Life Cycle and Biological Parameters of Several Brazilian Amazon Fish Species

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Abstract

This contribution summarizes knowledge on the biology (population dynamics, reproduction, ecology) of 25 fish species from the Lower Amazon, Brazil, based on data from a Brazilian-German field project (IARA) and a review of the literature.

Introduction

Fish represent one of the most important resources of the Lower Amazon Region of Brazil. Fish also play an important role in the local diet as one of the primary sources of protein for the majority of the population. In addition, income derived from the export of fish products, both within and outside Brazil contributes significantly to the local economy. However, little data currently exist on important fishery resources.

In recent years, attempts have been made to improve data collection for the Amazonian fisheries, principally in the state of Pará. One of these is the IARA Project, funded as part of a program of technical cooperation between IBAMA (Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis) and GTZ (Gesellschaft für Technische Zusammenarbeit, Germany). The project is currently carrying out research to assess the fish stocks of the Lower Amazon and to develop appropriate management strategies for the fisheries.

This paper aims to offer a global view of the available knowledge on the most important fish species of the Lower Amazon based on our research and on available literature.

Materials and Methods

Data were collected daily in 1992 and 1993 from the fish markets of Santarém (02°25'11"S-54°43'16"W), at the confluence of Tapajós and Amazon rivers. The fish sampled had been caught by a number of methods: gillnet, harpoon, longline with baited hooks, trident, stick, line and hook baited, drift net, purse seine and beach seine, and arrows shot with or without bows.

Each fish was measured, to the nearest cm, from the tip of the snout to the tip of the longest caudal fin. The weights of the fish were measured on a balance with a precision of 10 and 50 g, according to the length of fish. Random samples were taken to examine the gonads. Maturity stages were classified according to Vazzoler (1981) in four groups: I-virgin or resting, II-maturing, III-mature and IV-spent.

Parameters a and b of length-weight relationships were estimated through logarithmic transformation, with a and b estimated by ordinary least-squares regressions.

Individual lengths were grouped into monthly length frequencies. A seasonal Bertalanffy model was used to fit growth curves to length data series, while length converted catch curves were used to estimate the total mortality (Z) (Pauly 1987; Gayanilo et al. 1995). The empirical equation of Pauly (1980) was used to estimate natural mortality (M), given a water temperature of 26°C.

Results and Discussion

Reproduction and Life History

Amazonia is characterized by innumerable rivers, streams and creeks, but true lakes, i.e., as semi-closed and permanent waterbodies, are rarely found. The large river forms enormous floodplains, because of water level fluctuations, whose amplitude can vary geographically between 5 and 20 m per year. When the water goes down, the floodplains become littered with oxbow lakes, lateral leveelakes, etc. in part isolated from the river and of which many dry out completely (Junk 1984). The fish fauna is strongly influenced by these ecological conditions, as dry periods force the fish to undertake more or less well developed migrations.

According to the reproductive strategies, Amazon fish can be divided into three large groups: seasonal, in equilibrium and opportunist (Winemiller 1989).

Most of the commercially important Amazon fishes belong to the seasonal group. They present a strong adaptation to the annual precipitation regimes, undertaking during the dry season (August-December) spawning, trophic and dispersal migrations. Therefore, fish abundance changes drastically according to the season. Spawning is synchronic, total and occurs in a restricted period, at the beginning of the flood season (December-February), generally in well oxygenated waters. A large proportion of these species are detritivorous, or feed on terrestrial food such as fruits,

Table 1. Life history and reproductive information of important fish of the Lower Amazon.

