
HOW ARE THE LAKES? ENVIRONMENTAL PERCEPTION BY FISHERMEN AND ALIEN FISH DISPERSAL IN BRAZILIAN TROPICAL LAKES

FLÁVIA PEREIRA LIMA, ANDERSON OLIVEIRA LATINI
and PAULO DE MARCO JÚNIOR

SUMMARY

Alien species introduction is considered worldwide as one of the most important threats to biodiversity. In the Middle Doce River (Southeastern Brazil) the introduction of alien fish had caused the decline and local extinction of some native fishes. In the present study 50 inhabitants of two nearby communities (Baixa Verde and Cava Grande) were interviewed in order to explore their environmental perception and to determine their role in intentional fish dispersal in this river system. The majority of respondents were dedicated to artisanal fishery. Local people perceived environmental alterations, including the reduction of fish population, but few could relate this alteration to alien

fishes. They heard about alien fishes, but only half of the interviewees could explain what an alien species is. The difficulty in explaining the meaning of alien species and the weak perception of the link between alien fish presence and reduction of native fish by the interviewed people was considered an indication of poor knowledge by local people about fish introductions. A well designed management plan to address this problem should focus on scientific education questions, on the increase of community participation in environmental decisions, and on increasing the strength of local environmental institutions.

Human activity has a pronounced influence on natural ecosystems, reducing the distribution and abundance of species, and sometimes promoting its extinction (Sala *et al.*, 2000). The introduction of alien or exotic species is considered to be the second largest threat to biodiversity, only surpassed by habitat fragmentation (Clout, 2004), or at least one of the major causes of declines in population of native species (Gurevitch and Padilla, 2004). For instance, it is estimated that 29% of continental fishes and 30% of amphibians present in South-American red lists are threatened by the introduction of exotic species (Rodríguez, 2001). Recent evidences suggest that these introductions

are threatening biodiversity in a world-wide scale, increasing local diversity (α -diversity) at the cost of diminishing diversity across sites (β -diversity) in a phenomenon called biotic homogenization (Olden *et al.*, 2004; Olden, 2006; Rahel, 2007).

Alien species can also cause alterations in ecological interactions such as predation, herbivory, competition and habitat modification (Sakai *et al.*, 2001). Its introduction can also facilitate the introduction of new parasite species and the possibility of hybridization between the new species with native populations, reducing of genetic variability (Lee, 2002; Olden, 2006). In particular, fish introduction may decrease the abundance of many native fishes and is considered as

one of the most important causes of extinction in freshwater species (Rodríguez, 2001; Leprieur *et al.*, 2008).

After invasion, dispersal of aliens could be considered a key feature for the success of invasive species (Kolar and Lodge, 2001; Sakai *et al.*, 2001). It can be classified as active or passive. In active dispersal, an individual arrives at a new habitat by its own displacement capacity, inherent to its bionomic traits. In passive dispersal, the individual is transported by other agents such as water, wind, animals and human activities, including accidental and intentional transportation (Kolar and Lodge, 2001). Usually, intentional species introduction is due to economic interests, especially in the case of fish species.

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Flávia Pereira Lima. Biologist. M.Sc. in Rural Extension, Universidade Federal de Viçosa, Brazil. Professor, Universidade Federal de Goiás (UFG), Brazil.

Anderson Oliveira Latini. Zootechnologist. D.Sc. in Ecology, Conservation and Wildlife Management, Universidade Federal de Minas Gerais, Brazil. Professor, Universidade Federal de São João Del Rei, Brazil.

Paulo De Marco Júnior. Biologist. D.Sc. in Ecology, Universidade Estadual de Campinas, Brazil. Professor, UFG, Goiás, Brazil. Address: Laboratório de Ecologia Teórica e Síntese, Departamento de Biologia Geral Universidade Federal de Goiás, Goiânia, Goiás, Brasil. e-mail: pdemarco@pq.cnpq.br

The main causes of fish introduction around the world are food and ornamental aquaculture, and sport-fishing (Welcomme, 1988). Casal (2006) suggested that aquaculture was one of the major reasons for fish introduction and that the worldwide increase in food demand directly affects its rate. Following the same argument, Leprieur *et al.*, (2008) showed that natural factors have no predictive power about the number of non-native fishes in a given river basin, but economic activity does. In many cases, the introduction of recreational fishes is desired by local inhabitants (Crawford and Muir, 2008) without any major concern about its possible environmental impacts.

