VI.5. FISH FAUNA
VI.5a. Native species
The *Orestias*

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Apart from *Salmo gairdneri* Richardson, 1836, introduced in 1941–42 and *Basilichthys bonariensis* (Valenciennes, 1835), introduced in 1955–56 (Loubens, 1989; Loubens and Osorio, 1988), the fish fauna of Lake Titicaca also includes the genera *Trichomycterus* and *Orestias*, both endemic to the Andean Altiplano. The Trichomycteridae family is very widespread in South America, but little is known about the *Trichomycterus* living in the lake. It is likely that there are only two species: *T. rivulatus* and *T. dispar* (Hanek (ed.), 1982).

The genus *Orestias* Valenciennes, 1839 belongs to the Orestiini tribe, of the sub-family Orestinae, family Cyprinodontidae according to Parenti's (1981) classification. These peculiar fish, that have only a single gonad, are also distinguished from other cyprinodonts by the absence of ventral fins, vomer and first postcleithrum (Parenti, 1981).

Systematics (Figs 1 and 2)

Many publications have been devoted to the systematics of this remarkable genus since the early work of Valenciennes (1839). Only the major studies and revisions are mentioned here: Valenciennes *in* Cuvier and Valenciennes (1846); Garman (1895); Eigenmann and Allen (1942); Tchernavin (1944); Lauzanne (1982); Parenti (1984). Tchernavin (1944), working on the extensive collections from the 1937 Percy Sladen Expedition, recorded for the whole Andean Altiplano: 20 species, five subspecies, two hybrids and two new species (sp. 1 and sp. 2) which he did not name. As for Lake Titicaca itself, he mentioned 16 species, three subspecies, the two new species and one hybrid:

O. cuvieri Valenciennes, 1846
* *O. pentlandii* Valenciennes, 1846
O. agassii tschudii Castelnau, 1855
O. agassii pequeni Tchernavin, 1944

C. Dejoux and A. Iltis (eds.), Lake Titicaca, 405–419.

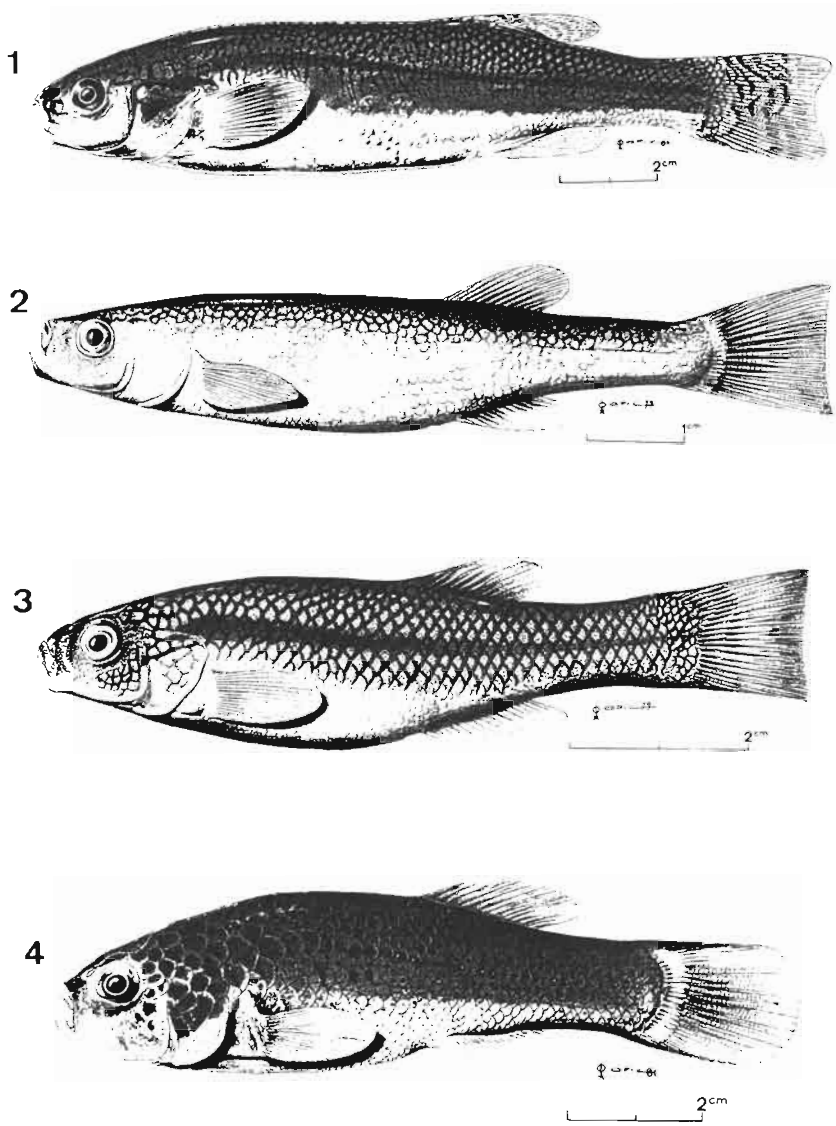

Figure 1. The principal *Orestias* of Lake Titicaca (1: *O. pentlandii*; 2: *O. ispi*; 3: *O. forgeti*; 4: *O. agassii*).

