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Historical Changes in the Rio das Velhas Fish Fauna—Brazil

CARLOS BERNARDO M. ALVES* AND PAULO S. POMPEU

Projeto Manuelzão – Universidade Federal de Minas Gerais, Avenida Alfredo Balena, 190 /10.012 Belo Horizonte (MG) Brasil 30130-100

Abstract.—The Rio das Velhas is a tributary of the Rio São Francisco, one of Brazil's largest rivers. It is the Rio São Francisco's second most important tributary in water volume (mean annual discharge of 631 m^3/s), with a drainage area of 27,867 km^2, length of 761 km, and mean width of 38 m. Like many other rivers around the world, it became heavily polluted in the 1900s. The Rio das Velhas is the most polluted river of Minas Gerais state because the basin contains approximately 4.5 million people. Unlike other Brazilian rivers, its fish fauna was studied from 1850 to 1856. Fifty-five fish species were recorded; 20 of them were first described at that time, when there were previously no more than 40 known species in the entire São Francisco basin. Recent fish collections, approximately 150 years later, indicate 107 fish species, but some may be locally extinct. There are good prospects of rehabilitating this fauna because of the connectivity of the Rio das Velhas with the São Francisco main stem, its well-preserved tributaries, and increased investments in sewage treatment.

Introduction

The neotropical biogeographic area is the world's richest fish species region (around 8,000 species, Schaefer 1998), but also one of the least known (Menezes 1996). Despite having one of the richest fish faunas in the world, there are few published studies regarding the past richness, distribution, and ecology of Brazilian fishes. Many of these studies are associated with modifications resulting from dam construction; for example, in the Paraná basin, compartmentalization and flow regulation significantly altered fish populations, especially of migratory species (Agostinho and Júlio, Jr. 1999).

In Brazil, untreated sewage effluents, deforestation, mining, dam construction, siltation, introduction of nonnative species, and water diversions contributed to rapid declines in fish species richness and altered spatial distributions (Agostinho and Zalewski 1996). This scenario is common to many areas of the country and is worst in highly industrialized or urbanized areas.

The aim of this chapter is to evaluate the changes in the fish assemblage of the Rio das Velhas basin in the past 150 years and associate those changes with environmental disturbances.

Methods

Study Area

The Rio das Velhas, located in central Minas Gerais state (Figure 1), is one of the most important tributaries of the Rio São Francisco, one of Brazil's largest rivers. It is the second most important tributary in water volume (mean annual discharge of 631 m^3/s), with a basin area of 27,867 km^2, length of 761 km, mean width of 38 m (CETEC 1983; PLANVASF 1986), and maximum width of 400 m (Sílvia Magalhães, Projeto Manuelzão, personal communication). The Rio das Velhas basin has the