Brazil has one of the largest fish fauna of the world (~21%; Agostinho *et al.*, 2005), and a large human population that may use this as an important resource. However, this does not prevent importing exotic fishes that strongly affect its native environment (Rodríguez, 2001; Agostinho *et al.*, 2005). Current knowledge about fish introductions in Brazil shows a similar general pattern in the spread of alien fish species as in other Neotropical countries with more important aquaculture activities (Latini and Petrere, 2004; Latini *et al.*, 2004; Vitule *et al.*, 2006, 2009; Pelicice and Agostinho, 2009). Vitule (2009) observed that many fish introductions in Brazil are so old that they were culturally embraced by local populations and attained a “naturalized” state (e.g. the common carp introduction dating from 1882). Vitule (2009) also claims that “this long coexistence period is certainly one of the many characteristics which made the perception or detection of exotic fishes harder in Brazil, contributing to its ‘invisibility’ to Brazilian society”. One emblematic example is the introduction of peacock bass (*Cichla* spp.) in freshwater watersheds outside its original areas in the Amazonian region (Sunaga and Verani, 1991; Latini and Petrere Jr., 2004; Pelicice and Agostinho, 2009). Despite being forbidden by Brazilian law, the practice is widespread and has strong appeal among sport fishermen, motivating clandestine introductions.

Freshwater fish introductions in Brazil were more common in the 60’s and 70’s, when Amazonian species were introduced into the Northwest and Southeast regions (Agostinho *et al.*, 1994; Agostinho, 1996). In this period, the tucunaré (*Cichla* cf. *ocellaris* Bloch and Sch-

neider, 1801) and the piranha (*Pygocentrus nattereri* Kner, 1858) were introduced in some tropical lakes in the middle Doce River basin, South-eastern Brazil, with sport fishing purposes (Sunaga and Verani, 1991). These species caused the decline of native fish populations and the local extinction of some species (Latini and Petrere, 2004), and also invaded 76.8% of 72 natural lakes on the left margin of the Doce River (Latini *et al.*, 2004). The current alien fish distribution at this basin is better explained by the active dispersal of fishes during the rain season, possibly boosted by flood events (Latini and Petrere, 2004), and intentional dispersal by local and intentional dispersal by local fishers. The existence of such activities and the understanding of the reasons why local people have been introducing alien fish are important to any environmental management plan in this ecosystem.

Considering the many cultural aspects related to fish introduction, it is important to know how human populations living near water bodies perceive this process. Social perception could be conceptualized as the way people build its images of the environment and how they create meanings to their experience with ecosystems and with other social players (Castillo *et al.*, 2005). Since environmental perception is the way people perceive the changes in its environment, it can be concluded that some social components of human societies may strongly affect their perception, such as: i) past experience; ii) social view of the economic value of natural resources; iii) social view of non-valuable natural resources; and iv) accumulated ecological knowledge of the area by the population. In short, environmental perception may be bounded by human values about nature and may be extremely important to determine community concerns about environmental impacts (Pinheiro, 2004; Castillo *et al.*, 2005; Silvano *et al.*, 2005). For instance, the studies of Maurstad *et al.* (2007) show that fishermen’s experience of its local environment is reliable to identify fish decline and other environmental changes that occur simultaneously to fish farm establishment. Nevertheless, a cautionary note must be added to the evaluation of environmental perception, since it is important to distinguish between what is said about the environment and ecological knowledge, established among the compo-

nents of a fishery community (Palmer and Wadley, 2007).

The identification of how alien species invasion occurs in a given area is considered the most promising way to deal with the problems related to biological invasion (Kolar and Lodge, 2001). Nevertheless, one important component of this process is the perception of local human communities about fish introduction and the environmental changes in the region, and about the alien species introduction and its consequences to native species. Local knowledge, considered as the cumulative knowledge and beliefs about the environment, culturally transmitted through generations (Berkes and Folke, 2000), could directly affect the behaviour of the human community towards the alien species and their consequences, and be the determinant factor of success in related environmental management. In some communities where fishing resources are at least sporadically used, the cumulative knowledge about the ecological functioning of the environment may be related to fishing frequency, which is probably a better measure of how often the fisherman experiences the environment (Silvano and Begossi, 2002).

