Are Biological Species and Higher-Ranking Categories Real? Fish Folk Taxonomy on Brazil's Atlantic Forest Coast and in the Amazon

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CA+ Online-Only Material: Supplements A–F

Analysis of Brazilian fishers' classifications of 24 marine (Atlantic coast) and 24 freshwater (Amazon) fish species reveals that fishers from the Atlantic coast identify fish mainly through generic names (primary lexemes), while riverine Amazonian fishers typically identify them through binomials. The similarity of Amazonian fish species seems to contribute to the detailed folk taxonomy used by riverine fishers. High-ranking groups called "relatives" or "cousins" are sorted by fishers in terms of similarities of habitat, diet, and morphology and, secondarily, behavior. The general correspondence between the folk and scientific taxonomies reinforces the reality of both the supracategories used by these fishers and the biological groups as discontinuities in nature. Given the urgency of biological inventories and the lack of knowledge of high-biodiversity environments such as the Atlantic Forest and the Amazon, these results suggest that fisher knowledge and experience could contribute to scientific research.

The reality of species has been the subject of debate since the early days of evolutionary biology. Darwin defined species as varieties that are well demarcated and defined and actually exist at a certain point in time, but his analysis left open the possibility that species might be arbitrary constructions of the human mind (Darwin 1859*a* [1982], 1859*b*; Coyne and Orr 2004). The term "species" is vague because it includes both the species category and the *taxon*, its practical application (Bock 2004). Coyne and Orr (2004) offer the following arguments for the reality of species:

1. Species are real because they are recognized as real by everyone, even across cultures.

2. Species are real because there is concordance between folk and scientific species. This argument is based on ethnobiological studies that have identified species and compared them with the Linnean, or biological, species (Berlin 1992; Medin and Atran 1999; Diamond and Bishop 1999; Begossi and Garavello 1990; Marques 1991; Begossi and Figueiredo 1995; Paz and Begossi 1996; Hunn 1999; Seixas and Begossi 2001).

3. Considering that folk taxonomy may be a form of cluster analysis, a way of grouping organisms on the basis of the similarity of particular characteristics or variables, we could not statistically discriminate or identify groups if they did not exist.

Ethnobiological studies have identified five hierarchical categories for the classification of organisms in different cultures: unique beginner, life form, generic, specific, and varietal (Berlin 1973; see CA+ online supplement A). The generic category has been observed to be the most common in folk systematics. Life forms vary in scale and uses, from intermediate (families/ethnofamilies) to supracategorical (orders, classes), and they are probably among the least-understood categories of ethnobiological nomenclature (see Brown 1984). This may be because of the variety of life forms in both qualitative and quantitative terms, since cultures differ in the number of life forms they describe. As societies move toward urbanization and large-scale organization, they lose their intimate contact with nature, and the number of life-form designations tends to increase. Cultures that rely directly on natural resources, in contrast, tend to have a detailed knowledge of organisms and, as a result, emphasize generic/specific terms. These observations have been supported by comparing animal life forms in 144 languages. Languages with few biological life forms are usually spoken by people living in small-scale societies whose detailed knowledge identifies hundreds of separate plant and animal species (Brown 1984).

Folk taxonomy and folk systematics also reflect the availability of animals in the environment. For example, bird and fish life forms are the most salient animal concepts in American English, Arabic, and Spanish, while languages spoken in the highlands of New Guinea lack the "fish" life form, examples of which are either absent or rare in the local environment (Brown 1984). Therefore, the fish life form seems to constitute a salient discontinuity in nature, as is found in many languages. Clusters of fish may be intermediate categories, sometimes called "families" (Paz and Begossi 1996). Such intermediate groups, between life forms and generic ranks, are seen as covert taxa (Berlin 1992). Analyses of the universal markings of life forms suggest that binary opposition, criteria clustering, dimension salience, and utilitarian concerns influence the classification by name (Brown 1984).

We have been conducting studies on the ethnoichthyology

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of Brazilian fishers for more than ten years (Begossi and Garavello 1990; Begossi and Figueiredo 1995; Paz and Begossi 1996; Seixas and Begossi 2001). These and other studies have revealed aspects of the folk taxonomy (nomenclature) and ethnoecology (habitat, diet, and migration) of marine and freshwater fishes (Silvano et al. 2001; Mourão and Nordi 2002; Silvano and Begossi 2002, 2005; Ramires de Souza and Barrella 2004; Silvano 2004; Cabalzar, Lima, and Lopes 2005; Clauzet, Ramires, and Barrella 2005). In this study, we examine fish nomenclature and attempt to understand the criteria for clustering (grouping) by artisanal fishers from the coast of the Atlantic Forest of Brazil and from the Negro River, Amazon.

Fishers are an interesting subject for ethnotaxonomical studies because their day-to-day extractive activities are a way of acquiring very detailed knowledge of fish biology and ecology, in addition to a particular way of grouping these organisms. Comparing the ethnotaxonomy of fish in two culturally similar groups might therefore be helpful in understanding the process of folk classification. The *caiçaras* of the Atlantic Forest coast and the *caboclos* of the Amazon (for the latter, see Morán 1974) are rural inhabitants of Brazil, descended mostly from Portuguese colonizers and native peoples, who live in aquatic environments and depend on marine species of the coast (for the *caiçaras*) or riverine fish (for the *caboclos*). *Caiçaras* and *caboclos* are also similarin engaging in small-scale agriculture (manioc) as well as artisanal fishing, but they live far apart (CA+ online supplement B) and differ in their aquatic environments (coastal and riverine, respectively) and their local histories (for details, see Begossi 1998; Begossi et al. 2004). In other studies (Begossi and Garavello 1990; Begossi and Figueiredo 1995), morphological and ecological variables such as habitat and fish diet were found to be important in the folk nomenclature of the fish studied. Our objective was to discover what groupings were formed by artisanal fishers and what criteria influenced these groupings. In this study, we were particularly interested in the criteria used by fishers to classify intermediate ranks or categories included in the fish life form and in the group of organisms clumped together as "fish" by the biological, scientific, or Linnean nomenclature. Using cluster analysis, we tested the hypotheses that morphology and ecology, represented by size, color, shape, diet, and habitat, were important criteria. Our methods included interviews with artisanal fishers based on pictures of 24 fish species that were considered available in each of those localities. Detailed discussion of our methods appears in CA+ online supplement C).