* Corresponding author: curimata@uai.com.br

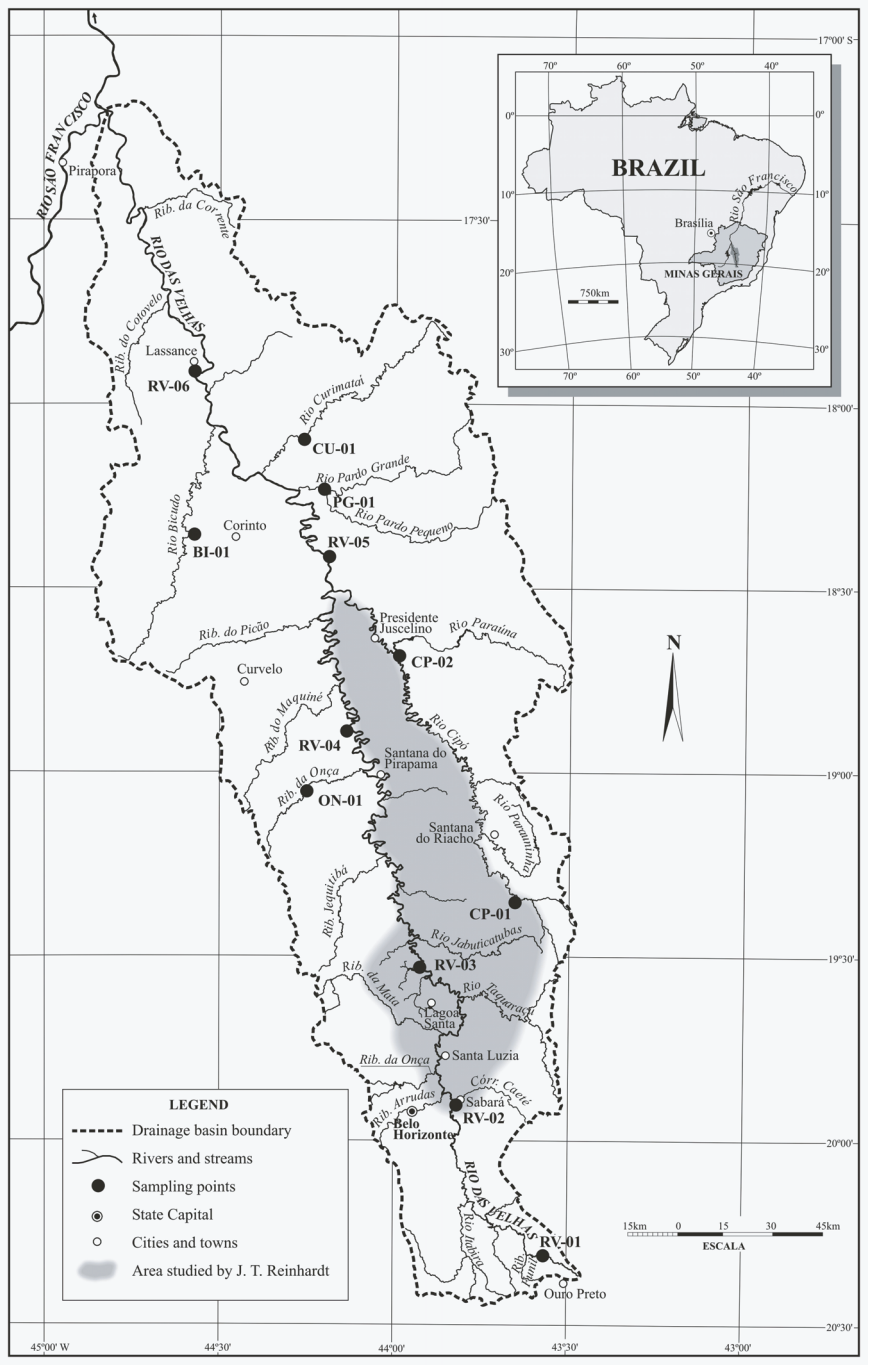

Figure 1.—Rio das Velhas basin, present sampling stations, and relative position in Minas Gerais state and Brazil. The shaded area indicates the probable collecting area of J. T. Reinhardt in the 19th century. (modified from Alves and Pompeu 2001)

largest metropolitan region, the highest gross domestic product, the largest human population, and the longest river course in the Sao Francisco basin. Its headwaters occur at 1,520 m above sea level and its confluence with the Rio São Francisco at an altitude of 478 m. Mean annual precipitation ranges from 110 to 160 cm (www.codevasf.gov.br). There are no available data on river depths, although it was navigable up to Sabará, near the Metropolitan Region of Belo Horizonte (MRBH[1]), in the 19th century (Burton 1977). Presently, many stretches are heavily silted, allowing one to wade across the river.

The Rio das Velhas' headwaters are located in a transition zone between the Atlantic rainforest and cerrado, which is the typical savanna-like vegetation of central Brazil. Both biomes are identified as world diversity hotspots because they have exceptional concentrations of endemic species undergoing exceptional loss of habitat (Myers et al. 2000). Below its headwaters to its mouth, Rio das Velhas flows only through cerrado. Another vegetation formation occurs near high elevation headwaters: the campos rupestres (literally, rock fields), a type of shrubby montane savanna, such as seen in the Rio Cipó, one of its most important tributaries. This formation is very rich in floral and faunal species, with high diversity and endemism (Costa et al. 1998).

Like many other rivers around the world, the Rio das Velhas became heavily polluted in the 20th century. The Rio das Velhas is the most polluted river of Minas Gerais state, partly because the basin has a total human population of 4.5 million people (IBGE 2000), and domestic sewage and industrial wastes of the MRBH are only partially treated (Table 1). The sewage of 3.2 million people is collected, but only 27.5% of it is primarily treated (www.copasa.com.br). New sewage treatment plants (STPs) and wastewater conveyances are being built to increase the rate of sewage treatment.

Fish Sampling

Johannes T. Reinhardt collected fish in two trips to Brazil, between 1850 and 1856. All specimens were sent to the Zoological Museum of Copenhagen University (Denmark). The sampling methods were not formally described, but Reinhardt did travel to many locations with local fishermen, and they brought him any different, rare, or interesting fish species. Reinhardt assigned Christian F. Lütken the rights to publish the monograph describing his collections (Lütken 1875). Not only the fishes, but also all field annotations, preliminary studies, and drawings were donated to Lütken. The expected sampling area of Reinhardt's collections is drawn in Figure 1 as a polygon formed by each cited collection location in Lütken's book. In the introduction of his monograph, the author pointed out the importance of the material:

> "… that was the first time ichthyological material was collected in the South American continent, as a result of a long stay of a naturalist in a single area, which permitted the local freshwater fish to be the subject of a specific study."

Present sampling stations include six sites on the Rio das Velhas main stem and other six sites on the five tributaries. The mean distance between Rio das Velhas collecting sites was 59 km (ranging from 27 to 95 km). Each tributary had only one sampling site, except Rio Cipó with two sites because of its greater length. All sites were selected depending on access and distance between upstream and downstream sites (main channel) in order to represent upper, medium, and lower river stretches. One tributary (Rio Cipó) and three main stem stations approximate Reinhardt's collection locations, justifying their selection for temporal comparisons. Except for Rio Cipó, which was sampled five times, every site was visited two or three times since 1999 to represent both dry and wet seasons.

Fish were caught with gill nets (20 m long, with 3–16 cm stretch measure mesh), seines (5 m long, 1 mm mesh), cast nets (3 cm stretch measure mesh), and kick nets (1 mm mesh). Gill nets were fished in the water column for 14 h overnight. Seines were used in shallow areas or littoral zones, kick nets were employed in near-shore aquatic macrophytes (both shorelines) and in riffles, and cast nets were used in habitats too deep to wade. The three latter methods were employed for 1–3 h. They were used only quali-

[1] The Metropolitan Region of Belo Horizonte is formed by 34 counties located around the Minas Gerais state capital, representing a total area of approximately 9,500 km^2.

Table 1.—Upriver to downriver water quality of the Rio das Velhas in 1999 (from Alves et al. 2000).