Scientific name	Common name	Spawning: Months	Spawning: Season	Spawning: Habitat	Spawning: Type	Spawning: Behavior	Migration	Fecundity	Age at first maturity (years)	Length at first maturity (TL; cm): Min	Length at first maturity (TL; cm): 50%	Strategy	Feeding	References
Arapaima gigas	Pirarucu	Nov-Dec	Late dry season	Lentic-bottom	partial	N,PC*	No	47,000	6	?	212	equilibrium	fish	Allsopp (1958); Lüling (1964); Lowe-McConnell (1975)
Astronotus crassipinis	Acará-açu	Dec-Jul	Flood season	On stones-lentic	?	T,N,PC	No	961-3,452	1	?	?	equilibrium	invertebrates	Fontenele (1951)
Auchenipterus nuchalis	Mandubé	Nov	Late dry season	Lotic	partial	IF	?	15,000	?	?	16	equilibrium	insects cladocers	Vazzoler et al. (1993)
Brachyplatystoma vaillantii	Piramutaba	?	Late dry season	Lotic (?)	total	No	Yes	?	?	40	?	seasonal	fish	Barthem et al. (1991)
Brycon melanopterus	Matcincha	?	Late dry season	Water fronts-lotic	total	No	Yes	?	?	?	22	seasonal	fruit	Junk (1985)
Cichla spp.	Tucunaré	Dec-Jul	Flood season	Wooden species-lentic	partial	N,PC	No	1,500-8,000	1	29	35	equilibrium	fish	Fontenele (1950)
Colossoma macropomum	Tambaqui	Dec-Mar	Early flood season	Lotic	total	No	Yes	1,000,000	4	50	56	seasonal	fruit, zooplankton	Junk (1985); Goulding and Carvalho (1982); Isaac et al. (in press)
Electrophorus electricus	Poraquê	Sep-Dec	Late dry season	Residual water pools	partial	N,PC	No	17,000	?	90	?	equilibrium	carnivore	Assunçao and Schuwassmann (1992)
Hoplias malabaricus	Traira	Nov	Late dry season	Lakes-Shallow waters	partial	N,PC	No	6,000-61,000	1	?	20	?	fish	Azevedo and Gomes (1943); Vazzoler and Menezes (1992)
Hypophthalmus marginatus	Mapara	Mar-May (?)	Flood season	?	?	No	Yes	?	?	27	45	?	plankton	Carvalho (1978); Junk (1985); Isaac et al. (in press)
Metynnis spp.	Pacu	Dec-Mar	Early flood season	Water fronts-lotic	total	No	Yes	?	?	?	?	seasonal	herbivore	Junk (1985)
Mylossoma spp.	Aruana	Dec-Jan	Early flood season	Lake-lentic	partial	PC	No	182-210	2	?	?	equilibrium	omnivore	Lowe-McConnell (1964); Goulding (1980)
Osteoglossum bicirrhosum	Pescada	whole year	-	Lake-lentic	partial	No	No	800?	1	?	18-20	opportunistic	fish, insects crustaceans	Worthmann (1982)
Plagioscion spp.	Branquinha	Dec-Mar	Early flood season	Water fronts-lotic	total	No	Yes	?	?	?	?	seasonal	detritus, periphyton	Junk (1985)
Potamorhina latior	Curimata	Dec-Mar	Early flood season	Water fronts	total	No	Yes	300,000	1,5	25	35	seasonal	detritus	Schuwassmann (1978); Junk 1985; Isaac et al. (in press)
Prochilodus nigricans	Surubim lenha	?	Early flood season	?	total	No	Yes	?	?	?	?	seasonal	fish	Reid (1983)
Pseudoplatystoma fasciatum	Surubim tigre	?	Early flood season	?	total	No	Yes	?	?	52	?	seasonal	fish	Reid (1983); Isaac et al. (in press)
Pseudoplatystoma tigrinum	Aracu	Nov-Jan	Early flood season	Water fronts-lotic	total	No	Yes	high	?	14	30	seasonal	herbivore	Santos (1982); Isaac et al. (in press)
Schizodon fasciatus	Jaraqui	Dec-Mar	Early flood season	Water fronts	total	No	Yes	?	?	?	24-26	seasonal	detritus	Vazzoler et al. (1989); Ribeiro and Petrere (1990)
Semaprochilodus spp.	Piranha	?	Flood season	Root of aquatic plants	?	N,PC	No	?	?	?	?	equilibrium	omnivore	Bruker (1963); Myers (1972)
Serrasalmus spp.	Sardinha	Dec-Mar	Early flood season	Water fronts	total	No	Yes	?	?	?	?	seasonal	omnivore	Sazima and Zamprogno(1985) Junk (1985)
Triportheus elongatus														

*N = nest building; PC = parental care; T = territorial behavior; IF = Internal fertilization

Table 2. Length-weight relationships of 32 species of fish occurring in the Brazilian Amazon with column headings as defined in the text.

