Argentina's Freshwater Systems, Aliens In Wonderland

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Abstract

To date a total of 34 alien taxa have been detected in Argentine freshwater systems. Knowledge about these organisms in terms of their actual spread and invasive status is scarce. Despite the existence of some laws regulating the import of foreign organisms, the issue if acknowledged by researchers does not occupy a prime position in research or official agendas. This is mostly due to a lack of awareness of the implications of alien aquatic invaders by policy makers, and the economic instability of the country, which has diverted funds into other areas considered more important. This paper focuses on generating a first assessment of the problem and designing a system that would allow for low-cost gathering of information regarding alien aquatic invaders, and making it readily available for researchers throughout Argentina.

Key Words

Alien aquatic species, Argentina.

Introduction

Argentina extends from a little north of the tropic of Capricorn (21° Lat. S) down to the tip of Tierra del Fuego (55° Lat. S) and from the Atlantic on the East (54° Long. W.) to the Andes on the West (56° Long. W), covering a surface area of 2 791 810 km2 that rises from sea level up to 7000 m above it (Figure 1). This means the presence of all kind of climates and freshwater systems and habitats, which provide a wide array of conditions for the settlement of alien aquatic species, whether intentional or by accident. The country has a good number of research institutions related to universities or governmental laboratories spread throughout its territory that may address the problem of alien aquatic invasive species. However, literature on the subject of aquatic alien species in Argentina is, at best, scarce and related to pinpoint reports on the presence of particular species. Most information regarding presence or absence of species is gray literature such as internal reports of research institutions or personal notes of researchers. In general terms, and with few exceptions, problems in relation to aquatic invasive species seem to go unnoticed for most part of the Argentine scientific community. Because of this we set out an attempt to build an overview of the issue of alien species in Argentine freshwater systems, having as goals to make a first assessment of the subject, establish future needs and to construct a project proposal to address those needs.

Materials and Methods

In order to do this we conducted a review of existing legislation, available papers, internal reports of research institutions and official organizations, as well as conducting informal email interviews with key researchers and official figures. Information gathered in relation to introduced aquatic alien species and/or detected alien taxa in Argentine freshwater systems found the state of knowledge about each one. The invasive status and problems caused have been summarized, and when possible distribution maps have been drawn with the aid of the GIS RAISON (NWRI 1998). Since for many environments the original biota was not known until recently, we concentrated our efforts on those species that are clearly alien to the country. Native species transplanted between regions or provinces of Argentina will be dealt with in the future.

Results and Discussion

Overall, the review of more than 600 publications and internal reports allowed us to identify only 34 *Limnoperna* alien species reported as introduced or present in freshwater systems of Argentina (Table 1.).

Table 1. List of aquatic related species introduced into freshwater systems or aquaculture facilities of Argentina.

Fishes	Molluscs	Crustaceans	Amphibians	Mammals
Cthenopharingodon idella	*Pseudosuccinea columnella*	*Cherax tenuimanus*	*Rana catesbiana*	*Castor canadensis*
Hypothalmichthys molitrix	*Melanoiddes tuberculata*	*Penaeus paulensis*		*Ondatra zibethicus*
Aristichthys nobilis	*Physella cubensis*	*Cherax quadricarinatus*		*Mustela vison*
Cyprinus carpio	*Physella venustula*	*Macroobracchium rosenbergii*		
Oreochromis niloticus	*Corbicula fluminea*			
Acipenser baeri	*Corbicula largillierti*			
Morone saxatilis	*Lymnoperma fortunei*			
Clarias gariepinus				
Carasius auratus				
Gambusia affinis				
Oncorhynchus mykiis				
Salvelinus fontinalis				
Salvelinus namaycush				
Salmo trutta				
Salmo salar sebago				
Oncorhynchus kisutch				
Oreochromis spp.				
Salmo salar				
Oncorhynchus tshawytscha				

Aquatic Plants

No publications or reports were found describing the presence of aquatic plant invaders, and consultation with aquatic plant specialists revealed that they did not know of any published work concerning aquatic plant invaders. This is in itself strange, because according to aquarium shops aquatic plants are commonly imported for the aquarium trade even though we have been unable to locate records about species and volumes imported. Meanwhile we also have to consider that imported aquarium fish and molluscs seem to have found their way into the wild, yet aquatic plants have not been reported. This is probably due to the fact that people are not generally aware of alien aquatic plant species being a potential nuisance. Given that any new plant as something not previously noticed, to the untrained eye an exotic aquarium plant is indistinguishable from a native one.