River kilometer	Coordinates	Dissolved oxygen (mg/L)	Biochemical oxygen demand (mg/L)	Chemical oxygen demand (mg/L)	Total dissolved solids (mg/L)	Total suspended solids (mg/L)	Volatile suspended solids (mg/L)	Ammonia (mg/L)	Chlorophyll-a (mg/m3)
20	43°34'39"W20°18'43"S	–	–	–	–	–	–	–	–
78	43°47'24"W20°05'17"S	8.0	–	–	2,355.0	11.0	–	1.2	–
114	43°48'52"W19°53'37"S	5.19	9.0	73.6	–	–	–	–	–
204[a]	43°54'39"W19°33'36"S	0.0–2.2	3.6–42.0	9.5–210.4	139.7–657.1	16.4–467.0	15.3–1,608.0	0.0–12.2	2.0–9.6
299	44°01'10"W19°14'07"S	1.0–3.4	2.0–17.9	9.9–42.2	129.3–2,081.0	2.3–1,721.0	3.7–269.0	0.0–11.0	2.4–15.5
373	44°02'14"W19°00'37"S	1.6–9.5	0.3–7.3	7.2–15.2	127.1–956.1	0.7–381.0	0.6–90.0	0.0–6.9	1.3–40.2
400	44°07'13"W18°57'07"S	0.2–12.7	0.5–11.5	5.6–40.0	111.1–941.0	0.3–416.0	6.7– ,192.0	0.0–2.9	3.5–44.3
454	44°09'04"W18°48'27"S	0.6	3.1	6.4	416.0	68.7	585.7	1.8	–
493	44°11'33"W18°40'15"S	2.9–10.6	–	–	–	–	–	–	–

[a] Approximately 40 km upstream of this point, the Rio das Velhas receives the sewage of the Metropolitan Region of Belo Horizonte (MRBH).

tatively to provide a more complete species richness list. Site lengths were 50–100 m, depending on water depth and velocity.

Results

Present samples in the basin have produced 107 species, 81 of which occurred in Reinhardt's study area (Figure 1). Lütken (2001) described 55 species in the Rio das Velhas basin, 46 were found in the main stem, and 24 in tributaries near Lagoa Santa and the Rio Cipó. Three levels of comparison with Lütken were performed: (1) all data together, (2) only the Rio das Velhas main stem, and (3) only the Rio Cipó (Figure 2). Rio Cipó had been chosen for analysis because it was the most cited tributary in the past work. Presently, it is one of the most preserved rivers and has a national park in its headwaters. For all data together, 34 species were reported by both Lütken and us, 21 species were reported only by Lütken, and 47 species were collected only by us. In the Rio das Velhas, 16 species were collected in both our studies, 27 species were reported only by Lütken, and 28 species were collected only by us. In the Rio Cipó, 13 species were collected in both studies, 11 species had occurred only in Lütken's report, and 48 species occurred only in our collections. We have added 26 fish species to Lütken's list, the great majority consisting of small-sized fishes with adults less than 10 cm long (Figure 3).

Ecological attributes have been reported for 20 extinct species in Reinhardt's study area (Table 2). Only a few of these attributes appear relevant to the species' extinctions. For example, the Siluriformes represent less than 35% of the Rio das Velhas basin fish fauna, but 70% of the locally extinct fish species.

Discussion

Surveys of fish species richness provide information for analysis of spatial-temporal and community structure patterns, assessment of biological integrity, and conservation of biodiversity (Cao et al. 2001). The number of samples, site size, and distance between sites is critical to an accurate assessment, since conclusions depend on species richness and fish assemblage composition. Cao et al. (2001) suggested the evaluation of sampling sufficiency based on the relationship between the proportion of total richness and the similarity among replicate samples. Hughes et al. (2002) calculated the optimal site distance for electrofishing Oregon rivers. For tropical

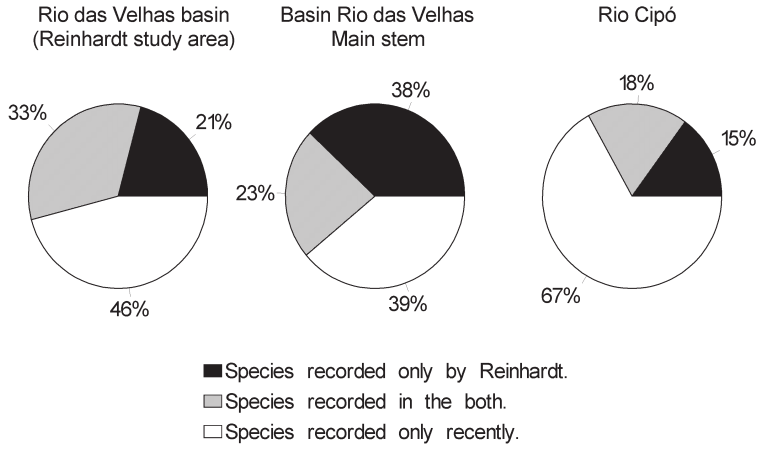

Figure 2.—Temporal and spatial comparisons of fish assemblages of the Rio das Velhas, considering the whole area studied by Reinhardt, the main stem, and Rio Cipó separately, showing the common and exclusive species between his and recent studies. (adapted from Alves and Pompeu 2001)