Local ecological knowledge (LEK) is a powerful concept that helps understand how local communities manage their resources (Silvano and Valbo-Jørgensen, 2008). At least for fisheries, it was shown that there is general agreement between LEK and scientific ecological knowledge (Begossi and Silvano, 2008, Silvano *et al.*, 2008). Otherwise, detailed knowledge of fish diets and ecology is more likely to occur for large and abundant fishes (Silvano and Begossi, 2002). Silvano and Begossi (2002) highlighted that LEK is not restricted to those social groups with a long history of use of fish resources, but small scale commercial fishermen also had detailed knowledge of fish diets and habitats, possibly accumulated by a few generations using the resource. It should also be noted that the LEK is flexible enough to include recent fish introductions. For instance, traditional fishermen have accumulated information about the introduced fishes *Plagioscion squamosissimus* and *Liposarcus* aff. *anisits* at the Piracicaba River (Silvano and Begossi, 2002).

Considering the interaction of local knowledge, environmental perception and fish introduction, it is not expected that fishermen

communities be aware of the risk of fish introduction, unless they perceive the alien fish species presence as a threat to their economic activities or social life. In this study, this hypothesis was explored, evaluating the environmental perception of local communities regarding intentional fish dispersal in lakes at the Doce River basin, Southeastern Brazil, and the consequences upon native fish communities. Whether or not environmental perception of the lakes and knowledge about alien species are positively related to the fishing frequency was then tested.

Methods

Study site

The Doce River lake system is located in the Atlantic Forest domain in Brazil, which is considered one of the most important biodiversity hotspots (Myers *et al.*, 2000). This system comprises about 130 lakes, of which 72 are on the left river margin, distributed over the 36000ha of the Doce River State Park (Parque Estadual do Rio Doce; PERD) and also through 22000ha of the Agriculture Forest Company (Companhia Agrícola Florestal; CAF, Arcelor Group). These lakes are usually paleo-courses of the river and belong to three small river sub-basins: Belém, Turvo and Mombaça. This special topography facilitates active alien fish dispersal, especially in extreme flood events during the rainy season.

Two human communities are inserted among these lakes, Baixa Verde (BV) in the municipality of Dionísio, and Cava Grande (CG) in the Marliéria municipality, both in Minas Gerais, Brazil. Each of these communities has about 2000 inhabitants who live next to the lakes and use them in leisure activities, including sport fishing. We interviewed 50 inhabitants of these two communities using a semi-structured questionnaire with 26 open questions subdivided in five groups (Table I).

To assure independence among respondents for statistical analysis, respondent's houses were randomly chosen in different streets. Whenever possible, the respondents in each house were selected among those directly involved in fishing activities,

TABLE I
QUESTIONNAIRE USED TO INTERVIEW
INHABITANTS IN BAIXA VERDE AND CAVA
GRANDE COMMUNITIES

- | |
|--|
| A. Basic information |
| 1. Age: |
| 2. Profession: |
| 3. How long have you lived in this district? |
| 4. Do you fish in the lakes? |
| 5. What is your fishing frequency? |
| 6. What fish do you catch more frequently? |
| 7. Why do you fish? |
| 8. How many times do you fish per week? |
| B. Environmental perception |
| 9. Have you noticed fishing changes in the last years? |
| 10. If you perceive any difference in fishing, do you know what the reason is? |
| 11. Have you noticed a new fish in the lakes? |
| 12. Have you noticed if any fish are fewer than before? |
| 13. Have you perceived any change in lakes in the last years? |
| 14. Do you consider important to protect the lakes? |
| 15. Do you agree with the investment of public resources in lake's protection? |
| 16. Do you have some benefit from living near the lakes? |
| 17. Do you have some difficulties due to living near the lakes? |
| C. Knowledge about alien fish |
| 18. Have you heard about alien fish? |
| 19. Could you explain what an alien fish is? |
| 20. Could you quote an alien fish name? |
| 21. Do you know how alien fish arrived? |
| D. Dispersal potential |
| 22. Which fish do you prefer to eat? |
| 23. If you had a fish pond, which fish would you rear? |
| 24. If you had the possibility, would you transport fish between lakes? |
| E. Dispersal history |
| 25. Have you transported fish between lakes? |
| 26. Do you know someone that has transported fish between lakes? |
| 27. Why do people transport fish between lakes? |