* *O. jussiei* Valenciennes, 1846
O. jussiei puni Tchernavin, 1944
* *O. olivaceus* Garman, 1895
* *O. luteus* Valenciennes, 1846
* *O. albus* Valenciennes, 1846
O. uruni Tchernavin, 1944

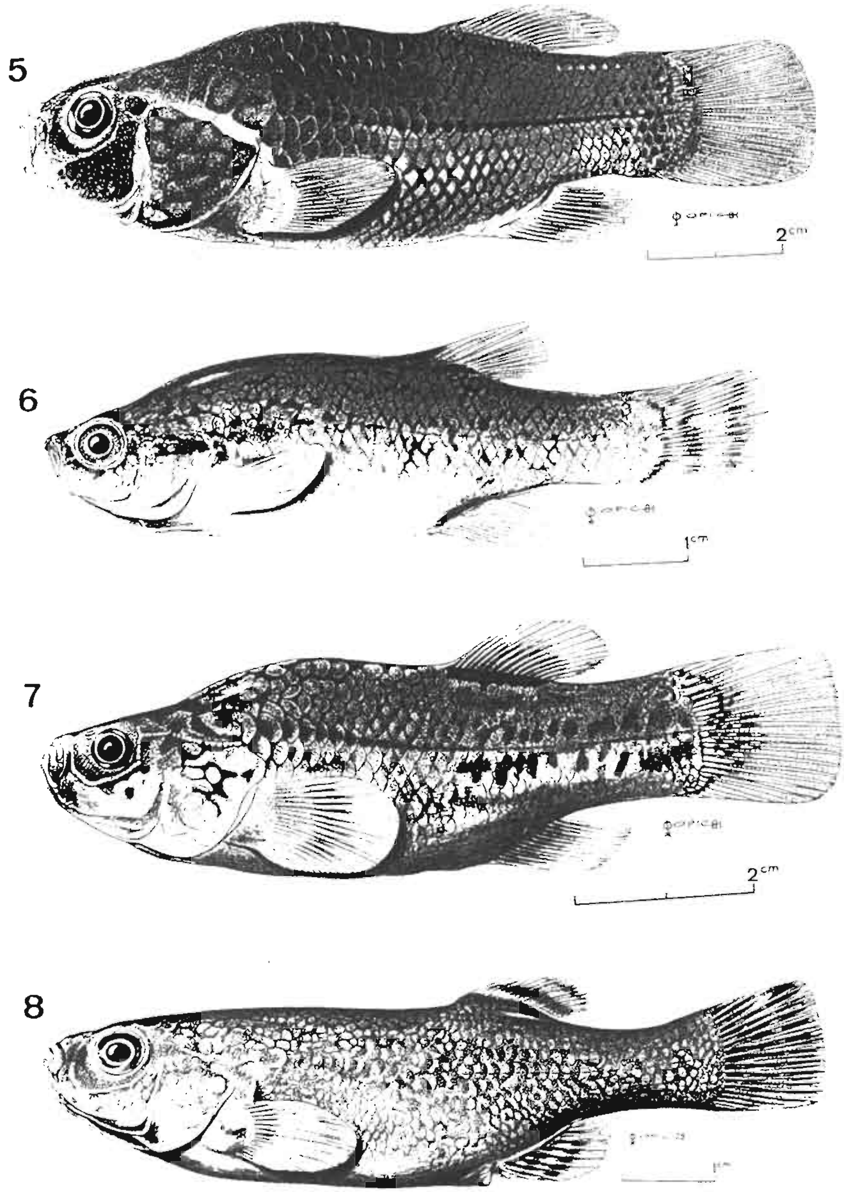

Figure 2. The principal Orestias of Lake Titicaca (5: *O. luteus*; 6: *O. olivaceus sensu* Lauzanne, 1982; 7: *O. albus* juvenile; 8: *O. mulleri*).