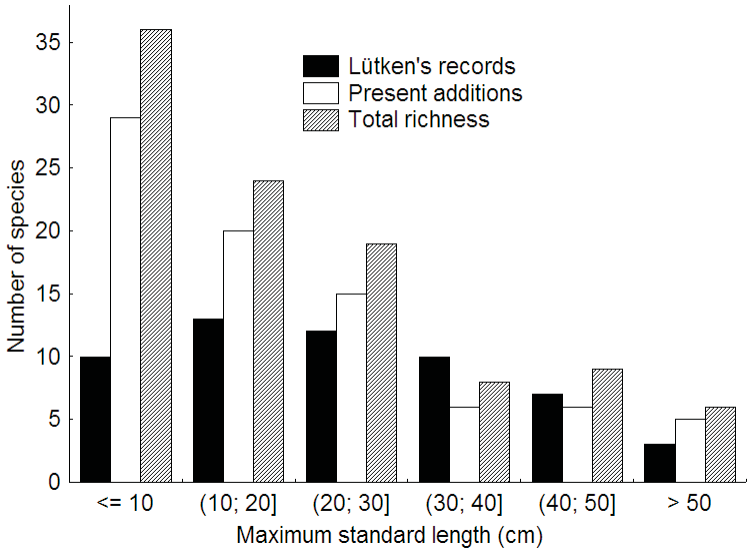

Figure 3.—Past records of fish species, recent additions to the Rio das Velhas basin, and total richness, by size-classes. (Adapted from Alves and Pompeu 2001).

waters, especially for Brazilian rivers, sampling effort studies are rare, despite their importance. Penczak et al. (1998) provided information regarding fishing effort and use of different fishing gears in the Rio Paraná basin. They demonstrated that different fishing gears play a complementary role in fish inventories and showed statistically significant differences between riversides at the same site. Climate and river size peculiarities support the need for further studies of this type to provide accurate and precise data in tropical fish surveys. For the Rio das Velhas, site selection was based on accessibility and river regions represented (upper, middle, and lower reaches), and the number of samples at each site was intended to characterize rainy and dry seasons. We used different kinds of fishing gears to maximize species richness assessments.

Costa et al. (1998) estimated fish species richness for the main river basins in Minas Gerais: São Francisco (170 species), High Paraná basin (120), Doce (77), Paraíba do Sul (59), Jequitinhonha (36), and Mucuri (44). Recent studies with new species descriptions and new occurrence records allow a more accurate estimation of Rio São Francisco' richness (176 species) within Minas Gerais boundaries (Alves et al. 1998). Because of the lack of collections in many portions of the São Francisco basin, such as small headwater streams, the whole basin may support 250–300 fish species. To support this hypothesis, we have registered 107 species in the Rio das Velhas; seven of which are new to science (*Hisonotus* sp.1, *Hisonotus* sp.2, *Planaltina* sp., *Bunocephalus* sp.1, *Bunocephalus* sp.2, *Rineloricaria* sp., and *Harttia* sp.). Voucher specimens are deposited at Museu de Zoologia da Universidade de São Paulo (MZUSP) (Appendix A).

Following Lütken's work, a number of new species records were added to the São Francisco basin list. The greatest number of species added to Lütken's listed species from the Rio das Velhas were particularly significant in the tributaries, where 48 were recorded for the first time. On the other hand, in the upper Rio das Velhas, only 28 species are newly recorded. In general, the different sampling techniques may account for the number of species added by the recent studies. Because the great majority of fish listed by Lütken were caught by fishermen, smaller species certainly were underestimated. Fishermen are always interested in fish that command good market prices or that are large enough to interest human consumers. Twenty-six species, measuring less than 10 cm total length, or 37 if we con-

Table 2.—Ecological attributes of fishes extinct in Reinhardt's study area. Bold font = extinct species in the Rio das Velhas basin.

Species[a]	Maximum length (cm)[b]	Main food Items[c]	Migratory Behavior[c]	Endemic[d]
Characiformes				
Family Characidae				
Brycon orthotaenia	40.1	fruits, insects	yes	yes
Serrapinnus piaba	4.6	plankton	no	yes
Hasemania nana	2.6	insects	no	yes
Roeboides xenodon	11.5	insects, fish scales	no	yes
Siluriformes				
Family Doradidae				
Franciscodoras marmoratus	26.2	?	no	yes
Family Auchenipteridae				
Glanidium albescens	12.4	?	no	yes
Trachelyopterus galeatus	15.7	insects, fishes, plants	no	no
Family Pimelodidae				
Bagropsis reinhardti	31.4	?	?	yes
Conorhynchos conirostris	73.4	mollusks	yes	yes
Rhamdiopsis microcephala	9.8	insects	no	yes
Pimelodella vittata	9.2	insects	no	yes
Pseudopimelodus charus	26.2	fishes	no	yes
Family Trichomycteridae				
Stegophilus insidiosus	5.0	fish mucous	no	yes
Trichomycterus brasiliensis	7.9	insects	no	no
Family Loricariidae				
Hypostomus alatus	40.6	algae	no	yes
Hypostomus francisci	28.8	algae	no	yes
Hypostomus lima	21.0	algae	no	yes
Rineloricaria lima	18.3	algae	no	?
Perciformes				
Family Sciaenidae				
Pachyurus francisci	39.3	fishes	no	yes
Pachyurus squamipennis	40.6	fishes	no	yes

[a] = according to Britski (2001); [b] = according to Lütken (1875, 2001); [c] = according to Alves *et al.* (1998); [d] = according to Reis et al. (2003).

sider species less than 20 cm, have been added to the first historical list. Comparing the size-class distribution between the past and present studies (Figure 3), smaller species currently represent the greater number of species. The only added species greater than 50 cm was the common carp *Cyprinus carpio*, which is a nonnative species.