Crustaceans

Only three crustacean species are reported as having been introduced into Argentina, all of them for aquaculture purposes and supposedly into closed systems (Luchini, pers. comm.). *Macrobrachium rosenbergii*, (De Mann) was introduced into Misiones, Entre Ríos and Mendoza provinces (Figure 1) before the creation of the aquaculture regulatory

agency, it was believed that it does not reproduce naturally and does not survive under 18°C (Luchini, pers. comm.) Two other species were introduced with aquaculture purposes in mind: *Cherax tenuimanus* (Smith) was authorized to be used in aquaculture facilities in Buenos Aires and Mendoza provinces meanwhile *Cherax quadricarinatus* (Von Martens) was introduced with approval by provincial governments into the provinces of Mendoza, Entre Ríos Santa Fe and Corrientes provinces. Dates of introduction for both species are not known. Specimens are mostly raised in relation to the aquarium trade and therefore it is believed that they may have reached, or will reach, the waterways of the provinces where they were introduced. However, they posses low thermal tolerance and that may help to prevent their spreading. All three species were introduced in provinces belonging to the Parana and Uruguay River basins, which drain water from tropical regions. If they escape from the closed systems the potential exists for their spread into northern parts of Argentina, Uruguay, Paraguay and Brazil, but this has never been fully studied.

Molluscs

Three gastropods and two bivalves have been reported in Argentine continental waters. *Pseudosuccinea columnella* Say 1817 was reported in the 1950s by Hylton Scott (1953), as present in the northern portions of the Parana and in the Uruguay River (Figure 2). It was probably introduced as a by-product of the aquarium trade, and its possible point of origin is Philadelphia. Due to the complexity of these two river basins, and the favorable conditions in them, it is probable that its actual range extends into a much farther area than the two rivers mentioned, but this needs to be confirmed by field surveys.

Melanoiddes tuberculata (Müller 1758), originally from South Asia, was detected for the first time by Peso and Quintana (1999) within the Yacireta dam in the higher reaches of the Parana River (Figure 2). No data exist about the range of it s spread.

Physella cubensis (Pfeiffer 1839) and *Physella* venustula (Gold 1844) detected for the first time by Miquel (1985) have been reported as present on La Plata basin and on Patagonian rivers that drain into the Atlantic respectively (Figure 2). However, this does not provide for an accurate description of their actual range due to the complexity of the Plata basin and the number of drainages in Patagonia that flow to the Atlantic Ocean. In both cases the aquarium trade is thought to be responsible for the introduction of these species, but their points of origin are not known.

Bivalves

Three species of alien bivalves have been found so far in Argentine freshwater systems. These are *Corbicula fluminea* (Müller 1774) known as the Asiatic clam, *C. largillierti* (Philippi 1844) (Corbiculidae) and *Limnoperna fortunei* (Dunker, 1857) called the golden mussel (Mytilidae). These are the three most well know invertebrate invaders, and all three seem to have been introduced accidentally from Southeast Asia trough the Río de la Plata river (Darrigran and Ezcurra de Drago 2000).

Both *C. fluminea* and *C. largillierti* were detected for the first time at the beginning on the 1980s in Argentina by Ituarte (1981) in the Río de la Plata, and by Veitenher-Mendez (1981) in Brazil. Since then a series of papers by various authors summarize the actual knowledge about the species in Argentina (Darrigran 1991, 1992a, 1992b; Darrigran and Colautti 1994; Cazzaniga 1997). The original introductions to both countries probably occurred at the end of the 1960s or the beginning of the 1970s. From then on both species seemed to initially have gone through an expansion phase settling on the Río de la Plata shores. It has been proposed (Darrigran 1991; Darrigran 2000) that *C. fluminea* has some competitive advantage with regards to *C. largillierti*, which would explain the higher densities of the former when living in simpatry. The actual confirmed distribution covers the Río de la Plata, Parana and Uruguay rivers (Darrigran 1992b) main tributaries of the Plata basin (Figure 3), which means that the genus has probably extended to the vast and intricate network of flowing waters that form the basin. The genus *Corbicula* has also been found outside the Plata basin on the Colorado River (Cazzaniga 1997) (Figure 3).