Results

Identification, Nomenclature, and Classification in the Atlantic Forest Coast (São Paulo State)

When we showed 101 fishers from the Atlantic Forest coast pictures of the 24 species of fish (table C1, CA+ online supplement C), they responded as recorded in table 1. We obtained 27 generic names and 54 binomials (the generic name and a corresponding describer or adjective; CA+ online supplement D). Some species, among them groupers, mullets, bluefish, certain jacks, sand drums, southern kingcroakers, and cutlass fish, were readily recognized by most fishers and also identified quite homogeneously. In contrast, the hogfishes *Bodianus rufus* and *Bodianus pulchellus* were not recognized by 41 and 25 fishers, respectively; the weakfish *Cynoscion jamacensis* was not recognized by 16 fishers; and the damsel *Stegastes fuscus* was not recognized by 38 fishers.

Generic richness was higher for some species than for others, and these were often species that were not recognized by most fishers. In other words, the number of genera cited increased for less recognized species (different fishers cited different generic names). The less knowledge fishers had of fish, the greater the diversity of names cited (figure E1, CA+ online supplement E). Other things being equal, about 30% of the lack of knowledge of a species was responsible for the increase in diversity of fish nomenclature, in particular, the diversity of fish genera cited.

Fishers formed many fish groups by ordering species as "relatives" (*parentes*) or "cousins" (*primos*). The ways in which they explained these groupings—for example, morphological similarity, swimming together, eating the same food, having similar behavior, and living in the same place (habitat)—were similar in all seven communities. A strong tendency to group fish in terms of morphological similarity was observed during the interviews, but diet and habitat were also mentioned. The groups formed by at least 20% of the fishers interviewed are shown in figure 1. We thus have five groups formed by 12 species, corresponding to five biological families: Mugilidae, Carangidae, Labridae, Pomacentridae, and Serranidae. Genera were mostly grouped together, for example, *Mugil*, *Bodianus*, *Epinephelus*, and *Mycteroperca*. *Caranx* does not follow the same pattern, and we should recall that *Caranx crysos* has been considered by some writers to belong to another genus, *Carangoides crysos* (Menezes et al. 2003). Some *Caranx* are still identified and reported as *Carangoides*, for example, *Carangoides ciliarius* (*Caranx armatus*) (Goren and Dor 1994), but most have been reclassified as *Caranx* (Froese and Pauly 2005). The Pomacentridae, despite belonging to different genera, were grouped together. The Mugilidae and Carangidae, along with the Serranidae, are strong groups, having been grouped by 92, 70, and 87 fishers, respectively. The Serranidae were placed in subgroups corresponding to taxonomic genera by some fishers.

To compare the results obtained with the information given in the literature (table 2), we performed cluster analysis (Bray-Curtis) with regard to morphological (size, color, and shape) and ecological (fish diet and habitat) parameters. The scientific clusters based on ecology and morphology, represented by dendrograms (figs. 2 and 3, respectively), formed groups similar to the folk groups. Despite the importance of morphological variables, ecological variables showed more proximity among species, and this result parallels the fishers' em-

Table 1. Fish Names, Atlantic Forest Coast Fishing Communities

Scientific Name	Generic Name	Binomial	Times Cited		Does Not Know	Total Generic Richness
			Generic Only	Total		
19. *Abudefduf saxatilis*					10	9
	Tiniuna, tinhuna		47	47		
	Sinhá-rosa		25	26		
		Sinhá-rosa-riscada		1		
	Corintiana, corintiano		25	25		
9. *Bodianus pulchellus*					25	9
	Bodião, gudião		32	54		
		Bodião-querido		2		
		Bodião-sabonete		1		
		Bodião-vermelho		5		
		Gudião-amarelo		1		
		Gudião-batata		4		
		Gudião-caranhado		1		
		Gudião-colorido		1		
		Gudião-fogueira		6		
		Gudião-papagaio		1		
1. *Bodianus rufus*					41	4
	Bodião, gudião		37	53		
		Bodião-dentusco		1		
		Gudião-papagaio		3		
		Gudião-azul		2		
		Gudião-batata		8		
		Gudião-colorido		1		
		Gudião-fogueira		1		
12. *Caranx crysos*					2	5
	Carapau		61	61		
	Xarelete		34	34		
4. *Caranx latus*					0	12
	Xaréu		55	60		
		Xaréu-branco		1		
		Xaréu-cacunda, cacundo		2		
		Xaréu-da-pedra		1		
		Xaréu-olhudo		1		
	Olhudo		24	24		
17. *Centropomus parallelus*					1	1
	Robalo		99	112		
	Robalão		1	1		
		Robalo-cambira		1		
		Robalo-flecha		5		
		Robalo-peba, robalo-peva		6		
14. *Cynoscion jamaicensis*					16	6
	Goete		65	67		
		Goete-cascudo		1		
		Goete-da-pedra		1		
	Pescada		11	24		
		Pescada-branca		2		
		Pescada-cambuçu		1		
		Pescada-cascuda		1		
		Pescada-goete		8		
	Pescadinha		2	2		
		Pescadinha-branca		1		
2. *Epinephelus marginatus*					0	4
	Garoupa		91	97		
		Garoupa-comum		1		
		Garoupa-legítima		2		
		Garoupa-prêta		1		
		Garoupa-São Tomé		1		
		Garoupa-vermelha		1		
3. *Epinephelus morio*					9	4
	Garoupa		29	76		
		Garoupa-banana		8		
		Garoupa-da-areia		1		

Table 1. (*Continued*)

Scientific Name	Generic Name	Binomial	Times Cited: Generic Only	Times Cited: Total	Does Not Know	Total Generic Richness
		Garoupa-legítima		1		
		Garoupa-São Tomé		34		
		Garoupa-vermelha		2		
		Garoupa-chita		1		
20. *Euthynnus alleteratus*					5	9
	Bonito		78	86		
		Bonito-banana		1		
		Bonito-cachorro		1		
		Bonito-pintado		4		
		Bonito-pulador		2		
24. *Lutjanus synagris*					10	7
	Vermelho		66	78		
		Vermelho-caranha		3		
		Vermelho-dentão		1		
		Vermelho-cióba		8		
23. *Menticirrhus americanus*					4	6
	Betara, imbetara		72	79		
		(*Im*)*betara-prêta*		1		
		(*Im*)*betara-roliça*		6		
	Perna de moca		41	41		
13. *Micropogonias furnieri*	*Corvina, curvina*		98	98	0	2
7. *Mugil curema*					0	2
	Parati		84	85		
		Parati-guaçú		1		
	Tainha		20	20		
22. *Mugil platanus*					1	2
	Tainha		86	87		
		Tainha-facão		1		
18. *Mycteroperca acutirostris*					8	5
	Badejo		45	50		
		Badejo-mira		5		
	Miracelo, miracéu		34	34		
6. *Mycteroperca bonaci*					14	7
	Badejo		53	62		
	Badejote, badejinho		3	3		
		Badejo-branco		1		
		Badejo-mira		3		
		Badejo-prêto		1		
		Badejo-sabão		1		
10. *Oligoplites saliens*	*Guaivira, guarivira*		100	100	0	3
11. *Pomatomus saltatrix*	*Enchova, anchova*		97	97	3	3
16. *Scomberomorus brasilensis*					9	9
	Sororoca		60	60		
	Cavala		10	10		
	Cavalinha		11	11		
		Cavalinha-do-norte		3		
8. *Seriola lalandi*					11	11
	Olhete		70	73		
		Olhete-verde		3		
15. *Stegastes fuscus*	*Café torrado*		21	21	38	10
21. *Trichiurus lepturus*	*Espada*		100	100	1	1
5. *Umbrina coroides*					8	11
	Betara, imbetara		31	40		
	(*Im*)*betarinha*	(*Im*)*betarinha-da-fé*		1		
		(*Im*)*betara-mole*		2		
		(*Im*)*betara-sabá*		6		