Although Lütken's data can only be used qualitatively, since there were no measures of abundance and sampling efforts differed, this was a unique opportunity to evaluate the modifications that have occurred in the past 150 years. Many activities over this time, such as mining, agriculture, industrialization, urbanization, and population growth, likely produced direct and indirect negative effects on the fish fauna. All these activities altered chemical or physical habitats or both. For example, Pompeu and Alves (2003) demonstrated the local extinction of 70% of the original fish species of Lagoa Santa, a shallow permanent lake once connected to Rio das Velhas by a small stream. Among the factors that caused this drastic decrease were blockage from the main stem, introduction of nonnative species, changes in water level, elimination of littoral (Cyperaceae) and submerged (Characeae) vegetation, organic pollution, and siltation.

Among the 20 species not recorded recently in Reinhardt's area, 7 were collected outside it in the

Rio das Velhas basin (pirapitinga *Brycon orthotaenia*, piaba[2] *Serrapinnus piaba*, cascudos *Hypostomus alatus* and *Hypostomus francisci*, corvina *Pachyurus sguamipennis*, piaba *Roeboides xenodon,* and cangati *Trachelyopterus galeatus*), so they have been only locally extirpated. Thirteen species are apparently absent from the basin (mandi-bagre *Bagropsis reinhardti*, pirá *Conorhynchos conirostris*, mandi-serrudo *Franciscodoras marmoratus*, peixe-dourado *Glanidium albescens*, piaba *Hasemania nana*, cascudo *Hypostomus lima*, corvina *Pachyurus francisci*, mandi-chorão *Pimelodella vittata*, bagre-sapo *Pseudopimelodus charus*, candiru *Stegophilus insidiosus*, cambeva *Trichomycterus brasiliensis* bagrinho *Rhamdiopsis microcephala,* and cascudo-barbado *Rineloricaria lima*). The second of them, *C. conirostris*, plays a significant role in Rio São Francisco commercial fisheries. According to Reinhardt's observations, *C. conirostris* used to swim up-river in Rio das Velhas annually, from February to March. This movement could correspond to its reproductive migration to spawning grounds in the Rio das Velhas tributaries. The populations of this species seem to fluctuate significantly in time. After many years of being practically absent from commercial fisheries, the species became abundant following large 1996–1997 floods in the Rio São Francisco basin. In 1998, juveniles (ranging from 11.2 to 13.3 cm standard length) were caught in the Rio São Francisco near Rio Carinhanha (personal observation).

Among the species locally extinct, most are catfishes and armored catfishes. Generally, these are benthic species, living among rocks and gravel (Burgess 1989). The sedimentation that transformed the channel into a shallow river and eliminated navigability near MRBH also altered substrate composition. The major causes of this process were the mines in the Rio das Velhas headwaters, deposition of organic sediments from MRBH, vegetation clearing, sediment runoff from agriculture, and uncontrolled urbanization. Where there was once a diverse bottom of cobble, gravel, and sand, today there is a homogenized sandy substrate, eliminating many bottom feeders. Many catfishes are herbivorous or iliophagous, grazing algae and organic matter attached to rocks.

Burton (1977) described the abundance and sizes of fish species of the Rio das Velhas and the Rio São Francisco in 1867. He felt that the fishery had a greater economic value than mining. Today, fishes such as surubim *Pseudoplatystoma corruscans*, which once reached 100 kg or more, are rarely caught larger than 40 kg; most of them are 10–25 kg. Surubim is the most important commercial fish of the São Francisco basin (Godinho et al. 1997). Radio telemetry studies, with fish collected and marked in Rio São Francisco, have recently shown surubim migrates 200 km into the Rio das Velhas (Alexandre Godinho, Universidade Federal de Minas Gerais, personal communication). These data reinforce the importance of the Rio das Velhas to the São Francisco basin.

Nevertheless, there are regular fish kills in the Rio das Velhas, mainly in the beginning of the rainy season (Alves et al. 2000). Heavy organic discharges from the MRBH accumulate in the river bottom during the dry season. At the beginning of the summer rainy season, this material is suspended at the same time water temperatures are greatest. Rapid decomposition of the organic matter depletes dissolved oxygen, causing frequent fish kills. Annual kills of adults and burying of the eggs and larvae of those that survive leads to annual decreases of resident fish populations and those migrating from the Rio São Francisco. The consequences of this heavy pollution affect all river biota. Recent studies showed how the MRBH changes the expected water quality, fish, and benthic richness in the main stem (Alves and Pompeu 2001; Pompeu et al., in press).

A monitoring program for the Rio das Velhas basin has begun, analyzing chemical, physical and biological parameters (microbiological, phytoplankton, zooplankton, macroinvertebrates, and fish) at 37 sites located in the main stem, tributaries, and MRBH. The objective of this biomonitoring program is to establish the basin's general features and to locate reference sites for assessing the degree of perturbation (Hughes 1995), thereby facilitating empirical comparisons over space and time. The Rio das Velhas basin includes sites ranging from quite undisturbed to heavily polluted and highly

[2] Many characins, subfamily Tetragonopterinae are generically referred to as "piaba."

channelized reaches, so we are optimistic about assessing current and potential conditions.

Despite substantial environmental degradation and fish composition changes, we found an interesting case of culture conservation. Lütken reported that mandi-amarelo *Pimelodus maculatus* was frequently caught with adult wasps in its stomach contents. He was curious about how fish could eat so many adults of a free flying insect. The answer was that local fishermen used to put wasp nests inside their fish-traps, with the adults remaining inside the trap, attracting fishes (Lütken 1875, 2001). In 1999, we discovered a fisherman using the same fishing strategy, almost 150 years after Reinhardt recorded his observations (personal observation). Examining the contents of his trap, we found three specimens of bagre-sapo *Cephalosilurus fowleri*. Both fish species are catfish.