Impacts of both species have not been reported for Argentina except in terms of dietary changes of a native fish (Darrigran and Colauti 1994). Problems due to macrofouling phenomena by this genus have been reported only for southern Brazil (Darrigran and Ezcurra de Drago 2000).

Limnoperna fortunei is perhaps the most well known case of an invasive species in Argentina. Detected for the first time in Bagliardi beach on the Río de la Plata (Pastorino and Darrigran 1993) it is believed to have come from Southeast Asia as a stowaway in ballast water (Darrigran and Pastorino 1995). It has extended it is range into Brazil trough the Plata Basin at a rate of 240 km a year (Darrigran and Ezcurra de Drago 2000). According to Darrigran (in press) *L. fortunei* has high biotic potential, absence of competitors, the high densities it attains (circa 150 000 ind/m^2) and the problems it causes to both natural and man made environments makes them a highly invasive species. Its effects upon human environments have been compared to those caused by the zebra mussel in the northern hemisphere (Darrigran and Ezcurra de Drago 2000) and can be summarized as reduction and blockage of pipe diameters, decreased water velocities in pipes, and filter clogging. On the other hand in natural environments the effect of the golden mussel has been documented to have related to changes in physical and biotic characteristics of the benthos. Thus species diversity and richness of the benthic community is changed, with Oligocaheta and Hirudinea been favoured (Darrigran et al. 1998), meanwhile native molluscs are adversely affected (Martin and Darrigran 1994). Another type of impact has been reported in relation to trophic foods webs where L. *fortunei* has become another food item on fish diets (Penchaszadeh et al. 2000; Montalto et al. 1999).

As Darrigran correctly points out (Darrigran, in press) due to the watershed area of the Plata Basin (Figure 4) and the concentration of human population in it, *L. fortunei* is doomed to become a major problem in terms of its action upon water works and hydroelectric infrastructure. Even though the general public is not aware of the actual and potential problems, research has been fostered by those industries directly affected (see Darrigran this publication) giving rise to a number of papers (Darrigran et al. 1988; Darrigran and Escurra de Drago 2000; Darrigran et al. 1999; Ezcurra de Drago et al. MS; Maromas et al. MS).

Fish

Most alien aquatic species in Argentina that have been reported so far are fish with a total of 21 species (Lopez 2001). They are also the group for which most scientific knowledge has been generated throughout Argentina. The first recorded introduction corresponds to *Cyprinus carpio* Linnaeus 1758 that was apparently introduced for the first time in the 19th century into Entre Ríos province (Baigun and Quiros 1985). Propagation of the species (Figure 5) is due to aquaculture purposes (Marini and Mastrarrigo 1963), connecting waterways, and also probably from flooding and overflowing phenomena such as was experienced in 1982 in the Salado Basin. Considered a nuisance species, its commercial use has been regularly suggested as a food source as a form of control. A Hungarian variety of *C. carpio*, is reported as restricted to the province of Formosa, no clear indication of date of introduction, or location exist.

Specimens of *Ctenopharingodon idella* Valenciennes 1844 also called grass carp or "espejo" were introduced for the first time in 1970s from Japan in an attempt to use them as biological agents for plant control in waterways and lenthic bodies (Aramburu 1971; Baigun and Quiros 1985). Released originally in a small lagoon in Buenos Aires province they seemed to have adapted and spread (Figure 5). Its actual range is not known and no maps of its probable distribution can yet be drawn.

Two other species of carp *Aristichthys nobilis* (Richardson 1845) (silver carp) *Hypopthalmichthys molitrix* Valenciennes 1844 (bigheaded carp) were introduced with aquaculture in mind. No clear indication of its presence or absence from freshwater habitats exist (Figure 6). Meanwhile silver carp was introduced in 1970s and again in the 1980s, but no dates are available for the bighead carp. It is believed that both species do not reproduce in the wild.