Family/Species	Common name	a	b	N	r	Range (TL; cm) L_{max}	Range (TL; cm) L_{min}
Arapaimidae							
Arapaima gigas	Pirarucu	0.0278	2.7905	76	0.965	224	109
Osteoglossidae							
Osteoglossum bicirhosum	Aruana	0.0021	3.2713	591	0.956	74	37
Clupeidae							
Pellona castelnaeana	Apapá amarelo	0.0042	3.2146	1 116	0.979	75	25
Pellona flavipinnis	Apapá branco	0.0084	3.0129	1 150	0.976	62	22
Prochilodontidae							
Prochilodus nigricans	Curimata	0.0095	3.1785	1 144	0.953	42	21
Semaprochilodus taeniurus	Jaraqui fina	0.0018	3.6027	458	0.943	30	21
Semaprochilodus insignis	Jaraqui grossa	0.0102	3.1008	764	0.959	32	17
Anostomidae							
Schizodon fasciatus	Aracu	0.0251	2.7934	1 910	0.944	40	16
Leporinus friderici	Aracu cabeça gorda	0.0277	2.8245	433	0.960	39	21
Erythrinidae							
Hoplias malabaricus	Traira	0.0128	2.9874	308	0.962	50	23
Serrasalmidae							
Colossoma macropomum	Tambaqui	0.0279	2.9244	1 191	0.994	104	9
Piaractus brachypomus	Pirapitinga	0.0247	2.9766	1 073	0.986	80	15
Pygocentrus nattereri	Piranha caju	0.0194	3.1342	376	0.959	25	11
Mylossoma aureum	Pacu manteiga	0.1450	2.3624	181	0.840	21	14
Mylossoma duriventrii	Pacu manteiga	0.0403	2.8725	701	0.964	30	11
Characidae							
Brycon cephalus	Matrincha	0.0075	3.1956	567	0.990	56	25
Callichthyidae							
Hoplosterum littorale	Tamoatá	0.0112	3.2142	245	0.934	22	14
Loricariidae							
Liposarcus pardalis	Acarí-bodó	0.2552	2.0813	1 852	0.823	48	22
Hypophthalmidae							
Hypophythalmus edentatus	Mapará	0.0093	2.8973	402	0.928	55	25
Hypophythalmus marginatus	Mapará	0.0020	3.2661	1 890	0.915	56	26
Pimelodidae							
Brachyplatystoma flavicans	Dourada	0.0049	3.1012	2 741	0.972	167	32
Brachyplatystoma filamentosum	Filhote/Piraíba	0.0078	3.0347	1 076	0.983	193	32
Brachyplatystoma vaillanti	Piramutaba	0.0039	3.1963	322	0.942	93	31
Pseudoplatystoma fasciatum	Surubim lenha	0.0065	3.0334	698	0.968	120	43
Pseudoplatystoma tigrinum	Surubim tigre	0.0026	3.2535	1 160	0.984	130	42
Pimelodina flavipinnis	Fura-calça	0.0031	3.2751	858	0.032	44	17
Goslinia platynema	Barbado	0.0074	2.9543	357	0.938	110	50
Sciaenidae							
Plagioscion squamosissimus	Pescada	0.0073	3.1472	500	0.986	68	11
Pachypops furchraeus	Corvina	0.0425	2.5964	154	0.977	23	3
Cichlidae							
Astronotus crassipinis	Acará-açu	0.0285	2.9118	163	0.906	22	14
Cichla monoculus	Tucunaré	0.0085	3.1563	1027	0.979	69	20
Geophagus proximus	Acaratinga	0.0225	2.9478	231	0.855	27	12

leaves or insects. They have high fecundity, small eggs and do not exhibit parental care. Representative of these groups are characins, *Colossoma macropomum* (tambaqui), *Prochilodus nigricans* (curimata) or *Semaprochilodus* spp. (jaraquis) and the catfishes, *Brachyplatystoma vaillantii* (piramutaba) and *Brachyplatystoma flavicans* (dourada).

In equilibrium fish are mostly sedentary and exhibit territorial behavior, while their density does not change much during the year. They are usually omnivores or piscivores, feeding on items whose availability is relatively constant. The spawning season is protracted and does not necessarily occur at the beginning of the flood. Their individual fecundity is low, their eggs are large. Usually they present mating or courting behavior, build nests, and care for their brood, which increases the survival of their young. Species belonging to this group are the Cichlidae, *Cichla* spp. (tucunarés) or *Astronotus crassipinis* (acará-açu) and the Arapaimidae, *Arapaima gigas* (pirarucu), one of the largest freshwater fishes.

Opportunist fish are usually small in size, r-strategist species, with short life span and nonmigratory behavior. In a relatively short time they reach the first maturity. They usually exhibit batch spawning over the year and do not show any parental behavior. Juveniles colonize new habitats rapidly, even in unfavorable environmental conditions and under high predation pressure. Example of these species are the Sciaenidae, *Plagioscion* spp. (pescadas) and the Serrasalmidae of the genus *Serrasalmus* and *Pygocentrus* (piranhas).