Note: Numbers before scientific names refer to the order of pictures shown during interviews. Generic names cited were given by at least 20% of the 101 fishers interviewed in seven Atlantic Forest coast fishing communities. Totals for binomials and generic richness include all interviewees.

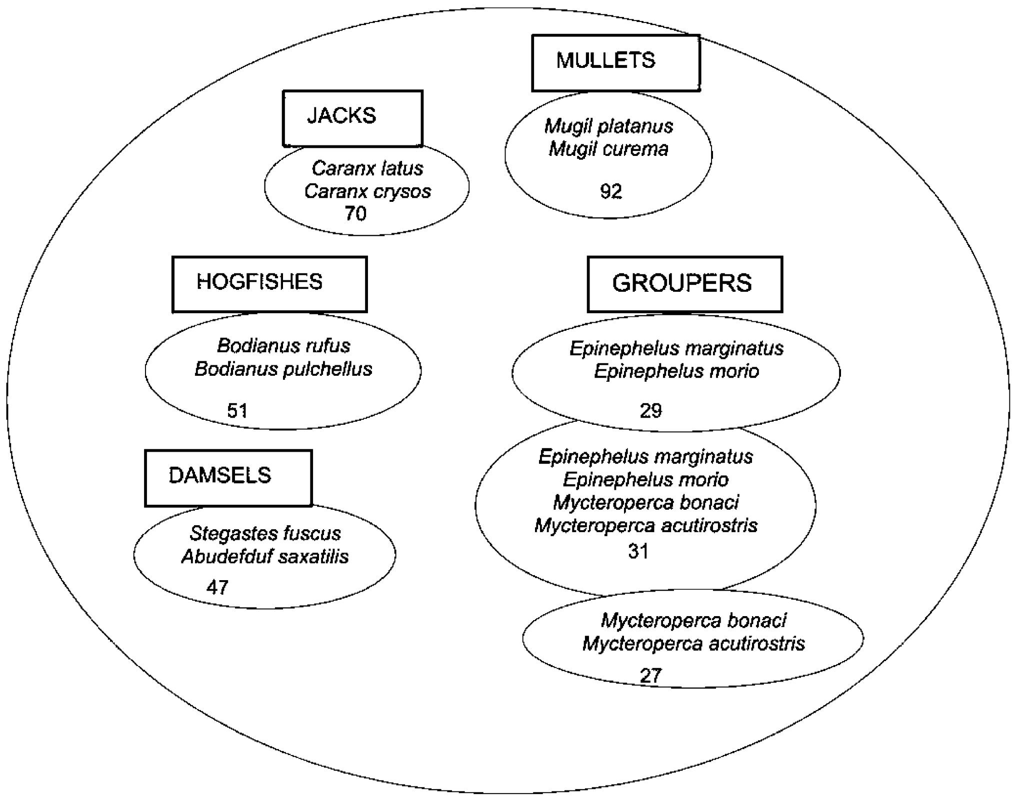

Figure 1. Groups (folk clusters) formed by at least 20% of the marine fishers (101 interviews) corresponding to fish locally called "relatives" or "cousins." The groups correspond to species from the same genera or from the same biological families.

phasis on diet, behavior (e.g., swimming together), and habitat as diagnostic variables.

Identification, Nomenclature, and Classification in the Amazon, Negro River (Barcelos)

In the interviews with 29 full-time fishers in Barcelos, fishers recognized and named all the species shown to them (table C2, CA+ online supplement C). Nomenclature based on binomials was rich; there were binomials instead of generic names for 18 of the 24 species identified (table 3). Fishers gave 49 folk binomials for the 24 species, with many names referring to color (see CA+ online supplement F). Folk binomials showed a certain homogeneity in the identification of, for example, *Myleus* gr. *rubripinnis* (*Myloplus rubripinnis*) and *Myleus torquatus* as *pacu-galo* (20 and 17 fishers, respectively), *Metynnis hypsauchen* as *pacu-erudá* (11), *Semaprochilodus insignis* as *jaraqui-da-escama-grossa* (18), *Semaprochilodus taeniurus* as *jaraqui-da-escama-miúda* (23), *Leporinus falcipinnis* as *aracu-canatí* (19), *Leporinus agassizi* as *aracu-branco* (26), and *Leporinus fasciatus* as *aracu-pinima* (28). Some species were identified by more than one folk binomial, especially *piranha* (*Serrasalmus* and *Pristobrycon*), *aruanã*, and *cará* (*azulão* and *papagaio*).

Six species were identified with folk generic names: *Brycon cephalus* as *matrinchã* (25 of 29 fishers), *Uaru amphiacanthoides* as *bararuá* (16), *Pinirampus pirinampu* as *barba-chata* (25), *Brachyplatystoma filamentosum* as *filhote* (27), *Auchenipterichthys longimanus* as *carauataí* (19), and *Pseudoplatystoma fasciatum* as *surubim* (23). For the 19 scientific genera represented by the 24 species, 20 folk genera were cited by the fishers. For a few species, fishers shared different identifications, such as for *Brycon melanopterus*, called *matrinchã* by 13 fishers and *jatuarana* by 10 fishers. *Brycon cephalus* was called *matrinchã* by 25 fishers.