O. minutus Tchernavin, 1944
* *O. minimus* Tchernavin, 1944
* *O. gilsoni* Tchernavin, 1944
O. tutini Tchernavin, 1944
O. taquiri Tchernavin, 1944
* *O. mulleri* Valenciennes, 1846
O. incae Garman, 1895
* *O. crawfordi* Tchernavin, 1944
* *O. mooni* Tchernavin, 1944
O. sp. 1
O. sp. 2
O. cuvieri × *O. pentlandii*

From 1978 to 1981 numerous and plentiful collections of *Orestias* were taken from Lago Pequeño by ichthyologists from UMSA and ORSTOM. These collections allowed Lauzanne (1981) to describe three new species: *O. ispi*, *O. forgeti* and *O. tchernavini* (Tchernavin's sp. 1). The study of the numerous specimens collected and re-examination of previous collections led to a review of *Orestias* from the Lago Pequeño (Lauzanne, 1982). The species in Tchernavin's list marked with an asterisk were confirmed and redescribed, using numerous biometric and meristic characters taken from very large samples. The great phenotypic variability of the members of the genus *Orestias* must be stressed, and also that it is imperative to work on very large samples, including age ranges from young to adult, in order to delineate the limits of variation in the characters used to define the species. It was thus, while studying certain biometric and meristic characters used by Tchernavin to characterise the various subspecies of *Orestias agassii* (especially *O. agassii tschudii* Castenau, 1855 and *O. agassii pequeni* Tchernavin, 1944 from Lake Titicaca), that we arrived at the conclusion that they were phenotypic varieties that should be included in the species *O. agassii*. Nevertheless, we recognise the presence in Lake Titicaca of littoral, pelagic and benthic forms or populations. In the same way, we do not recognise the subspecies *O. jussiei puni*, Tchernavin, 1944, which we include with *O. jussiei* Valenciennes, 1846. We also think that *O. minutus* Tchernavin, 1944, known only from two specimens, is synonymous with *O. minimus* Tchernavin, 1944.

O. cuvieri Valenciennes, 1846, a large and very characteristic species, was not found by the ORSTOM-UMSA team, despite an intensive search. It would appear that the last captures were made by the Percy Sladen Expedition in 1937 (Loubens, 1989). Many authors have accused *Salmo gairdneri* for having brought about the disappearance of *O. cuvieri* (Vellard, 1963; Villwock, 1962 and 1975; Lillelund, 1975; Laba, 1979). Loubens (1989) claimed that this hypothesis could be neither confirmed nor disproved.

We have also not found the following of Tchernavin's (1944) species: *O. uruni*, *O. taquiri* and *O. tutini* nor *O. incae* of Garman (1895), known only from very few individuals. These are perhaps valid species, but a larger number of specimens is needed in order to study the variability of the quantitative and qualitative characters which would allow the validity of these taxa to be confirmed or denied.

From the works of Lauzanne (1981, 1982), the following species known to be present with certainty in Lake Titicaca can be added to the species marked with an asterisk in Tchernavin's (1944) list:

O. agassii Valenciennes, 1846
O. jussiei Valenciennes, 1846
O. ispi Lauzanne, 1981
O. forgeti Lauzanne, 1981
O. tchernavini Lauzanne, 1981

To this list should be added the species which were present in Lake Titicaca in 1937 (Percy Sladen Expedition), but which have not been found again by the ORSTOM-UMSA team (1978–1981):

O. cuvieri Valenciennes, 1846
O. uruni Tchernavin, 1944
O. taquiri Tchernavin, 1944
O. tutini Tchernavin, 1944
O. incae Garman, 1895

Orestias cuvieri is, as we have stated, probably extinct. The others, much smaller species have perhaps evaded capture by collectors.

In 1984, Parenti published a revision of all the *Orestias* from the Andean Altiplano, based on the existing type specimens and on a large collection brought together in 1979 by Tom Coon, but without referring to the work of Lauzanne (1982). She recognized 43 species, of which 14 were new, for the Altiplano. For Lake Titicaca, she listed 28 species of which six were new.

Among the 10 species from Lake Titicaca in the Tchernavin list (those marked with an asterisk), she did not recognize, justly, *O. jussiei* of Valenciennes, 1846. This is an error made by Tchernavin, as Valenciennes' specimens (A. 9599) came from the river Guasacona in Peru and not from Lake Titicaca. On the other hand, Parenti considered Tchernavin's subspecies *O. jussiei puni* as a full species, *O. puni* Tchernavin, 1944. We disagree with this proposal because Lauzanne (1982) has shown that these are just large specimens of *O. jussiei* Valenciennes, 1846.

Parenti recognized *O. luteus* Valenciennes, 1846 and created two new very closely related species, *O. rotundipinnis* Parenti, 1984 and *O. farfani* Parenti, 1984, on the basis of a few specimens. Loubens (1989), using convincing arguments, denied the validity of these two species, which are synonymous with *O. luteus* Valenciennes, 1846.