performing a total of 25 interviews in each community. Despite not using an explicitly systematic approach to determine local experts *sensu* Davis and Wagner (2003), the method was based on the choice of interviewees which were pointed out by their relatives as experts; thus, this choice resembles the communities perception of those related to fishing activities. This also produced a more representative sample for the purpose of this study, because it focuses only on the sub-set of the entire community which has any recognized fishing activity. Each interview was considered a sampling unit in the experimental design.

As the majority of the answers were yes or no, the existence

of association among answers to different questions was tested by Pearson's χ^2 . For comparison of ages we tested differences using standard t-test for independent samples. All statistical analysis were performed according to Zar (1999).

Results

Interviewees' general characteristics

The general aspects of the two communities are similar. The average age of interviewees was 42.5 yr, with no statistical difference among communities ($t = -0.736$; $df = 48$; $p = 0.465$). The majority of respondents (68%) have economic activities related to urban general services (painting, construction, taxi drivers etc.), 16% were retired, 12% were related to agriculture labor and 4% were reported as students.

Most of the respondents have lived in the region for more than 20 years (74%; $N = 50$) and declared to fish regularly (80%; $N = 50$). However, the respondents that reported fishing activities were younger (average age 35.5 yr) than those that do not fish (average age 48.0 yr; $t = 2.655$; $df = 48$; $p = 0.011$). Of eventual fishermen, more than half used to fish at least once a month (55%; $N = 50$). Half of the respondents used to fish for leisure. However, 16% ($N = 50$) declared that they fish for food supply and 12% declared that they fish for both purposes. Only 36% of the interviewed persons eat fish at least once a week.

Out of 14 fish species suggested to be captured by the interviewed fishermen ($N = 50$), the most frequently mentioned were the native *traíra* (*Hoplias malabaricus* Bloch, 1794; 44%) and the *lambari* (*Astyanax* sp; 34%) followed by the aliens *tucunaré* (*Cichla* cf. *ocellaris*; 22%) and *piranha* (*Pygocentrus nattereri* Kner, 1858; 14%).

Environmental perception

The distribution of the answers related to environmental perception in the questionnaire was not related to fishing frequency (Table II), which did not support the hypothesis that environmental perception depends on fishing frequency in these commu-

nities. The most common explanation given by the interviewees to lake changes was water volume reduction. One respondent said "The lakes are dying much more in the dry season". Only one person (2%) pointed out the change of fish community composition. Nevertheless, most of the people like the lakes and are supportive of their conservation.

Fishing changes in recent years was mostly explained by the reduction of the amount of fish caught (by 70%; N=50), which was attributed to the increase of fishing (by 38%), mainly by the use of improved fishing gears, such as the gillnet: "The fish are disappearing after the shift from hooks to gillnets". The people also suggested that the natural forest conversion and pollution are possible causes of the reduction in fish abundance, but only 6% of interviewees pointed alien fish introductions as a possible cause.

A total of 84% (Table II) of the interviewed noted the appearance of new fish species in the lakes. The fish considered as the most recently introduced in the region were the *bagre africano* (*Clarias gariepinus* Burchell, 1822) and the *tamboatá* (*Hoplosternum littorale* Hancock, 1828). The decrease of fish abundance was also observed (82%) and the species that suffered the most effects were the native *traíra* (*Hoplias* spp.), *lambari* (*Astyanax* spp.) and *piau* (*Leporinus steindachner* Eigenmann, 1907).