All 24 species were included in the groups formed by the fishers in the Amazon (fig. 4). Some of the folk groups formed represented taxonomical families, among them the Anostomidae (*Leporinus* spp.), the Characidae (*Brycon* spp.), the Prochilodontidae (*Semaprochilodus* spp.), and the Osteoglossidae (*Osteoglossum bicirrhosum*). Others represented subfamilies of the Serrasalmidae (Silvano et al. 2001) and included groups with different food habits, such as the carnivorous

Table 2. Aspects of Morphology and Ecology for 12 Marine Fish Species Grouped by Fishers

Scientific Name	Size[a]	Coloration[b]	Shape	Diet	Habitat
Abudefduf saxatilis	Small	Color	Round	Invertebrates, plankton, algae	Reef, coastal
Bodianus pulchellus	Small	Color	Round-long	Invertebrates	Reef, coastal
Bodianus rufus	Medium	Color	Round-long	Invertebrates	Reef, coastal
Caranx crysos	Large	Light	Oval	Fish, invertebrates	Coastal, pelagic
Caranx latus	Large	Light	Oval	Fish, invertebrates	Reef, coastal, beach, estuary
Epinephelus marginatus	Large	Dark	Oval	Fish, invertebrates	Reef, coastal, deep water
Epinephelus morio	Large	Dark	Oval	Fish, invertebrates	Reef, coastal, deep water
Mugil curema	Medium	Light	Long	Detritus	Coastal, beach, estuary, sand, mud
Mugil platanus	Large	Light	Long	Detritus	Coastal, beach, estuary, sand, mud
Mycteroperca bonaci	Large	Dark	Oval	Fish, invertebrates	Reef, coastal, deep water, demersal
Mycteroperca acutirostris	Large	Dark	Oval	Fish, invertebrates	Reef, coastal, deep
Stegastes fuscus	Small	Dark	Round	Invertebrates, algae	Reef, coastal, demersal

Source: Froese and Pauly (2005).
[a]Adult length: small (<30 cm), medium (30–60 cm), or large (>60 cm).
[b]Color: bright, colorful; dark: brown or black; light: white, silver, or gold.

Serrasalmus and *Pristobrycon* and the herbivorous *Myloplus*, *Myleus*, and *Metynnis*. The Pimelodidae family is well represented by the group that includes *Pimelodus*, *Pinirampus*, *Pseudoplatystoma*, and *Brachyplatystoma*, but fishers included one member of the Auchenipteridae in this group as well. This group was, however, assembled by just 14 fishers out of 29.

The most common fishes in Barcelos are the *cará*s (including the *Hoplarchus* spp.), the *tucunaré*s (*Cichla* spp.), the *pacu*s (*Myloplus*, *Metynnis*, *Myleus*), the *aracu*s (*Leporinus* spp.), the *piranha*s (*Serrasalmus* and *Prystobrycon*), and certain *bagre*s (catfishes), including *Brachyplatystoma* and *Pseudoplatystoma* (Silva and Begossi 2004).

Following the reasons given by fishers for their groupings (appearance and schooling, eating, or living together), we performed a cluster analysis based on data from the literature (table 4). The dendrogram for the morphological variables size, color, and shape (fig. 5) shows a few groups similar to the folk groups, especially *Cichla* spp., *Brycon*, and two species of *Leporinus*. The dendrogram based on the ecological variables diet and habitat (fig. 6) is closer to the folk and biological families or subfamilies than that for the morphological variables but still does not follow those taxonomies closely.

Discussion

The Frequency of Binomials

The richness of binomials cited by the fishers in Barcelos is striking in comparison with that for the Atlantic Forest coast fishers. While on the coast fish are identified mostly by primary lexemes (generic names), in the Amazon they are identified by binomials (specific names). At first glance, one might interpret this difference as due to the high degree of biodiversity in the Amazon; the greater the number of organisms, the greater the need for detail to differentiate them. Environmental diversity, however, does not necessarily indicate that fishers have access to such diversity. For example, of the nearly 400 species of fish that are found in the Negro River (Goulding, Carvalho, and Ferreira 1988), fishers may have access to about one-quarter. Our study of fish landings in Barcelos indicated the occurrence of approximately 60 fish species in 79 fishing trips for a total yield of 2,184 kg, with concentrations of *tucunaré* (*Cichla* spp., 710 kg), *cará* (other Cichlidae, 622 kg), *traíra* (*Hoplias malabaricus*, 208 kg), and *pacu* (Serrasalmidae, 157 kg) (Begossi, Silvano, and Ramos 2005).

Data on marine fishes along the Brazilian coast suggest that about 600 fish species are found in the Argentine Province, a region that includes the Brazilian coast from Rio de Janeiro to Rio Grande do Sul and extends to eastern Argentina (Figueiredo 1981). Again, we do not believe that fishers have access to all of this faunal diversity, because a large number of those species are mesopelagic (Figueiredo et al. 2002) or live in deep waters (Bernardes et al. 2005) and are probably out of the fishers' reach. One detailed study on artisanal fishers of the Brazilian coast showed that 114 different fish species occurred in 905 fish landings over 14 months of sampling on Búzios Island, in the state of São Paulo, and that about 30 fish species were commonly consumed by fishers' families (Begossi 1989, 1996; Begossi and Richerson 1993; Begossi and Figueiredo 1995; Camargo and Begossi 2006). Taking into account the data from a later study at Búzios Island (Silvano 2001), 134 fish species were known by fishers. Therefore, access to fish diversity must be regarded as similar in the marine environment of the state of São Paulo and the riverine environment of the Negro River. Other possible explanations for the frequency of binomials among fishers from the Negro River are as follows:

1. Almost all the freshwater fish species of riverine Amazonian environments such as the Negro River are grouped into three large taxonomic orders—Characiformes, Siluriformes, Gymnotiformes—and the Cichlidae family (Perciformes). Their external morphology often follows a limited number of patterns. The need to differentiate among similar fishes