Parenti recognized *O. agassii* Valenciennes, 1846 and she reinstated *O. frontosus* Cope, 1876, on criteria of the shape of the snout and head and the colour, a taxon that Tchernavin had classified in the subspecies *O. agassii tschudii*. She included *O. agassii pequeni* Tchernavin, 1944 in with *O. frontosus*. She also reinstated *O. tschudii* Castelnau, 1855 which had been included under the subspecies *O. agassii tschudii* alongside *O. owenii* Günther, 1866, *O. ortoni* Cope, 1876, *O. agassizi* Garman, 1876, *O. agassizi* Starks, 1906 and *O. agassii* Rendahl, 1937. However, Lauzanne (1982) had shown, on the basis of metric and meristic characters, that all these species and subspecies of the *O. agassii* group were probably only phenotypic variations of the species *O. agassii* Valenciennes, 1846. Within this very polymorphic complex it seems unreasonable to erect numerous species, because at the extreme it would be possible to create as many species as there are specimens. If *O. agassii* is in reality an assembly of several species the proof could not be provided by analyses based only on morphological characters, but by using more detailed methods such as the examination of karyotypes, the study of the enzyme polymorphism or breeding experiments in aquaria. In the meantime, it seems advisable to only retain *O. agassii*, while acknowledging that it is extremely polymorphic.

Parenti also created *O. gracilis* (closely related to *O. mulleri* and *O. imarpe*) *O. robustus* and *O. tomcooni* (related to *O. gilsoni*) on samples of between 10 and 21 specimens. Not having seen this species we can neither confirm nor disprove the validity of the taxa.

She also recognized Tchernavin's *O. minimus* and *O. minutus*. As for *O. minutus*, Lauzanne (1982) considered that this is a synonym of *O. minimus*.

She considered Tchernavin's *O. tutini*, *O. taquiri* and *O. uruni* and also Garman's *O. incae* to be valid species. However, as with Lauzanne (1982), she did not collect these, so there is a possibility that these no longer exist.

Loubens (1989) studying the biology of *O. olivaceus* (*sensu* Lauzanne, 1982) correctly stated that the species that he was studying was not the *O. olivaceus* Garman, 1985 as presented by Parenti (1984). "*Plusieurs caractères métriques et méristiques (nombre de rayons à la dorsale, nombre d'écailles en série latérale, longueur et largeur de la tête, hauteur du pédicule caudal) ont des valeurs très différentes. Les écailles de la partie antérieure du corps sont épaisses pour Parenti, présentent des stries concentriques et de très fines granulations pour Lauzanne. Les figures (n° 22 chez Lauzanne, 44 chez Parenti) montrent des poissons d'aspect dissemblable. Enfin le principal caractère signalé par Parenti comme permettant de distinguer O. olivaceus de toutes les autres espèces d'Orestias n'existe pas chez O. olivaceus sensu Lauzanne. Il s'agit des orbites qui sont orientées dorsolatéralement de telle sorte que, en vue de dessus, ces deux orbites sont presque entièrement visibles. Il n'est donc pas possible qu'il s'agisse de la même espèce*". This error of identification (Lauzanne, 1982) results from the fact that we were unable to compare our specimens with Garman's type (MCZ: 3946), but only with the Tchernavin's very small individuals (BMNH: 1944–6–6: 456–467). We also stated: "*qu'un léger doute subsiste quant à l'identification de nos exemplaires*". Whatever the case, *O. olivaceus sensu* Lauzanne, 1982, which is very abundant in the

Lago Pequeño, is almost certainly a good species (close to *O. crawfordi*), which is at the moment unnamed.

Based on the above, we therefore propose the following list of *Orestias* spp. described from Lake Titicaca, grouped into four major complexes according to their phylogenetic affinities (Parenti, 1984). Some of them, marked with an asterisk, have not been found since the Percy Sladen Expedition of 1937:

O. cuvieri Complex
- * *O. cuvieri* Valenciennes, 1846
- *O. pentlandii* Valenciennes, 1846
- *O. ispi* Lauzanne, 1981
- *O. forgeti* Lauzanne, 1981

O. mulleri Complex
- *O. mulleri* Valenciennes, 1846
- *O. gracilis* Parenti, 1984
- *O. crawfordi* Tchernavin, 1944
- *O.* sp. (*O. olivaceus sensu* Lauzanne, 1982)
- * *O. tutini*, Tchernavin, 1944
- * *O. incae*, Garman, 1895

O. gilsoni Complex
- *O. gilsoni* Tchernavin, 1944
- * *O. taquiri* Tchernavin, 1944
- *O. mooni* Tchernavin, 1944
- * *O. uruni* Tchernavin, 1944
- *O. minimus* Tchernavin, 1944
- *O. tchernavini* Lauzanne, 1981
- *O. tomcooni* Parenti, 1984
- *O. imarpe* Parenti, 1984
- *O. robustus* Parenti, 1984