The present condition of the upper Rio das Velhas, which is worse than other reaches in the São Francisco basin, can be changed in the near future. There are 12 sewage treatment plants already installed within the MRBH, and others are projected. The two larger ones (STP Arrudas and STP Onça) have treatment capacities of 4,500 L/s and 3,600 L/s, respectively. The other positive features of the das Velhas basin are its direct connection with the Rio São Francisco, with no natural or artificial barriers, as well as the quality of its tributaries, which support 75% of its present fish species. The natural purification capacity in the Rio das Velhas must also be stressed because the lower river does not seem to be altered by the sewage effluents of MRBH.

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Appendix A.—Fish species of Rio das Velhas basin

	Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
1.	*Acestrorhynchus lacustris* (Lütken 1875)	Peixe-cachoro	native		22.4	MZUSP 73745, 73755, 73775, , 73779
2.	*Anchoviella vaillanti* (Steindachner 1908)	Sardinha	native		5.4	–
3.	*Apareiodon hasemani* (Eigenmann 1916)	Canivete	native	endemic	4.7	–
4.	*A. ibitiensis* (Amaral Campos 1944)	Canivete	native		8.2	MZUSP 73687, 73813
5.	*A. piracicabae* (Eigenmann 1907)	Canivete	native		11.6	MZUSP 73681, 73804
6.	*Apteronotus brasiliensis* (Reinhardt 1852)		native		20.3	MZUSP 73674
7.	*Astyanax bimaculatus* (Linnaeus 1758)	Lambari-do-rabo-amarelo	native		12.7	MZUSP 73658, 73719, 73747, 73764
8.	*A. eigenmanniorum* (Cope 1894)	Lambari	native		9.2	MZUSP 73702, 73717, 73721
9.	*A. fasciatus* (Cuvier 1819)	Lambari-do-rabo-vermelho	native		15.5	MZUSP 73710, 73746, 73792
10.	*A. scabripinnis* (Jenyns 1842)	Lambari	native		9.3	MZUSP 73714
11.	*A. taeniatus* (Jenyns 1842)	Lambari	native		10.0	MZUSP 73827
12.	*Astyanax* sp.	Lambari	native		7.2	–
13.	*Bergiaria westermanni* (Lütken 1874)	Mandi	native	endemic	21.8	MZUSP 73806
14.	*Brycon nattereri* (Günther 1864)	Pirapetinga	native	threatened	14.7	–
15.	*B. orthotaenia* (Günther 1864)	Matrinchã	native	endemic	28.5	MZUSP 73836
16.	*Bryconamericus stramineus* (Eigenmann 1908)	Piaba	native		4.3	MZUSP 73680, 73696
17.	*Bryconops affinis* (Günther 1864)	Piaba	native		8.4	MZUSP 73679, 73791
18.	*Bunocephalus* spN.1		native	endemic	4.9	–
19.	*Bunocephalus* spN.2		native	endemic	3.7	MZUSP 73800
20.	*Callichthys callichthys* (Linnaeus 1758)	Caborja, tamoatá	native		11.4	MZUSP 73729
21.	*Cephalosilurus fowleri* (Haseman 1911)	Bagre-sapo	native	endemic	28.0	MZUSP 73667, 73756, 73815
22.	*Cetopsorhamdia iheringi* (Schubart & Gomes 1959)	Bagrinho	native		7.8	MZUSP 73676, 73695
23.	*Characidium fasciatum* (Reinhardt 1867)	Mocinha	native		8.3	MZUSP 73715, 73790

Appendix A.—Continued.

Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
24. C. lagosantensis (Travassos 1947)	Mocinha	native	endemic and threatened	2.7	MZUSP 73708, 73797
25. C. zebra (Eigenmann 1909)	Mocinha	native		5.4	MZUSP 73666, 73689, 73700, 73751, 73795, 73814
26. Cichla cf. *monoculus*	Tucunaré	alien		31.0	MZUSP 73767, 73772
27. Cichlasoma facetum (Jenyns 1842)	Cará-preto	native		6.3	MZUSP 73726
28. C. sanctifranciscense (Kullander 1983)	Cará-preto	native		10.0	MZUSP 73760
29. Crenicichla lacustris (Castelnau 1855)		native		4.3	–
30. Curimatella lepidura (Eigenmann & Eigenmann 1889)	Manjuba	native	endemic	7.6	–
31. Cyphocharax gilbert (Quoy & Gaimard 1824)	Sagüiru	native		9.3	MZUSP 73728, 73732
32. Cyprinus carpio (Linnaeus 1758)	Carpa	alien		70.0	–
33. Duopalatinus emarginatus (Valenciennes 1840)	Mandi-açu	native	endemic	23.4	MZUSP 73738, 73812, 73819
34. Eigenmannia virescens (Valenciennes 1842)	Peixe-espada	native		36.0	MZUSP 73660, 73739, 73757, 73765, 73802
35. Geophagus brasiliensis (Quoy & Gaimard 1824)	Cará	native		15.0	–
36. Gymnotus carapo (Linnaeus 1758)	Sarapó, tuvira	native		24.2	MZUSP 73787
37. Harttia leiopleura (Oyakawa 1993)	Cascudinho	native	endemic	6.1	MZUSP 73712
38. Harttia sp.N	Cascudinho	native	endemic	11.5	MZUSP 73692
39. Hemigrammus gracilis (Lütken 1875)	Piaba	native		2.4	–
40. H. marginatus (Ellis 1911)	Piaba	native		2.7	–
41. Hemipsilichthys cf. *mutuca* (Oliveira & Oyakawa 1999)	Cascudinho	native	endemic	3.6	MZUSP 73698
42. Hisonotus sp.N1	Cascudinho	native	endemic	3.3	MZUSP 73682, 73694, 73793
43. Hisonotus sp.N2	Cascudinho	native	endemic	3.4	MZUSP 73707, 73794
44. Homodiaetus sp.N		native	endemic	3.6	MZUSP 73693
45. Hoplias lacerdae (Miranda Ribeiro 1908)	Trairão	alien		57.5	MZUSP 73655, 73735, 73837, 73839, 73842