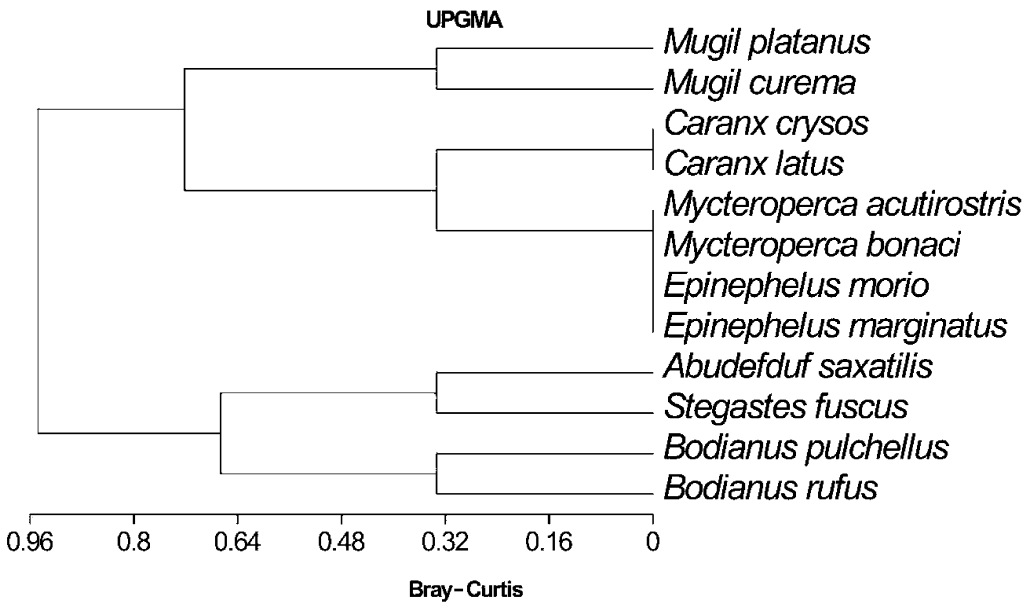

Figure 2. Dendrogram based on a cluster of morphological data for marine fishes (see table 2). UPGMA, unweighted pair-group method using arithmetic averages.

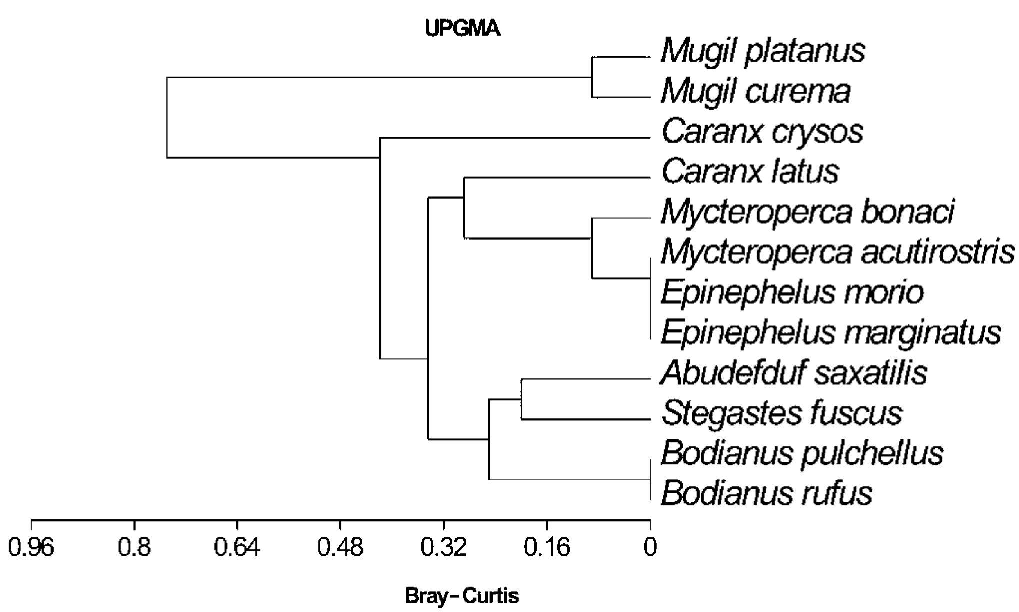

Figure 3. Dendrogram based on a cluster of ecological data for marine fishes (see table 2). UPGMA, unweighted pair-group method using arithmetic averages.

Table 3. Fish Names, Barcelos (Amazon)

Scientific Name	Generic Name	Binomial	Times Cited: Generic Only	Times Cited: Total	Generic Richness
22. *Auchenipterichthys longimanus*					5
	Carauatai		19	19	
	Anujá		7	7	
21. *Brachyplatystoma filamentosum*	*Filhote*		27	27	2
11. *Brycon cephalus*	*Matrinchã*		25	25	3
18. *Brycon melanopterus*					4
	Matrinchã		13	17	
		Matrinchã-gogó		3	
		Matrinchã-miúda		1	
	Jatuarana		10	10	
2. *Cichla monoculus*					1
	Tucunaré		0	36	
		Tucunaré-paca		17	
		Tucunaré-açú		11	
		Tucunaré-sarabiano		7	
		Tucunaré-pintado		1	
5. *Cichla temensis*					1
	Tucunaré		0	34	
		Tucunaré-sarabiano		17	
		Tucunaré-paca		15	
		Tucunaré-açú		2	
10. *Hoplarchus psittacus*					3
	Cará		0	37	
		Cará-azulão		26	
		Cará-papagaio		10	
		Cará-uá-çú		1	
9. *Leporinus agassizi*					2
	Aracu		0	31	
		Aracu-branco		26	
		Aracu-comunário		3	
		Aracu-dome		2	
8. *Leporinus falcipinnis*					1
	Aracu		0	30	
		Aracu-canatí		19	
		Aracu-pinima		8	
		Aracu-flamengo		2	
		Aracu-pintado		1	
23. *Leporinus fasciatus*					1
	Aracu		0	30	
		Aracu-pinima		28	
		Aracu-flamengo		1	
		Aracu-canatí		1	
17. *Metynnis hypsauchen*					2
	Pacu		0	20	
		Pacu-erudá		11	
		Pacu-í		4	
		Pacu-branco		2	
		Pacu-pitoa		2	
		Pacu-leso		1	
	Erudá		8	11	
		Erudá-mole		1	
		Erudá-pingo-de-sangue		1	
		Erudá-branco		1	
4. *Myleus torquatus*					1
	Pacu		1	29	
		Pacu-galo		17	
		Pacu-anário		5	
		Pacu-branco		4	
		Pacu-erudá		1	
		Pacu-gordo		1	

Table 3. (*Continued*)