Table 1 contains available information on the reproductive biology of important fish species of the Lower Amazon.

Length-Weight Relationships

Table 2 gives for each species the a and b values, the number of fish available in the study (N), the correlation coefficient for the log-transformed length-weight data pairs (r), and the length of the smallest (L_{min}) and largest (L_{max}) fish measured.

Growth and Mortality

Table 3 gives the results for the von Bertalanffy growth parameters and the total mortality (Z) of several Brazilian Amazon fish species. Seasonal oscillations of growth occurred in all species, with lower growth rates during the dry season, when food availability is low.

The values of K and L_∞ of *P. tigrinum* and *P. fasciatum* estimated by Payne (1987) were 0.12 and 0.15 year^{-1}, and 142 and 119 cm, respectively, lower than those obtained in the present study. The estimates of K and L_∞ for tambaqui (*Colossoma macropomum*) were very close to those obtained by Petrere (1983), K = 0.243 year^{-1} and L_∞ = 107 cm, but higher than those found by Payne (1987), K = 0.18 year^{-1} and L_∞ = 96 cm. The range of values estimated by Payne and Harvey (1989) for *Prochilodus platensis* were K (0.3 to 0.42 year^{-1}) and L_∞ (56.1 to 61.5 cm). Petrere et al. (1991) reviewed the growth parameters of three species of genus *Prochilodus* and found values of K and L_∞, ranging between 0.28 and 0.61 year^{-1} and 48 and 64 cm, respectively. Valderrama Barco and Petrere (1994) found K = 0.378 year^{-1} and L_∞ = 60 cm for *Prochilodus magdalenae* of the Magdalena River, Colombia.

Growth parameters of catfish dourada (*Brachyplatystoma flavicans*) and aracu (*Schyzodon fasciatus*) were not found in the literature. Little is known about the life cycle of dourada. This species probably undertakes upriver migration in the Amazon channel and is a top predator (Goulding 1979). Some records of mature individuals were obtained during the flooding season by Barthem et al. (1991). Some research on the feeding and reproductive biology of aracu (*Schyzodon fasciatus*) were presented by Santos (1980, 1982).

Further Research Needs

According to Roberts (1972), 1,300 species were recorded from the Amazon, and Goulding (1980) states that about an equal number still

Table 3. Growth and mortality parameters of the Lower Amazon.

Species	Common name	Year	K (year^{-1})	L (TL; cm)	C	WP	M (year^{-1})	Z (year^{-1})
Prochiladus nigricans	Curimata	1992	0.50	68	1.00	Jul	0.87	4.57
		1993	0.45	58	0.50	Jun	0.85	4.42
Colossoma macropomum	Tambaqui	1992	0.23	121	0.51	Jul	0.45	1.40
		1993	0.23	118	0.50	Jul	0.44	1.37
Schyzodon fasciatus	Aracu	1993	0.52	58	0.50	Dec	0.93	3.14
Cichla monoculus	Tucunaré	1992	0.36	71	0.30	Aug	0.69	2.13
Pseudoplatystoma tigrinum	Surubim tigre	1992	0.26	181	0.40	Sep	0.43	2.19
		1993	0.30	184	0.20	Sep	0.47	1.98
Pseudoplatystoma fasciatum	Surubim	1992	0.33	178	0.50	Jul	0.51	2.40
	lenha	1993	0.27	169	0.47	Sep	0.45	1.90
Brachyplatystoma flavicans	Dourada	1992	0.22	161	0.68	Aug	0.40	0.87
		1993	0.20	168	0.38	Aug	0.38	1.22
Hypophthalmus marginatus	Mapará	1992	0.38	69	0.55	Feb	0.73	2.21
		1993	0.38	70	0.30	Mar	0.72	2.68

needs to be identified. Studies on the ecology and biology of Amazon fish species have been conducted since the 1970s, and some papers present global reviews, particularly referring to characin species (for example: Goulding 1983; Junk 1984; Lowe-McConnell 1987; Pauly 1995). Nevertheless, much taxonomic and basic biological research of life history and fish movements is still needed (Lowe-McConnell 1994).

Also, more fishery data and stock assessment are needed, considering that fishery effort has intensified significantly in the last decades and the first signals of overexploitation are occurring (Bayley and Petrere 1989; Goulding 1980, 1981). Good catch-effort statistics are essential to correct overfishing (Lowe-McConnell 1994).

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