Almost all respondents considered important to protect the lakes (98%; Table II) and there is also a high proportion of respondents that considered necessary the use of public resources to lake protection (86%). The majority of the people considered that living close to the lakes brings some benefits (70%) including the availability

TABLE II
ENVIRONMENTAL PERCEPTIONS OF STUDIED COMMUNITIES AND THEIR RELATION WITH FISHING FREQUENCY

Question	No(%)	Yes(%)	χ^2	p	N
A- Have you perceived any change in lakes in the last years?					
No fishing	32.1	67.9	0.542	0.462	28
Fishing	22.7	77.3			22
B- Have you noticed fishing changes in the last years?					
No fishing	21.4	78.6	1.395	0.238	28
Fishing	9.1	90.9			22
C- Have you noticed a new fish species in the lakes?					
No fishing	17.9	82.1	0.163	0.686	28
Fishing	13.6	86.4			22
D- Have you noticed if any fish are fewer than before?					
No fishing	25.0	75.0	1.917	0.166	28
Fishing	9.5	90.5			21
E- Do you consider important to protect the lakes?					
No fishing	3.6	96.4	0.802	0.371	28
Fishing	0.0	100.0			22
F- Do you agree with the investment of public resources in lakes protection?					
No fishing	17.9	82.1	0.786	0.375	28
Fishing	9.1	90.9			22
G- Do you have some benefit from living near the lakes?					
No fishing	25.0	75.0	0.035	0.852	28
Fishing	22.7	77.3			22
H- Do you have difficulties due to living near the lakes?					
No fishing	89.1	10.7	2.289	0.130	28
Fishing	72.7	27.3			22

χ^2 is the Chi-square statistic, p is the p-value for the test with one degree of freedom and N is sample size.

No fishing: no fishing or rarely fishing, Fishing: fishing at least once a month.

On the other hand, 18% of respondents considered that making a living nearby the lake is bad for the health, mainly due to the presence of mosquitoes.

Knowledge about alien fish - cognitive questions

It was observed that 76% of the interviewees heard about an alien fish species (Table III). However, only 48% present a clear knowledge about those species. This perception is directly associated to the declared fishing frequency ($\chi^2= 3.848$; $df= 1$; $p= 0.049$).

One half of the respondents said that an alien fish is that which occurs in another region. For 33% of the interviewees, alien fish are those not previously recorded that appear in lakes, and 17% told that these are fish that eat other fish, mainly juveniles. Some assertions that exemplify these answers are: "These are carnivorous fish that eat the juveniles of native fish";

ty of water and leisure: "We will not suffer from clean water shortage"; "When I am tired, I go to the lake".

"The fishes are brought here. They were not here in the past."; "These fishes are from another region".

TABLE III
GENERAL ASPECTS OF KNOWLEDGE ABOUT ALIEN FISH OF STUDIED COMMUNITIES AND THEIR RELATION WITH FISHERY FREQUENCY

Question	No(%)	Yes(%)	χ^2	p	N
A- Have you heard about alien fish?					
No fishing	32.1	67.9	0.542	0.462	28
Fishing	22.7	77.3			22
B- Could you explain what an alien fish is?					
No fishing	64.3	35.7	3.848	0.049	28
Fishing	9.1	90.9			22
C- Could you quote an alien fish name?					
No fishing	39.3	60.7	2.613	0.106	28
Fishing	18.2	81.8			22
D- Do you know how alien fish arrived here?					
No fishing	57.1	42.9	0.674	0.412	28
Fishing	45.5	54.5			22

No: no fishing or rarely fishing, Yes: fishing at least once a month.

Respondents were also asked to mention an alien fish name and about 70% of them pointed to at least one name (Table III). Four alien fish were mentioned by interviewees (*bagre africano*, *tamboatá*, *tucunaré* and *piranha*). However, the species that were introduced for a longer time, *tucunaré* and *piranha*, were the less cited ones (18% and 10%, respectively). There was no relation of this answer to fishing frequency ($\chi^2 = 2.613$; $df = 1$; $p = 0.106$).

Many of the respondents perceived human-driven dispersal as the first cause to alien fish introduction in the lakes (48.1%; $N = 27$). The second suggested reason was their escape from aquaculture ponds (29.6%; $N = 27$).

Dispersal history

Two explicit questions about recent events of fish dispersal by humans were asked. Some respondents recognized that fish dispersal by humans is an illegal practice, but two individuals, one in each community, admitted that they have been transporting alien species between lakes (Table IV). Nevertheless, the records of human-driven dispersal increased if the question was changed to: Do you know someone that has practiced the fish transportation? Taking both communities into account, the total of human dispersal recorded this way was 48%.