O. agassii Complex
- *O. agassii* Valenciennes, 1846
- *O. jussiei* Valenciennes, 1846
- *O. luteus* Valenciennes, 1846
- *O. albus* Valenciennes, 1846
- *O. olivaceus* Garman, 1895

Habitats and communities (Fig. 3)

The main data concerning the habitats of the fish communities come from the American/Peruvian work of the Puno laboratory, and the French/Bolivian work of the UMSA-ORSTOM group (Bustamante and Treviño, 1980; Franc *et al.*, 1979; Collot, 1980; Johannesson *et al.*, 1981; Hanek (ed.), 1982; Lauzanne, 1982; Treviño *et al.*, 1984; Loubens *et al.*, 1984, 1985, 1988; Vaux

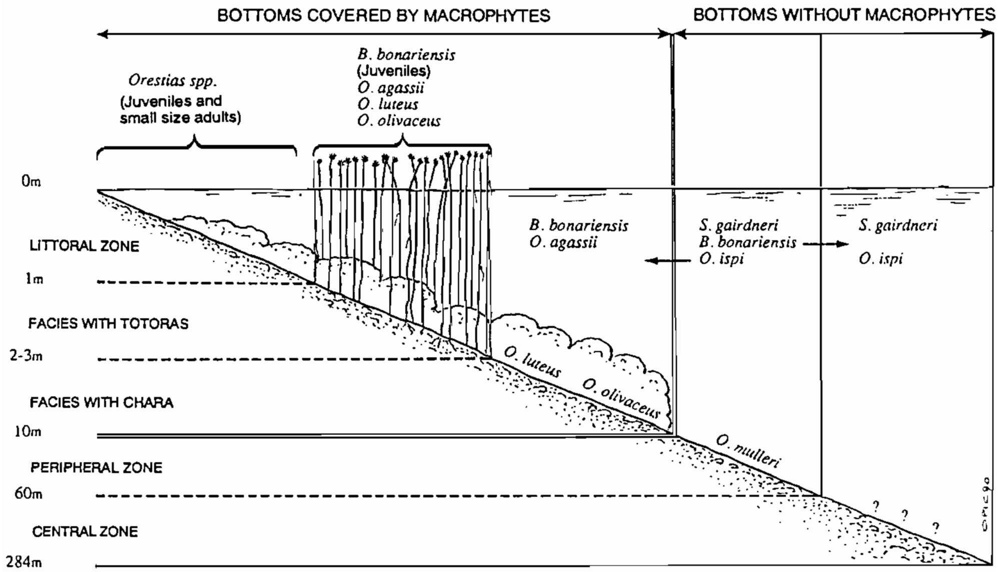

Figure 3. The different environments and their characteristic species.

et al., 1988; Loubens, 1989). For reasons of ecological consistency we also include *Salmo gairdneri* and *Basilichthys bonariensis*, the only true piscivores in the lake, in this description of communities.

The lower limit for macrophyte growth, at approximately 10 m depth, separates the lake into two very unequally sized zones: a zone with aquatic vegetation and a non- vegetated zone (about 80% of the total area).

The zone of bare sediments extends from 10 m down to the maximum depth (284 m).

We have some information on the pelagic communities in the most central part of the lake, but the demersal communities, if they exist, are unknown. Only two species are known for certain from pelagic zone, *S. gairdneri* and *O. ispi*, from catches made by local fishermen using surface gill nets. These nets only capture the trout, whose stomachs contain nothing else than *O. ispi*. This observation is corroborated by the results of an echo-location survey carried out in 1979 in the Peruvian part of the lake (Johannesson *et al.*, 1981). This survey revealed a large stock of fish at depths of between 20 and 50 m, which probably consisted of *O. ispi* (Loubens, 1989). It is also likely that *B. bonariensis* makes incursions into this zone.

The populations of the peripheral part of the bare sediment zone are better known, at least down to a depth of about 60 m. Near the bottom, the dominant species is *O. mulleri*, but the benthic form of *O. agassii* is also found (Loubens, 1989). The pelagic zone is much more familiar from commercial and experimental fisheries. The community is comprised of *S. gairdneri*, *B. bonariensis*, *O. agassii* and *O. ispi*, which are very abundant around

25 m depth (Vaux *et al.*, 1988). *O. pentlandii* is a much sought-after species that Bustamante and Treviño (1977, 1980) found in fair abundance in certain parts of Lago Grande (Pusi Bay, the mouth of the Río Ramis) and in the north-western part of Lago Pequeño.

The macrophyte zone extends from the shore, down to a depth of about 10 m. Three different biotopes can be distinguished, depending on the plant associations.