Scientific Name	Generic Name	Binomial	Times Cited: Generic Only	Times Cited: Total	Generic Richness
1. *Myloplus rubripinnis* (*Myleus* gr. *rubripinnis*)					1
	Pacu		1	32	
		Pacu-galo		20	
		Pacu-anário		6	
		Pacu-branco		3	
		Pacu-comum		1	
		Pacu-zolhudo		1	
16. *Osteoglossum bicirrhosum*					4
	Aruanã		6	30	
		Aruanã-branca		12	
		Aruanã-prêta		12	
19. *Pimelodus albofasciatus*					1
	Mandi		20	27	
		Mandi-í		2	
		Mandi-pintado		3	
		Mandi-casaca		1	
		Mandi-manteiga		1	
		Mandi-rajado		1	
20. *Pinirampus pirinampu*	*Barba-chata*		25	25	5
15. *Pristobrycon serrulatus*					1
	Piranha		5	29	
		Piranha-branca		10	
		Piranha-caju		9	
		Piranha-pacu		4	
		Piranha-manteiga		1	
24. *Pseudoplatystoma fasciatum*					3
	Surubim		23	23	
	Capararí		7	7	
3. *Semaprochilodus insignis*					1
	Jaraqui		6	28	
		Jaraqui-da-escama-grossa		18	
		Jaraqui-da-escama-miúda		4	
7. *Semaprochilodus taeniurus*					2
	Jaraqui		2	27	
		Jaraqui-da-escama-miúda		23	
		Jaraqui-da-escama-grossa		1	
		Jaraqui-pequeno		1	
13. *Serrasalmus gouldingi* (young, 11.5 cm)					1
	Piranha		8	30	
		Piranha-branca		16	
		Piranha-da-barriga-azul		2	
		Piranha-do-amazonas		1	
		Piranha-azul		1	
		Piranha-caju		1	
		Piranha-chidaua		1	
14. *Serrasalmus gouldingi* (adult, 24 cm)					1
	Piranha		6	32	
		Piranha-fula		10	
		Piranha-branca		7	
		Piranha-prêta		6	
		Piranha-do-campo		1	
		Piranha-mafurá		1	
		Piranha-mucura		1	
6. *Serrasalmus rhombeus*					1
	Piranha		3	29	
		Piranha-fula		12	
		Piranha-mucura		6	
		Piranha-caju		5	

Table 3. (*Continued*)

Scientific Name	Generic Name	Binomial	Times Cited: Generic Only	Times Cited: Total	Generic Richness
		Piranha-branca		1	
		Piranha-cachorro		1	
		Piranha-caçoaca		1	
12. *Uaru amphiacanthoides*					3
	Bararuá		16	16	
	Cará		0	15	
		Cará-barú		15	

Note: Numbers before scientific names refer to the order of pictures shown during interviews. Generic names cited were given by at least 20% of the 29 fishers interviewed in Barcelos (Amazon). Totals for binomials and generic richness include all interviewees.

may have forced fishers to develop significant binomiality in their folk nomenclature. In contrast, marine fishes show striking morphological differentiation, and as a result, they are grouped in many orders. For example, the largest order of marine fishes, Perciformes, includes bluefish, groupers, wrasses, gobids, remoras, and the largehead hairtail, among others. Other orders also display great morphological variation, for example, the sea horses (Gasterosteiformes) and the pufferfish (Tetraodontiformes). Thus, among marine fishers generic names take into account high morphological variability, while in the Amazon the binomials account for differentiation among closely related species and similar morphologies.

2. Riverine fishers have greater knowledge of the environment than Atlantic Forest coastal fishers. This hypothesis is based on empirical studies (Brown 1984) that show an increase in the generality of life-form categories associated with decreasing intimacy with nature. For example, the Itzaj Maya nomenclature is richer in low-order categories (generic-specific) than that of Americans, which stresses higher-order taxa such as the life form (Atran 1999). In other words, the greater the knowledge of an environment, the greater the capacity to describe it in detail and to describe organisms in terms of binomials.

Salience

In both communities, the common occurrence of fish and their importance in commercial fisheries are important determinants of their perception and consequent identification and classification. Utilitarian factors can be important in folk taxonomy, and a number of factors, such as color, size, utility, and dangerousness, have been pointed out as responsible for an organism's salience (Hunn 1982, 1999; Begossi and Figueiredo 1995).

On the Atlantic Forest coast, the nomenclature for the 24 fish species reveals binomials that are related to salient features such as color and form. The most easily recognized were the groupers (Serranidae), the mullets (Mugilidae), the bluefish (Pomatomidae), the tunny (Scombridae), the croakers (Sciaenidae), the cutlass fish (Trichiuridae), and some of the jacks (Carangidae), all of which are commercial fishes that are especially targeted because of their good prices on the market. The hogfishes and the damsels (Labridae and Pomacentridae), in spite of being colorful, were difficult for fishers to recognize. Utility, then, seems to be an important variable driving artisanal fishers' attention to some species over others.

The generic is the most salient biological category (Brown 1984), and Berlin (1992) observed that the folk generic taxon is the most memorable term for informants in the field, the one they use most frequently and very often the first one they give. As we have seen, as knowledge of nature decreases, as happens in urban communities, life-form categories increase in importance (Brown 1984). The high diversity of generic names for species that are less well known among the artisanal fishers of the Atlantic Forest coast suggests that generic terms increase in importance along with life form and other supraspecific categories where knowledge of organisms is relatively limited. Therefore, the importance of generic terms in ethnobiological classification may be due to the more superficial perception of organisms that are not salient for the particular community studied. It is of course possible that these results are due to some methodological weakness (e.g., in the quality of the pictures of fish species used in the interviews), but the fishers' ample knowledge of commercially targeted fish indicates that salience and knowledge may be connected. The importance of specific or binomial names in the Amazon does not necessarily indicate greater knowledge of local fish on the part of fishers but instead may be due, as we have suggested, to their greater need to differentiate species of similar morphologies.

Classification

Of the five main fish groups formed by the fishers interviewed on the Atlantic Forest coast, three represent commercial fishes (Mugilidae, Carangidae, Serranidae), and the other two are small reef fishes (Labridae and Pomacentridae). While the

Figure 4. Groups (folk clusters) formed by at least 20% of the riverine fishers (29 interviews) corresponding to fish locally called "relatives" or "cousins." The groups correspond to species from the same genera or from the same biological families.

groups of commercial fishes were readily recognized, the reef species were not, but this did not prevent the fishers from assigning them to a suprataxon (life form).