The main reason for human-driven dispersal of alien fish species was the understanding that this practice will maintain the amount of fish in the lakes (46.9%; $N = 32$) stated by the main assertion "If everybody puts fish in lakes, they will always exist." A secondary reason for alien fish transportation was the desire to have some species available in different lakes (25%; $N = 32$), showing

TABLE IV
GENERAL ASPECTS OF ALIEN FISH DISPERSAL HISTORY AND THEIR RELATION WITH THE STUDIED COMMUNITIES CAVA GRANDE AND BAIXA VERDE

Question	No(%)	Yes(%)	χ^2	p	N
1 - Have you transported fish between lakes?					
CG	96.0	4.0	0	1.00	25
BV	96.0	4.0			25
2 - Do you know someone that has transported fish between lakes?					
CG	80.0	20.0	0.439	0.508	25
BV	72.0	28.0			25

CG: Cava Grande, BV: Baixa Verde.

TABLE V
GENERAL ASPECTS OF POTENTIAL DISPERSAL OF ALIEN FISH AND THEIR RELATION WITH THE COMMUNITIES CAVA GRANDE AND BAIXA VERDE

Question	Native fish(%)	Alien fish(%)	χ^2	p	N
1 - Which fish do you prefer to eat?					
CG	91.7	8.3	10.578	0.001	24
BV	47.6	52.4			21
2 - If you had a fish pond, which fish would you rear?					
CG	41.7	58.3	1.394	0.239	24
BV	59.1	40.9			22
3- If you had the possibility, would you transport fish between lakes?					
CG	52.0	48.0	0.080	0.777	25
BV	48.0	52.0			25

CG: Cava Grande, BV: Baixa Verde.

a trend for the homogenization of fish species composition.

Communities' potential for alien fish dispersal

The analyses of the alien fish dispersal potential in the two communities were performed concerning three aspects: i) fish preference for food; ii) fish preference for aquaculture purposes; and iii) the possibility of fish dispersal between lakes.

A greater potential for introduction of fish species was registered in the community of Baixa Verde, since many respondents did prefer alien fish for food, particularly the *tucunaré* (52.4%; Table V), due to its taste and reduced number of bones. On the other hand, in the Cava Grande community, 91.7% of interviewees preferred native fishes and *traíra* was the most commonly cited (54.2%). Despite of this, 40% of the respondents prefer alien fish for aqua-

culture purpose. Half of the interviewees (Table V) declared that they would disperse fish between lakes if they have the opportunity.

Discussion

Local people's relation to alien fish

Water volume and quality has been perceived by the interviewed people in the Doce River as an important natural good, which brings security to the communities with possible water-distribution constraints. The most important biotic alterations perceived by the local community are the reduction of some species (such as the *lambari*) and the rise of new ones, but these alterations were not clearly

linked to the alien fish introduction by the local people. Lake quality may represent an important surrogate for the ecosystems services (*sensu* Constanza *et al.*, 1997) it may provide, and this justifies the local community perception. It seems that people correctly recognized the importance of lakes and support their conservation, but failed to perceive the introduction of alien fish as a problem.

The difficulty in explaining the meaning of alien species was considered as an indication of a poor knowledge about this theme by the local people, and was associated to individuals that spend shorter times in fishing activities. It was also considered that the weak link that the people established between the presence of alien fish and the reduction of native fish is a consequence of the lack of information about alien species. Similar results were observed by Pinheiro (2004) who interviewed an artisanal fishery community in the Pirai River, Santa Catarina, Brazil. In

our study, local people consider the intentional dispersal of fish among lakes as a conservation measure, devised to increase fish resources. This proposition evidences the difference between local knowledge and ecological research. Ecological research provides serious evidence that the increased presence of alien fish may produce a loss of native fish and not necessarily increase fish abundance and yield (Welcomme, 1988; Pimentel *et al.*, 2000; Latini and Petrere, 2004). Nevertheless, available information about Nile perch introduction proved that despite the serious effect of reducing native fish populations, total fish production increases (Goudswaard *et al.*, 2008).