The Chara biotope

This habitat, which extends from a depth of 2 to 3 m down to 10 m, is characterised by the dominance of the genus *Chara* and by the occurrence of the genera *Potamogeton*, *Myriophyllum*, *Elodea*, *Nitella* and *Ruppia*. Its pelagic fish community is qualitatively similar to the preceding one. The demersal, or rather the perimacrophytic community (Loubens *et al.*, 1984) is typified by *O. agassii* and juveniles of *B. bonariensis*. Three other species are present in reasonable abundance: *O. luteus*, *O. olivaceus* (*sensu* Lauzanne, 1982) and *O. ispi*. The sporadic appearance of *O. ispi* is related to reproductive activity, as is the case with *O. pentlandii* in some areas (Bustamante and Treviño, (1980).

The "totora" biotope

This biotope occupies a zone extending from depth of 1 m down to 2–3 m. It is typified by the presence of a species of Cyperaceae, *Schoenoplectus tatora* ("totora"), rooted in the bottom and with a stem emerging to a height of more than a metre above the water surface. The other species of macrophyte are also present in this biotope, and sometimes occupy the entire water column, forming a very dense thicket. The community in this habitat is entirely perimacrophytic, and on the whole is similar to that of the *Chara* biotope.

The littoral biotope

This zone, extending from the "totora" belt and the shore, is a fringe with a very small area in relation to that of the lake, but where small fish, both young and adults, abound.

To this should be added the rocky littoral biotope, with a very steep gradient, which occurs especially in the Lago Grande, but information is lacking on the fish communities occurring there.

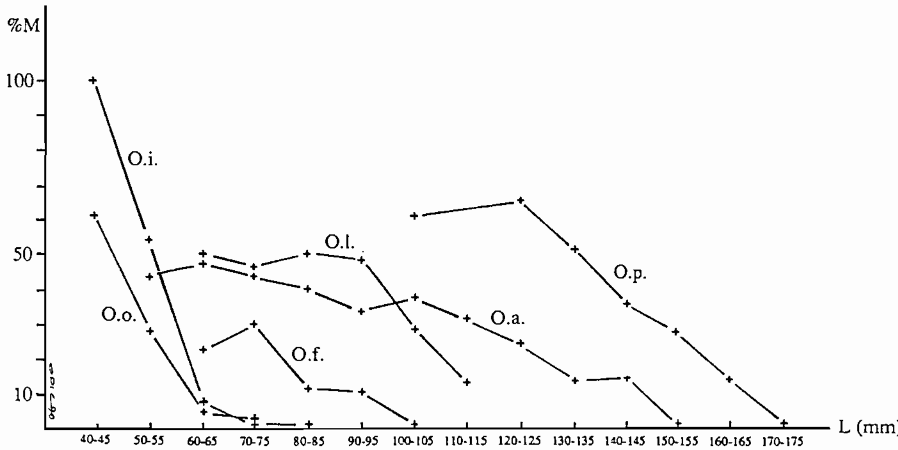

Figure 4. Changes in sex ratio in relation to length for some species of Orestias (O. o.: *O. olivaceus*; O. i.: *O. ispi*; O. f.: *O. forgeti*; O. l.: *O. luteus*; O. a.: *O. agassii*; O. p.: *O. pentlandii*). %M: Percentage of males. L: standard length. (from Loubens and Sarmiento, 1985 and Loubens, 1989).

Biological observations

Certain aspects of the biology of the *Orestias* are now fairly well-known from the work of Loubens and Sarmiento (1985), Loubens (1989) and Lauzanne and Loubens (in press). Other authors have helped to clear up particular points: (Zuniga, 1941; Treviño, 1974; Bustamante and Treviño, 1980; Leblond, 1983; Treviño *et al.*, 1984; Vaux *et al.*, 1988). The species studied are those with some importance for the commercial fisheries: *O. agassii*, *O. ispi*, *O. pentlandii*, *O. luteus*, *O. olivaceus* (*sensu* Lauzanne, 1982), *O. albus* and *O. forgeti*.

Sex ratio

For most species the same change is recorded in the percentage of males with increasing standard length (Fig. 4). Starting from a normal ratio (40–60%), the percentage of males decreases slowly or more sharply to reach very low values, or even zero in large adults. This phenomenon is usually explicable by the different growth rates in males and females. *O. ispi* would appear, however, to be a rather special case. In this species no females are found among the smallest individuals (40 to 45 mm length class), and the percentage of males falls very sharply to around zero in the 70 to 75 mm length class. It would appear to be a case of protandrous hermaphroditism, but this needs to be confirmed by histological examination of the gonads.

Length at sexual maturity (LSM)

The lengths at sexual maturity were estimated by Loubens and Sarmiento (1985) and Loubens (1989). The insufficient numbers of young individuals examined only allowed an upper limit to be given in five cases out of seven, rather than the precise length at sexual maturity:

O. albus	LSM $<$ 100 mm
O. forgeti	LSM $<$ 60 mm
O. ispi	LSM $<$ 55 mm
O. olivaceus	LSM $<$ 45 mm
O. pentlandii	LSM $<$ 125 mm
O. luteus males	LSM = 75 mm
O. luteus females	LSM = 82 mm
O. agassii males	LSM = 60 mm
O. agassii females	LSM = 60 mm

In all studies it has been noted that the LSM values are always much lower than the mean size of fish captured by commercial fishermen, which denotes a rather low exploitation rate.