The discontinuity of genera is supported by the identification of fish species and groups. Not all species, however, were recognized as separate entities, the same folk name sometimes being given to different biological species (underdifferentiation; Berlin 1973). A one-to-one correspondence of bird folk names and biological names has been found among the Ketengban of New Guinea (about 115 folk names), although in some cases a species had two names (Diamond and Bishop 1999). Among the fishers of the Atlantic Forest coast, the one-to-one correspondence occurs at the generic rather than the specific level. Since the inhabitants of New Guinea are apparently more integrated with nature than our artisanal coastal fishers, this difference is consistent with the

Table 4. Aspects of Morphology and Ecology for 24 Freshwater Fish Species Grouped by Fishers

Scientific Name	Size[a]	Coloration[b]	Shape	Diet	Habitat
Auchenipterichthys longimanus	Small	Dark	Long	Invertebrates	Demersal, flooded forest (*igapó*)
Brachyplatystoma filamentosum	Large	Dark	Long	Fish	River, demersal, estuary
Brycon cephalus	Medium	Light	Oval	Herbivore, invertebrates	River, demersal
Brycon melanopterus	Small	Light	Oval	Herbivore, invertebrates	Demersal
Cichla monoculus	Medium	Color	Oval	Invertebrates, fish	River, lake, near banks, submersed wood, or beaches
Cichla temensis	Large	Color	Oval	Fish	River, lake, near submersed wood, or beaches
Hoplarchus psittacus	Medium	Color	Round	Invertebrates, fish	Lake, near banks, submersed wood, flooded forest, beaches, or swamps
Leporinus agassizi	Small	Dark	Round-long	Herbivore, fish, detritus	Lake, demersal, near banks, submersed wood, or flooded forest
Leporinus falcipinnis	Small	Dark	Round-long	Herbivore, invertebrates	Demersal
Leporinus fasciatus	Small	Color	Round-long	Invertebrates, detritus	River, demersal, near banks, submersed wood, or flooded forest
Metynnis hypsauchen	Small	Light	Round	Herbivore, invertebrates	Pelagic
Myleus torquatus	Small	Light	Round	Herbivore	Demersal, near banks, submersed wood, or beaches or in flooded forest
Myloplus rubripinnis (*Myleus* gr. *rubripinnis*)	Medium	Light	Round	Herbivore	River, calm waters, demersal
Osteoglossum bicirrhosum	Large	Light	Long	Invertebrates, fish	Demersal, near banks, submersed wood, flooded forest, or beaches
Pimelodus albofasciatus	Small	Light	Long	Invertebrates	Demersal
Pinirampus pirinampu	Large	Dark	Long	Fish	River, demersal
Pristobrycon serrulatus	Small	Light	Round	Herbivore, fish	River, demersal
Pseudoplatystoma fasciatum	Large	Color	Long	Invertebrates, fish	River, demersal, flooded forest
Semaprochilodus insignis	Small	Light	Oval	Detritus	River, demersal
Semaprochilodus taeniurus	Small	Light	Round	Detritus	River, demersal
Serrasalmus gouldingi (young)	Small	Light	Round	Herbivore, fish	Demersal
Serrasalmus gouldingi (adult)	Small	Light	Round	Herbivore, fish	Demersal
Serrasalmus rhombeus	Medium	Light	Round	Fish	River, lake, demersal
Uaru amphiacanthoides	Small	Dark	Round	Herbivore, detritus	Demersal, near banks, submersed wood, flooded forest, beaches, or swamps

Source: Froese and Pauly (2005).
[a]Adult length: small (<30 cm), medium (30–60 cm), or large (>60 cm).
[b]Color: bright, colorful; dark: brown or black; light: white, silver, or gold.

idea that, as people move away from nature, supraspecific taxa will increase in importance.

In the case of Amazonian fishers, the groups identified were discrete and defined according to the scientific taxonomy. One species, *arawanã* (*Osteoglossum bicirrhosum*), was left out, showing its discontinuity as a monospecific group (fig. 4).

Diagnostic Variables and the Species Concept

Linnaeus used logical division as a basis for his classification method, in which the "real distinction" of a species—an Aristotelian notion of species essence—is given by the definition of its genus plus its *species differentia* (Ereshefsky 2001). Therefore, a classification is based on the traits used to differentiate the discontinuities found in nature.

According to the fishers interviewed, the diagnostic variables for the formation of fish groups were morphological similarity (shape, general appearance, colors) and ecological similarity (swimming together, eating the same food, living in the same habitat). A diagnostic property is one that is highly reliable in identification but is not logically necessary, as distinct from a defining property, which relates to the name that is applied to an organism (Ghiselin 1999). For example, the defining properties for fish species refer to the names and adjectives, whereas the diagnostic properties are morphological and ecological. Morphological variables are probably important in recognizing folk species, whereas both ecological and morphological variables are important in assembling folk species into high-ranking groups.

Comparison of these folk clusters with the clusters from the literature shows that ecology and morphology parallel the folk classification. Ecological variables from the literature formed groups that corresponded slightly better (smaller Bray-Curtis distances) to the folk clusters than groups formed

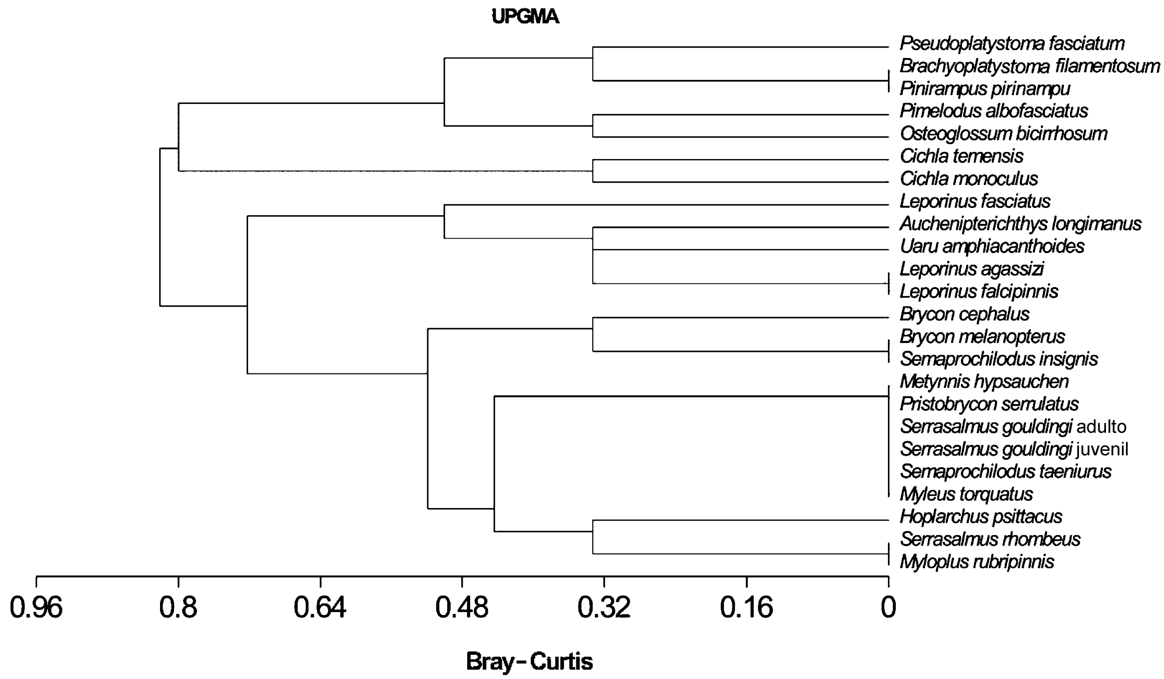

Figure 5. Dendrogram based on a cluster of morphological data for freshwater fishes (see table 4). UPGMA, unweighted pair-group method using arithmetic averages.

by morphological variables. Morphology (e.g., color and shape) seems to differentiate among folk species), while ecological variables define high-ranking folk categories such as the "cousins " or "relatives" referred to elsewhere as as "ethnofamilies" or "folk families" (Paz and Begossi 1996).