The lack of information could be considered as a possible reason for this general situation. School, TV and other media could be useful for the local population to learn about the impacts of alien fish. Nevertheless, the alien species invasion is not part of school programs in Brazil; this theme is not observed in National Curriculum Parameters, Primary Education (Brasil, 1998) and Secondary Education (Brasil, 2000) and is rarely discussed in the media. In Brazil, the discussion about biological invasions is recent and the first event was carried out by the National Environmental Agency in 2005. Besides, in the region of the middle Doce River no educational program with this theme has been developed. However, as the introduction of alien fish has been enforced by the Brazilian government in many lakes and reservoirs, people could not perceive that these actions could be negative to conservation of native species, only considering the possible economic benefits.

Local people, ecological knowledge and alien fish

Local knowledge is considered an important tool for ecological conservation, mainly due to its contribution to local management, as exemplified by studies on Brazilian Amazonian and Southeastern coast fishing communities (Begossi, 1998; Silvano and Begossi, 2005; Silvano *et al.*, 2006). This is based on the fact that local people had a well established knowledge of how ecological relations occur within its resource use practices (Berkes, 2000). Thus, they can have a better understanding of how different management practices could affect

their most important resources (Lykke, 2000; Silvano *et al.*, 2005).

This general reasoning is not applied to the alien species problem. Local people in the Doce River were not aware about the danger of the introduction of alien fish because they did not have any knowledge developed throughout their life, nor the experience of their ancestors, about how this alien fish introduction could affect the native fish community. "A fish is a fish" for those people that do not experience the effects of alien species introduction. As local knowledge is based on everyday and previous experience, and scientific knowledge also takes advantage on well established general theories, it is clear that in many instances local knowledge may produce equivocal results, compared to the scientific approach of a problem. Thus, our results contrast with the comparison made by Silvano *et al.* (2008) and Silvano and Begossi (2002) demonstrating an agreement between LEK and scientific knowledge. An explanation for this is the differences in the nature of the biological information evaluated in both studies. For instance, Silvano *et al.* (2008) demonstrated that Piracicaba river artisanal fishermen have a detailed knowledge about fish diet and habitats. This is a 'static' knowledge about which elements comprise the biodiversity and how they interact. The present study deals with a 'dynamic' component that includes a more elaborate abstract notion of cause and effect: the presence of such fish may alter the dynamic interactions of fishes and result in a biodiversity loss. The fishermen studied by Silvano and Begossi (2002) also have knowledge about biological aspects of introduced fish, but they do not perceive the negative effects on native fish species, as the fishermen of the Doce river lakes. Obviously, these differences between local and scientific knowledge are exaggerated in communities where fishery is not a dominant economic activity. Traditional fishermen, which rely on this activity for its maintenance, also take advantage of the cumulative information from their parents and relatives in a well established cultural relation. It is expected that the local knowledge on fishery resources, including the effects of alien species introduction will be higher in traditional fishermen communities.

However, this is only an apparent conflict since scientific

knowledge is far away from influencing some management decisions in these local communities of Brazil. Diffusion of our current understanding about alien species introduction does not reach the local people that face its effects. As a consequence, scientific knowledge is not properly used as a tool to guide the decisions of these communities about how to use their resources, and local knowledge is the only tool at hand.

Conclusion: Future actions

The local people in the Doce River lakes system recognize the presence of alien fish, but do not perceive the relationship between these species appearance and the reduction of native fish species. Under the local knowledge constraints, it was observed that there is a belief that the dispersal practice could be a conservationist measure. This misunderstanding was deeply rooted on the view of fish species as resources and on the perceived naturalization of the invaded species, such as *tucunaré* and *piranha*.

At present, the alien fish in the region of the middle Doce River have not caused an absolute depletion of the natural stock, and the fishing resources are still available to the population. However, recent studies demonstrated the ecological impacts upon natural fish communities due to the introduction of alien fish in this area (Latini *et al.*, 2004), but without stressing its social and economic impacts. The present results provide some insights about the social context leading to the introduction of species in this lake system, but other studies following this approach are needed to better understand other specific social aspects.