Breeding season, fecundity, spawning

The changes in the percentage of females ready to spawn (F5) and having spawned (F6), compared to the total number of adult females in the samples for each bimonthly period are given in Table 1 (from Loubens and Sarmiento, 1985 and Loubens, 1989). Changes in the mean gonadosomatic index (GSI) of the females are also given. The percentage of F5 + F6 females is always very high throughout the year, as is the GSI value. This indicates that breeding takes place throughout the year, without major variations. According to Loubens, 1989, the sexual life of the adults is characterised by an uninterrupted succession of $3 \rightarrow 4 \rightarrow 5 \rightarrow 6$ cycles and a return to stages 3 or 4 from maturity till death, the cycles of individual fish not being synchronised.

All species of *Orestias* produce demersal eggs that are heavier than water, adhesive, transluscent and frequently yellow in colour. They vary in size at spawning between 1.3 and 2.3 mm, depending on the species. At each spawning a female lays between 50 and 400 eggs, again depending on the species, but as the number of spawnings per year is unknown, we have no idea of the total fecundity.

As far as spawning behaviour is concerned, Bustamante and Treviño (1980) give some details for *O. ispi* and *O. pentlandii*. These two species approach the shores during the night and lay their eggs on submerged plants. In the case of *O. ispi*, the spawning shoals remain a few hours on the spawning grounds and then disappear until the following night; this lasts for

Table 1. Breeding seasons for 7 species of *Orestias*. GSI: mean gonadosomatic index. %F5 + F6: percentage of ripe females and females just having spawned.

MONTHS		1 + 2	3 + 4	5 + 6	7 + 8	9 + 10	11 + 12
Orestias agassii	GSI	4.1	5.1	4.2	7.1	7.2	3.5
	% F5 + F6	64	65	64	76	65	44
Orestias albus	GSI	6.5		6.7		8.9	8.7
	% F5 + F6	100		80		80	64
Orestias forgeti	GSI	6.8	7.7	3.9		8.8	4.4
	% F5 + F6	65	73	43		92	30
Orestias ispi	GSI	8.6	11.0			11.8	10.4
	% F5 + F6	100	100			100	86
Orestias luteus	GSI	7.6	6.9	5.2	9.0	8.5	6.7
	% F5 + F6	71	71	50	79	83	67
Orestias olivaceus	GSI	7.6	6.4	6.0	7.1	6.9	5.6
	% F5 + F6	77	77	73	80	93	72
Orestias pentlandii	GSI	4.6	2.9	4.4	8.1	3.6	4.4
	% F5 + F6	77	67	56	80	41	76

up to 15 consecutive days. It is almost certain that the other species also spawn in the vegetation belt, given the nature of their eggs and the sites where mature adults have been captured.

Condition

Condition has been studied in three species: *O. agassii* (Loubens and Sarmiento, 1985), *O. luteus* and *O. olivaceus*, *sensu* Lauzanne, 1982 (Loubens, 1989). The condition factor ($K = 10^5 \times P/L^3$) was used in these studies. This factor does not vary with sex and usually remains stable throughout the year in a given region (Fig. 5). From these studies it would seem that this stability is due to the great stability of environmental factors and also to the reproductive strategy (successive spawning spread over the year with absence of synchronisation of individual cycles). A more detailed regional study did, however, reveal small variations in condition factor for any given species. The authors suggest that these variations could be of genetic origin, "Il y aurait, chez ces poissons peu mobiles, panmixie incomplète avec le début de différenciation des stocks géniques".

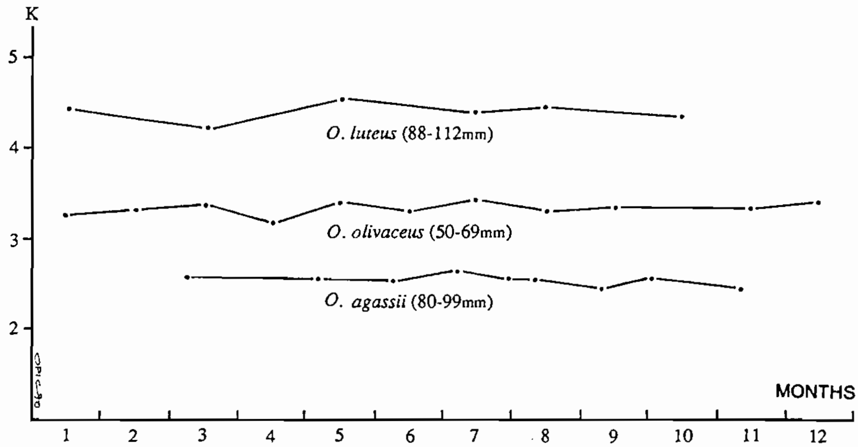

Figure 5. Monthly changes in condition factor ($K = 10^5 \times P/L^3$) in *O. luteus*, *O. olivaceus* and *O. agassii* in Lago Pequeño. (from Loubens and Sarmiento, 1985 and Loubens, 1989).