The long-standing debate over the species concept in biology has been enriched through new developments. For example, the classical biological concept (Mayr 1969, 2004) emphasizes the interbreeding of natural populations, the genetic concept focuses on the morphological and genetic distinctions among species, and phylogenetics deals with the evolution of the lineage of a species and the similarity of clusters of organisms to a parental pattern of ancestry (Wheeler and Meier 2000; Coyne and Orr 2004). The phenetic concept (Goren and Dor 1994) selects characters and organisms that will form taxa on the basis of resemblances. Pheneticists seek classifications in which entities share the most properties: the more properties it has in common, the higher the group's "predictive value" (Ereshefsky 2001). We found a tendency in fishers to use ecological diagnostic variables for high-ranking categories and morphological ones for specific categories. Taking into consideration the diagnostic variables given by the fishers and the complete lack of phylogeny in folk taxonomy, the phenetic concept is an appealing one for folk taxonomy, and phenetic folk taxonomies based on cluster analysis could be built. A taxonomic approach should provide empirically accurate classifications if the sorting and motivating principles are sensitive to empirical evidence (Ereshefsky 2001). These motivating principles, which we have called diagnostic variables, can be identified in the folk taxonomy and are congruent with scientific taxonomy.

Conclusions

Examining the ways in which communities of fishers in the Amazon and on the Atlantic Forest coast perceive, identify, and classify fish, we have found that generic names (primary lexemes) are more important on the coast and specific names, represented by binomials, in the Amazon. Having similar access to fish diversity, the fishers of the two places seem to differ in the need to differentiate, with the morphological similarity of local riverine fish species requiring fishers in the Amazon to develop a detailed folk taxonomy rich in binomials. When the fishers classified the fish shown to them into groups they called "relatives" or "cousins," these groups corresponded to scientific families or subfamilies, reinforcing the reality of groups perceived and sorted by people from different origins in terms of diagnostic variables.

Given the urgent necessity for taxonomic studies, the difficulties associated with gaining access to most of the biodiversity of the developing world (Wheeler, Raven, and Wilson 2004; Agosti 2006), and the importance of local knowledge (including knowledge of fish diet and fish migration (Berkes et al. 2000; Valbo-Jorgensen and Poulsen 2000;

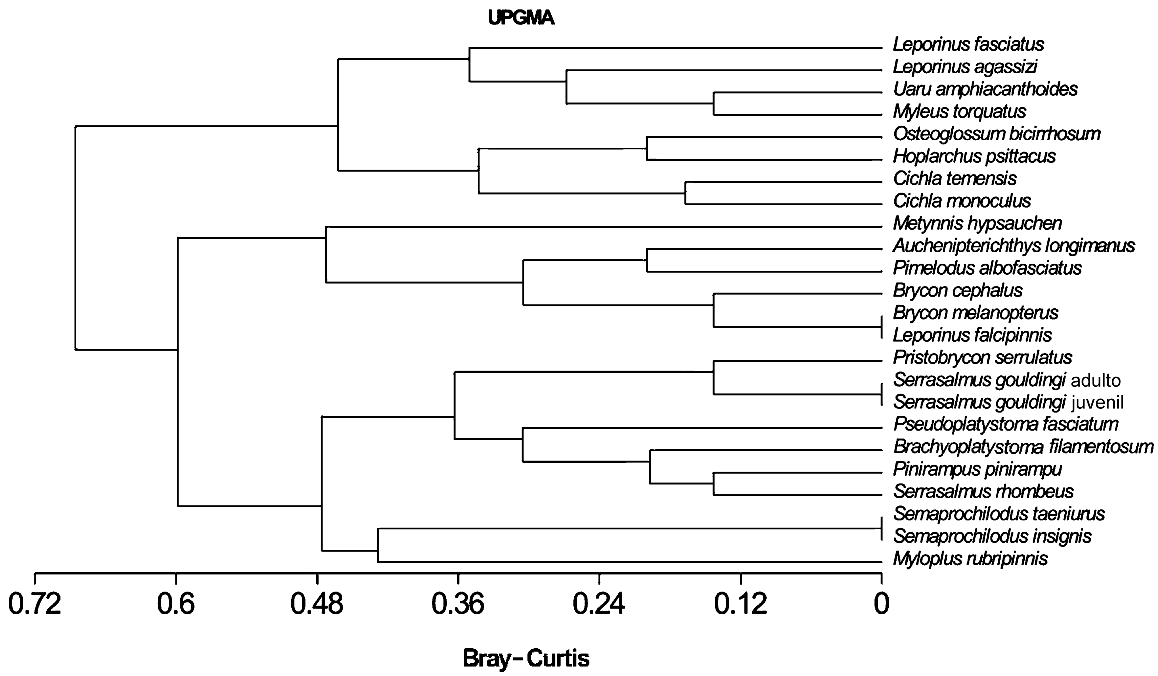

Figure 6. Dendrogram based on a cluster of ecological data for freshwater fishes (see table 4). UPGMA, unweighted pair-group method using arithmetic averages.

Silvano and Begossi 2002, 2005; Wilson, Nielsen, and Degnbol 2003; Sáenz-Arroyo et al. 2005]) for biology and management, we suggest that fishers be encouraged to become "parataxonomists" and "paraecologists." Their help could enhance research on biodiversity that will increase our biological knowledge and provide guidance for conservation efforts.

Acknowledgments

We are grateful to the Fundação de Amparo à Pesquisa do Estado de São Paulo for grants supporting this study (98/16160-0, 01/05263-2), as well as doctoral scholarships, to the Conselho Nacional de Desenvolvimento Científico e Tecnológico for a productivity scholarship to R.A.M.S., to K. S. Brown for helpful suggestions, and to J. Zuanon for the identification of fish from the Negro River.

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