733
	LR		64-79	60-99	65-99	64-78	64-84	65-98
RHC	#			1				
	Wt			145				
	LR			189				
RHG	#		1		1	3	1	1
	Wt		106		330	618	115	248
	LR		184		254	216-246	185	223
AGM	#							
	Wt							
	LR							
# nets set	1	2	4	7	7	7	3	7
m ² nets	97	189	218	504	504	504	181	504

Gill nets

Date		23/XI/82	24/XI/82	25/XI/82	26/XI/82
<u>Species</u>					
CIM	#	4	4	6	3
	Wt	521	1342	685	453
	LR	90-195	148-223	83-206	149-170
MIS	#	5	3	1	4
	Wt	1682	195	58	150
	LR	96-399	?	135	83-130
ASF	#	95	56	79	158
	Wt	1026	626	1065	3100
	LR	60-99	?	63-114	62-100
RHC	#				
	Wt				
	LR				
RHG	#	1	1		6
	Wt	208	133		961
	LR	232	193		142-185
AGM	#				
	Wt				
	LR				
# nets set		7	7	7	7
m ² nets		504	504	504	504

Electroshocker

Date	11/XI/80	12/II/81	18/III/81	15/XII/81	30/IX/82	25/XI/82	5/I/83
<u>Species</u>							
CIM #	2	57	114	23	12	20	47
Wt	17	1120	*2131	901	*261	*292	1913
LR	44-72	29-197	35-196	53-256	85-167	53-114	33-187
MIS #		4	7	9	75	17	83
Wt		65	*18	52	*470	*332	*1831
LR		46-114	24-60	45-80	30-108	29-133	22-149
ASF #	97	21	20	26	5		17
Wt	204	*49	*70	101	*67		*141
LR	35-54	38-50	33-54	46-63	69-90		26-83
RHG #				1	7	7	3
Wt				5	*266	*738	161
LR				67	85-167	97-241	81-195
GYC #				2			1
Wt				*18			24
LR				95-161			181
Gear	C/N	E/sh	E/sh	E/sh	E/sh	E/sh	E/sh

Appendix 3: Poeciliid and cichlid taxonomy

(These keys and distribution maps are reproduced from unpublished theses by Alpirez-Quesada, 1971, (Poeciliids) and Moya-Meño, 1979, (Cichlids), from the Universidad Nacional de Costa Rica. They are presented here because they may otherwise be unavailable in Honduras.)

Clave tentativa de las especies del complejo "Poecilia sphenops"

- 1a. Dientes internos tricúspides, en numerosas filas, muy juntos, formando una masa conspícua. Papilas labiales abundantes y evidentes a lo largo del borde interno del labio superior. Mancha negra (presente o no) en la base de la aleta caudal. Hueso preorbital no libre ventralmente.....
P. sphenops.
- 1b. Dientes cónicos o unicúspides, en pocas filas, separados, no formando una masa conspícua. Papilas labiales escasas, poco evidentes, a lo largo del borde interno del labio superior. Sin mancha negra en la base de la aleta caudal. Hueso preorbital libre ventralmente.....2.
- 2a. Poros preorbitales más cerca del borde anterior del orbital que de la boca, 26-28 escamas laterales, 16 o 18 escamas alrededor del pedúnculo caudal.....3.
- 3a. Usualmente 27 escamas laterales, 16 escamas alrededor del pedúnculo caudal, sistema de poros del supraorbital incompleto, poros: 2b, 3, 4a, 4b, 5, 6a, 6b, 7..... P. gillii
- 3b. Usualmente 28 escamas laterales, 18 escamas alrededor del pedúnculo caudal, sistema de poros del supraorbital completo, poros: 1, 2a, 2b, 3, 4a, 4b, 5, 6a, 6b, 7..... P. mexicana.
- 2b. Poros preorbitales cerca del medio entre el borde anterior del orbital y la boca, 28-30 escamas laterales (usualmente - 29), siempre 18 escamas alrededor del pedúnculo caudal....4.
- 4a. Sistema de poros del supraorbital completo, poros: 1, 2a, 2b, 3, 4a, 4b, 5, 6a, 6b, 7..... P. sp.
- 4b. Sistema de poros del supraorbital incompleto, poros: 2b, 3, 4a, 4b, 5, 6a, 6b, 7..... P. sp. (variante).