Diet

There has been no detailed study of the diet of *Orestias*, but numerous works partly deal with this aspect of their biology. We have largely drawn on Loubens (1989) in attempting to classify the various species according to their dietary affinities.

Pelagic species feeding on zooplankton

These are *O. pentlandii*, *O. ispi* and *O. forgeti*, which feed mainly on entomostracan zooplankton: Copepoda and Cladocera.

Perimacrophytic species

This group comprises *O. luteus*, *O. olivaceus* and *O. jussiei*. These species feed on plants and animals living on and around macrophytes: phytoperiphyton and zooperiphyton, insects, amphipods and molluscs. *O. luteus* and *O. olivaceus* seem to have a marked preference for molluscs.

Demersal species

O. mulleri and *O. crawfordi* feed on animals such as chironomid larvae, amphipods, ostracods, cladocerans and molluscs living on the bottom. *O. crawfordi* seems to consume only molluscs.

O. agassii an ubiquitous species

This fish, as noted before, is capable of colonising various habitats, its diet therefore covers a very wide spectrum, from algae and macrophytes to zooplankton, amphipods, ostracods, insects and insect larvae. Depending on the habitat in which it lives, one or other of these prey items may dominate.

O. albus, mainly piscivorous

This species mainly consumes small *Orestias*, but also a certain quantity of gastropods and lamellibranchs. *O. albus*, therefore seems to be the only piscivorous species of *Orestias*, since the disappearance of *O. cuvieri*.

It should be noted that some major food resources such as the phytoplankton, macrophytes, oligochaetes and organic detritus, are little or not at all exploited. In addition, the terminal piscivorous consumers are only represented among the *Orestias* spp. by *O. albus*, an uncommon species. The introduced species *S. gairdneri* and *B. bonariensis* make up the backbone of this group in Lake Titicaca. *S. gairdneri* feeds mostly on *O. ispi* and *B. bonariensis*, once it has reached a length of about twenty centimetres, eats mostly *O. agassii*, *O. olivaceus* and *O. ispi*.

Parasitism

The *Orestias* of Lake Titicaca are very often parasitised. The cranial cavity of several species (especially *O. olivaceus*) is invaded by a *Diplostomum* sp., but the most remarkable parasite is a platyhelminth (*Ligula intestinalis*, according to Hanek (ed.) 1982) which lives within the abdominal cavity of several *Orestias* spp. The parasite is especially abundant in *O. forgeti*, which led Loubens (1989) to study the host-parasite relationships in this species. About half of the fish are parasitised and the mean number of parasites per host is 2.73. The plerocercoids reach a length of 10 to 20 cm, or twice the length of the host. The maximum length recorded is 420 mm in a female measuring 87 mm. The mean ratio of the weight of the parasite to that of the host varies from 18% for the smaller fish to 42% for the largest. The maximum value recorded is 74.5%. This enormous additional burden hinders the swimming of the fish and leads to greater vulnerability to active fishing gear. In addition, parasitism leads to sterility, to the extent that sometimes

Plate 3. Above: fishing boats catching "pejerreys" with turning gillnets, in the Lake Huiñaimarca; Center: Gillnets catch. A young rainbow trout (above on the picture), 3 "pejerreys" (in the center), 1 *Trychomycterus* (down left) and different species of *Orestias* (down right); Down: Japanese aquaculture Station near the Tiquina strait. *Salmo gairdneri* (rainbow trout) is reared in floating cages. (Photos Claude Dejoux.)




the gonads are so atrophied that it is no longer possible to identify the sex. It is likely that the very pronounced parasitism which affects numerous species has an effect on the health of the *Orestias* populations.

Conclusion

Major progress has been made in our knowledge of the genus *Orestias* over the last decade. The systematics and phylogenetic relationships between the various species are increasingly better understood. The deep water zone in Lake Titicaca has been little surveyed, however, and it is possible that it harbours species not yet described. The biology of the species of direct of commercial value has been studied to varying degrees, but there are still important variables, such as the growth rate, that have not been studied. The relationships between *Orestias* spp. and the introduced predatory species are relatively well known and it does not seem that these latter represent a danger for the survival of *Orestias* populations in Lake Titicaca at the present time.

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