Appendix A.—Continued.

Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
46. *H. malabaricus* (Bloch 1794)	Traíra	native		33.8	MZUSP 73651, 73838
47. *Hoplosternum littorale* (Hancock 1828)	Chegante, tamoatá	alien		20.0	MZUSP 73730, 73743, 73744, 73766, 73770
48. *Hyphessobrycon santae*	Piaba	native	endemic	-	MZUSP 73683
49. *H. alatus* (Castelnau 1855)	Cascudo	native	endemic	28.6	MZUSP 73823, 73832
50. *Hypostomus commersoni* (Valenciennes 1836)	Cascudo	native		11.1	MZUSP 73759, 73816
51. *H. francisci* (Lütken 1874)	Cascudo	native	endemic	20.3	MZUSP 73724
52. *H. garmani* (Regan 1904)	Cascudo	native	endemic	13.2	MZUSP 73665, 73810
53. *H. macrops* (Eigenmann & Eigenmann 1888)	Cascudo	native	endemic	22.2	MZUSP 73664, 73736, 73780
54. *H. margaritifer* (Regan 1908)	Cascudo	native		7.0	MZUSP 73668
55. *Hypostomus* sp. (cited in Britski et al., 1988)	Cascudo	native	endemic	19.3	MZUSP 73754, 73811
56. *Hypostomus* spp.	Cascudo	native		38.0	MZUSP 73688, 73737, 73798, 73809
57. *Hysteronotus megalostomus* (Eigenmann 1911)	Piaba	native	endemic	3.7	MZUSP 73705
58. *Imparfinis minutus* (Lütken 1874)	Bagrinho	native	endemic	4.9	MZUSP 73678, 73704, 73796
59. *Leporellus vittatus* (Valenciennes 1849)	Piancó, piau-rola	native		24.0	MZUSP 73652, 73725, 73734
60. *Leporinus amblyrhynchus* Garavello & Britski 1987	Timburé	native		13.5	MZUSP 73653, 73672
61. *L. marcgravii* (Lütken 1875)	Timburé	native	endemic	9.9	MZUSP 73657, 73706, 73784
62. *L. obtusidens* (Valenciennes 1836)	Piau-verdadeiro	native		42.5	MZUSP 73671, 73847
63. *L. piau* (Fowler 1941)	Piau-gordura	native	endemic	16.2	MZUSP 73778
64. *L. reinhardti* (Lütken 1875)	Piau-três-pintas	native	endemic	22.6	MZUSP 73781, 73818
65. *L. taeniatus* (Lütken 1875)	Piau-jejo	native	endemic	21.4	MZUSP 73663, 73691, 73777

Appendix A.—Continued.

Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
66. *Lophiosilurus alexandri* (Steindachner 1876)	Pacamã	native	endemic	25.5	MZUSP 73817, 73835
67. *Moenkhausia costae* (Steindachner 1907)	Piaba	native		6.3	MZUSP 73825
68. *M. sanctaefilomenae* (Steindachner 1907)	Piaba	native		5.3	MZUSP 73686
69. *Myleus micans* (Lütken 1875)	Pacu	native	endemic	17.2	MZUSP 73673, 73684, 73805
70. *Neoplecostomus franciscoensis* (Langeani 1990)	Cascudinho	native	endemic	6.7	MZUSP 73713
71. *Oreochromis niloticus* (Linnaeus 1758)	Tilápia	alien		22.2	MZUSP 73733, 73826
72. *Orthospinus franciscensis* (Eigenmann 1914)	Piaba	native	endemic	5.2	MZUSP 73763
73. *Pachyurus squamipennis* (Agassiz 1831)	Corvina	native	endemic	23.0	MZUSP 73807
74. *Pamphorichthys hollandi* (Henn 1916)	Barrigudinho	native		2.3	–
75. *Parodon hilarii* (Reinhardt 1867)	Canivete	native	endemic	11.4	MZUSP 73720, 73776
76. *Phalloceros caudimaculatus* (Hensel 1868)	Barrigudinho	native		3.2	MZUSP 73711
77. *Phenacogaster franciscoensis* (Eigenmann 1911)	Piaba	native	endemic	3.2	MZUSP 73661, 73799
78. *Phenacorhamdia somnians* (Mees 1974)	Bagrinho	native		5.6	MZUSP 73662, 73675, 73685, 73703, 73789
79. *Piabina argentea* (Reinhardt 1867)	Piaba	native		7.7	MZUSP 73654, 73690, 73697, 73753, 73786
80. *Pimelodella lateristriga* (Lichtenstein 1823)	Mandi-chorão, mandizinho	native		9.2	MZUSP 73669, 73752
81. *Pimelodus fur* (Lütken 1874)	Mandi-prata, mandi-branco	native		18.8	MZUSP 73740, 73742, 73821, 73824
82. *P. maculatus* (Lacepède 1803)	Mandi-amarelo	native		34.0	MZUSP 73782, 73844, 73848
83. *Pimelodus* sp. (cited in Britski et al., 1988)	Mandi	native	endemic	17.5	MZUSP 73820, 73828, 73830
84. *Planaltina* sp.N	Piaba	native	endemic	3.2	MZUSP 73709, 73785

Appendix A.—Continued.

Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
85. *Poecilia reticulata* (Peters 1859)	Barrgigudinho	alien		2.7	MZUSP 73718
86. *Prochilodus argenteus* (Spix & Agassiz 1829)	Curimatá-pacu	native	endemic	39.8	MZUSP 73849
87. *P. costatus* (Valenciennes 1850)	Curimbatá-pioa	native	endemic	44.0	MZUSP 73822, 73843, 73845
88. *Psellogrammus kennedyi* (Eigenmann 1903)	Piaba	native		5.7	MZUSP 73727
89. *Pseudoplatystoma corruscans* (Spix & Agassiz 1829)	Surubim	native		>110.0	–
90. *Pygocentrus piraya* (Cuvier 1819)	Piranha	native	endemic	14.9	MZUSP 73846
91. *Rhamdia quelen* (Quoy & Gaimard 1824)	Bagre	native		29.5	MZUSP 73659, 73716, 73723, 73769
92. *Rhinelepis aspera* (Spix & Agassiz 1829)	Cascudo-preto	native		46.9	MZUSP 73831
93. *Rineloricaria* sp.N	Cascudo	native	endemic	15.0	MZUSP 73783, 73829
94. *Roeboides xenodon* (Reinhardt 1851)		native	endemic	8.0	MZUSP 73758, 73803
95. *Salminus brasiliensis* (Cuvier 1816)	Dourado	native		58.5	MZUSP 73808, 73833
96. *S. hilarii* (Valenciennes 1850)	Tabarana, dourado-branco	native		28.3	MZUSP 73749, 73834
97. *Schizodon knerii* (Steindachner 1875)	Piau-branco	native	endemic	27.7	MZUSP 73762, 73841
98. *Serrapinnus heterodon* (Eigenmann 1915)	Piaba	native		3.4	MZUSP 73677, 73701, 73750, 73774, 73788
99. *S. piaba* (Lütken 1875)	Piaba	native	endemic	2.3	–
100. *Serrasalmus brandtii* (Lütken 1875)	Pirambeba	native	endemic	16.9	MZUSP 73761
101. *Steindachnerina corumbae* (Pavanelli & Britski 1999)	Sagüiru	native		10.3	MZUSP 73656, 73699, 73722, MZUSP 73731
102. *S. elegans* (Steindachner 1875)	Sagüiru	native		12.2	MZUSP 73748, 73801
103. *Sternopygus macrurus* (Bloch & Schneider 1801)	Sarapó	native		33.1	MZUSP 73670
104. *Tilapia rendalli* (Boulenger 1897)	Tilápia	alien		20.1	MZUSP 73768, 73771, 73773, 73840

Appendix A.—Continued.

Species (Scientific names) [1]	Common names [2]	Native /alien/ locally extinct	Endemism / Conservation status [3]	MRSL (cm)	Voucher specimens
105. Trachelyopterus galeatus (Lütken 1874)	Cangati	native			MZUSP 73741
106. Trichomycterus reinhardti (Eigenmann 1917)	Cambeva	native	endemic		–
107. Triportheus guentheri (Garman 1890)	Piaba-facão	native	endemic	8.7	–
108. Bagropsis reinhardti (Lütken 1874)	Mandi-bagre	locally extinct	endemic		–
109. Conorhynchos conirostris (Valenciennes 1840)	Pirá	locally extinct	endemic and threatened		–
110. Franciscodoras marmoratus (Lütken 1874)	Mandi-serrudo	locally extinct	endemic		–
111. Glanidium albescens (Lütken 1874)	Peixe-dourado	locally extinct	endemic		–
112. Hasemania nana (Lütken 1875)	Piaba	locally extinct	endemic		–
113. Hypostomus lima (Lütken 1874)	Cascudo	locally extinct	endemic		–
114. Pachyurus francisci (Cuvier 1830)	Corvina	locally extinct	endemic		–
115. Pimelodella vittata (Lütken 1874)	Mandi-chorão	locally extinct			–
116. Pseudopimelodus charus (Valenciennes 1840)	Bagre-sapo	locally extinct	endemic		–
117. Rhamdiopsis microcephala (Lütken 1874)	Bagrinho	locally extinct			–
118. Rineloricaria lima (Kner 1853)	Cascudo-barbado	locally extinct	endemic		–
119. Stegophilus insidiosus (Reinhardt 1859	Candiru	locally extinct	endemic		–
120. Trichomycterus brasiliensis (Lütken 1874	Cambeva	locally extinct			–

[1] According to Reis et al. (2003);

[2] As cited locally or at Três Marias region (Britski et al., 1988)

[3] Endemism checked in Fishbase (www.fishbase.org) and Catalog of Fishes (www.calacademy.org/reserach/ichthyology/catalog). Conservation status refers to any category of threat mentioned in Machado et al. (1998), and MMA 2004).MRSL = maximum recorded standard length in present studies in Rio das Velhas basin.