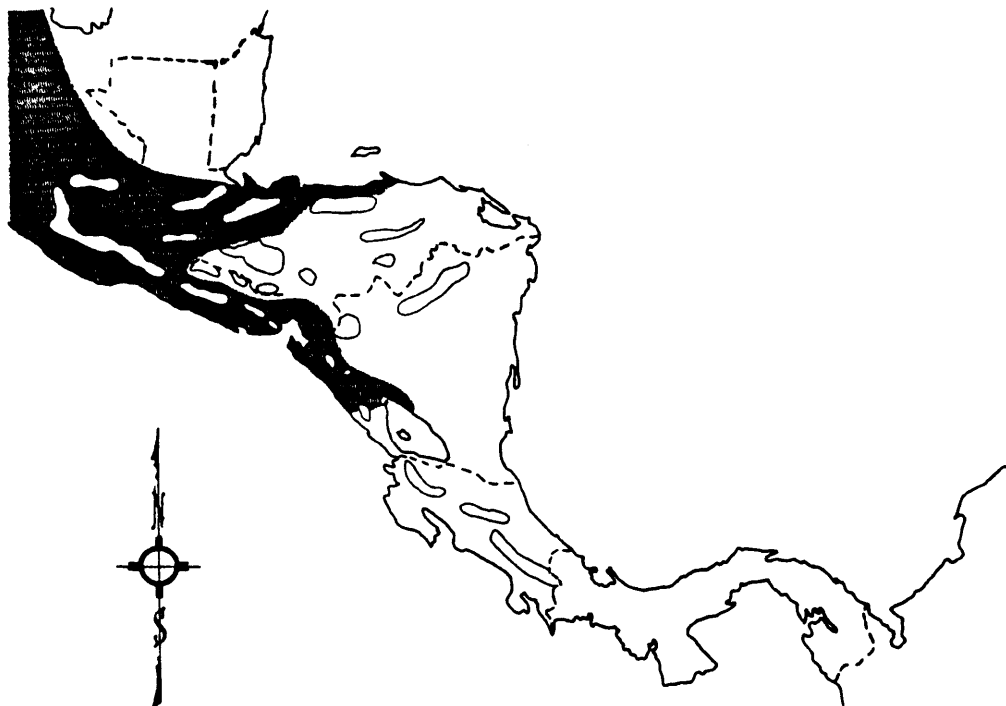


Fig. 22. Distribución geográfica, aproximada, de *Poecilia sphenops* en Centroamérica. Los espacios en blanco de forma alargada o redondeada representan altitudes mayores de 1,200 m.

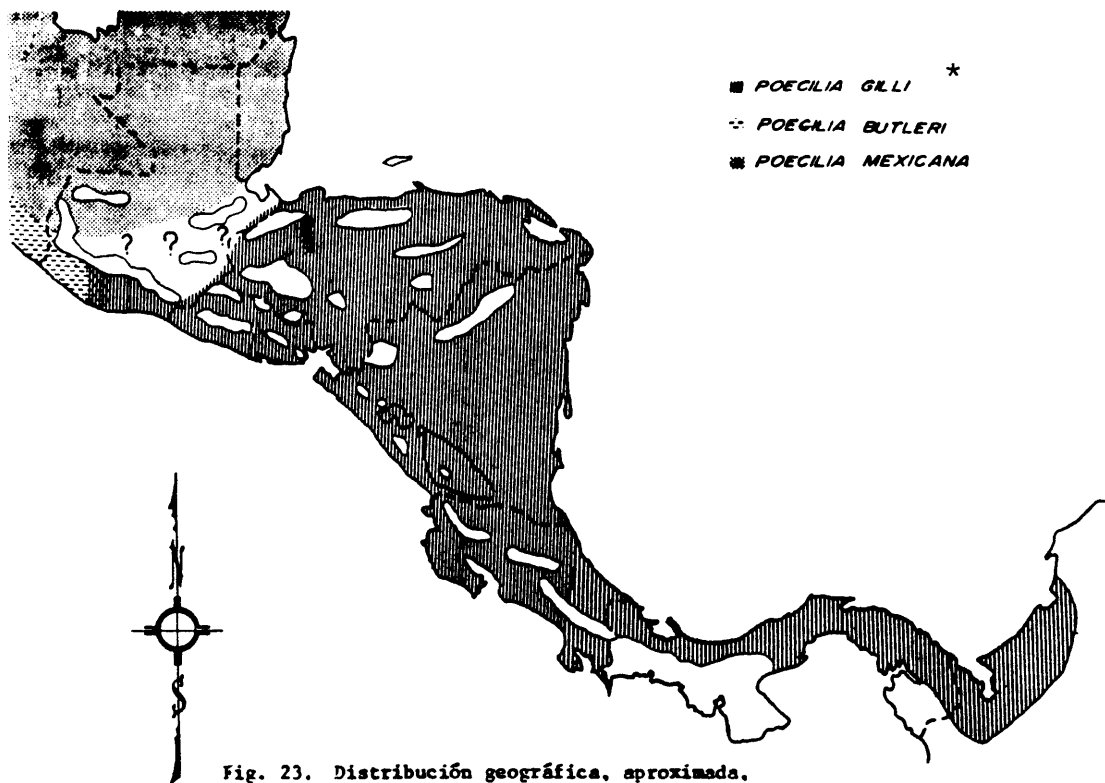


Fig. 23. Distribución geográfica, aproximada, de las especies: *Poecilia gilli*, *Poecilia butleri* / *Poecilia mexicana* en Centroamérica.

* See text for discussion of poeciliid distributions in Honduras.

3.3. CLAVE PARA LAS ESPECIES DE GUAPOTES DE AMERICA CENTRAL

- A. Borde superior del preopérculo con un lóbulo conspícuo en su ángulo inferior; 14 a 15 branquiespinas..... C. mansquense.
- AA. Borde posterior del preopérculo recto o con una hendidura en su ángulo inferior; 9 a 13 branquiespinas..... B.
- B. De 27 a 31 (\bar{X} = 29,3) escamas longitudinales; aletas pélvicas 1.0—1.3 (\bar{X} = 1,1) veces la longitud de la cabeza (>70 mm long. estan.). Máxima altura del cuerpo mayor que la longitud de la cabeza..... C. friedrichsthalii
- BB. De 30-34 (\bar{X} = 32,3) escamas longitudinales; aletas pélvicas 1.4—1,8 (\bar{X} = 1,6) veces en la longitud de la cabeza. Máxima altura del cuerpo menor que la longitud de la cabeza..C.
- C. Altura mínima del pedúnculo caudal 2,1 a 2,5 (\bar{X} = 2,3) veces en la longitud de la cabeza (>50 mm long. stand). De 21 a 23 (\bar{X} = 21,9) índice de conteo (suma del número de rad. dors. y poros de la línea lateral inferior). Banda lateral oscura en 6 a 7 secciones..... C. motaguense
- CC. Altura mínima del pedúnculo caudal 2,7 a 3,1 (\bar{X} = 2,8) veces en la longitud de la cabeza. De 23 a 28 (\bar{X} = 25,2) índice de conteo. Banda lateral oscura en 1 a 4 secciones..... C. davii.