A well designed management plan of alien fish introduction should focus on widespread ecological information delivered to the local inhabitants through a program of scientific education that deals with the local community and local resources valuation. To be efficient, these actions need to be based on the increase of community participation and the strength of local institutions (Alpert, 1995; Bawa *et al.*, 2004), as the communities focused in this study present a low level of social organization that hinders their participation in the policy-making process (Carvalho, 2004). Local fishermen associations as well as land owner associations could be involved in the establishment of the

conservation strategy and in the decision-making process that will affect the whole ecosystem in the region (Sheil and Lawrence, 2004). Several different approaches have been devised to address these problems, but some experiences suggest that increased awareness of the economic value of biodiversity should be a productive way to modify the environmental perception and generate successful conservation measures in those communities (De Boer and Baquete, 1998; Gillingham and Lee, 1999; Bauer, 2003).

The scientific knowledge about regional biodiversity must be used to support the management activities (Fleishman *et al.*, 1999) but also to include a new dimension to the local populations knowledge. The interaction of local people's knowledge, scientific methods and scientific knowledge in this social system may produce conservationist actions with a more balanced compromise between the different priorities (Lykke, 2000; McClanahan *et al.*, 2005; Silvano *et al.*, 2005).

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CÓMO SON LOS LAGOS? PERCEPCIÓN AMBIENTAL DE LOS PESCADORES Y LA DISPERSIÓN DE PECES FORÁNEOS EN LAGOS TROPICALES DEL BRASIL

Flávia Pereira Lima, Anderson Oliveira Latini y Paulo De Marco Júnior

RESUMEN

La introducción de especies foráneas es considerada en todo el mundo como una de las amenazas más importantes para la biodiversidad. En el Río Doce Medio (sureste del Brasil) la introducción de especies foráneas ha causado la declinación y la extinción local de algunos peces nativos. En el presente estudio 50 habitantes de dos poblaciones cercanas (Baixa Verde y Cava Grande) fueron entrevistados a fin de explorar sus percepciones del ambiente y determinar su papel en la dispersión intencional de peces en ese sistema fluvial. La mayoría de los entrevistados se dedicaban a la pesca artesanal. La población local percibió alteraciones ambientales, incluyendo la reducción en la población

de peces, pero pocos pudieron relacionarlo a peces foráneos. Habían oído acerca de éstos, pero sólo la mitad pudieron explicar en qué consiste una especie foránea. La dificultad en explicar el significado de especies foráneas y la débil percepción del nexo entre su presencia y la reducción de peces nativos por parte de los entrevistados se consideró como una indicación del pobre conocimiento de la gente acerca de la introducción de peces. Un plan de manejo bien diseñado para enfocar este problema debe enfocarse en aspectos de educación científica, en el aumento de la participación comunidad en decisiones acerca del ambiente, y en el reforzamiento de las instituciones ambientalistas locales.

COMO SÃO OS LAGOS? PERCEPÇÃO AMBIENTAL DOS PESCADORES E A DISPERSÃO DE PEIXES FORÂNEOS NOS LAGOS TROPICAIS DO BRASIL

Flávia Pereira Lima, Anderson Oliveira Latini e Paulo De Marco Júnior

RESUMO

A introdução de espécies forâneas é considerada em todo o mundo como uma das ameaças mais importantes para a biodiversidade. No Rio Doce Médio (sudeste do Brasil) a introdução de espécies forâneas tem causado a declinação e a extinção local de alguns peixes nativos. No presente estudo, 50 habitantes de duas populações próximas (Baixa Verde e Cava Grande) foram entrevistados com o fim de explorar suas percepções do ambiente e determinar seu papel na dispersão intencional de peixes nesse sistema fluvial. A maioria dos entrevistados se dedicava à pesca artesanal. A população local percebeu alterações ambientais, incluindo a redução na população de peixes, mas poucos

puderam relacioná-las a peixes forâneos. Haviam escutado sobre estes, mas somente a metade puderam explicar em que consiste uma espécie forânea. A dificuldade em explicar o significado de espécies forâneas e a fraca percepção do nexo entre sua presença e a redução de peixes nativos por parte dos entrevistados foi considerada como uma indicação do pobre conhecimento das pessoas sobre a introdução de peixes. Um plano de manipulação bem desenhado para destacar este problema deve focar-se em aspectos de educação científica, no aumento da participação da comunidade em decisões sobre o ambiente, e no fortalecimento das instituições ambientalistas locais.