Acipenser baerii Brandt 1869 (sturgeon) specimens were caught in the Uruguay River (Figure 6). These would be escapes from aquaculture facilities on the Uruguay Republic. It is thought that the species has not managed to acclimate itself as to produce naturally sustaining populations, but this is still to be proven. Recently a 3.5 kg specimen was caught in the Río de la Plata River at Buenos Aires, approximately 300 km from the point of escape in the Uruguay River.

Clarias gariepinus Burchell 1822, the African catfish, was illegally introduced into the province of Misiones (Figure 6) no precise date exists for this introduction, and even though there is an agreement and an official resolution to eradicate it, we have not been able to locate a contingency plan or agency in charge of the task.

The exact date of introduction of *Carassius auratus* (Linnaeus 1758) is not known. According to Baigun and Quiros (1985) this was probably by the end of the 19th century and the probable cause of introduction was for use as an ornamental fish. This species has a wide distribution in favorable environments of central Argentina from where it was first reported (Baigun and Quiros 1985) and probably propagated to other provinces through aquarium dumping into the river systems and outdoor ponds, and posterior emigration into connecting waterways. Thus it is probable that its actual range is far greater than that originally reported by Baigun and Quiros (1985) (Figure 6).

Morone saxatilis (Walbaum, 1792), stripped bass, was originally introduced in Entre Rios province (Figure 6) from the United States with permission by official agencies for aquaculture. Supposedly aquaculture systems are closed, and all specimens' triploids, and therefore they are not considered a direct threat.

Oreochromis niloticus Linnaeus 1758, known as the Nile tilapia, was introduced circa 1940 but the first official records date from the 1950s in Misiones province (Figure 6), where it was reintroduced on several occasions, as well as on Formosa province. Specimens from Paraguay and Brazil were brought in the 1970s, and been introduced into Corrientes province. Another variety of tilapia, known locally as red tilapia, was introduced from Israel into Misiones province (Figure 6) and is currently cultured to develop parental stocks. Supposedly they have not managed to establish self-reproducing populations despite numerous escapes from aquaculture facilities and this is unofficially attributed to environmental characteristics and predation from native fish.

Twenty thousand specimens of *Gambusia affinis* (Baird and Grant 1953) or mosquito fish were introduced in 1943 as a biological agent to control paludism (Mastrarrigo 1947; Marini and Mastrarrigo 1963; Ringuelet 1966) and apparently it had no problem acclimating itself to the environments found in Northeastern Argentina. Floods and its use as live bait insured a wide distribution for the species (Figure 7).

Introductions of salmonids with recreational fishing in mind started in 1904. Hatcheries were built and staffed by technicians hired from abroad, and importing eggs of different species both from the United States and Europe. This was followed by a massive unplanned stocking program of imported, and later on locally raised, broods that have allowed wide dispersal of three species *Oncorhynchus mykiss* (Walbaum 1792) (Figure 8), *Salmo trutta* Linnaeus 1758 (Figure 9) and *Salvelinus fontinalis* (Mitchill 1814) (Figure 10) and local settlements of four other species: *Salvelinus namaycush* (Walbaum 1792), *Oncorhynchus tshawytscha* (Walbaum 1792), and *Salmo salar* Linnaeus 1758 (Figure 7). Detailed reviews of the introductions have been given by Marini (1936); Baigun and Quiros (1985); Vigliano and Alonso (in press) and Pascual et al. (in press). However, it is noteworthy that *Oncorhynchus mykiss*, originally introduced from the US in 1904 and widely cultured in Patagonia since then, has been transplanted to almost any water body of Argentina that holds suitable conditions for the species. As a result this has become the most widely dispersed *salmo*nid ranging from cold mountain streams and rivers at the Argentine tropics down to the tip of Tierra del Fuego (Figure 8). It has also been found recently (Pascual, pers comm.) that the species has established sea runs in the province of Santa Cruz.

Specimens of *Salmo trutta* were originally introduced from England in 1909, then spreading through Patagonia (Figure 9). Culture of the species is almost non existent and mostly experimental. This species also managed to establish sea run stocks on Santa Cruz and Tierra del Fuego, which have become world-class sportfisheries (Vigliano and Alonso 2000).

Salvelinus fontinalis and *Salvelinus namaycush*, both introduced from the US in 1904, developed self supporting stocks in Patagonia. Brook trout is present in all Patagonia provinces and Tierra del Fuego (Figure 10), and lake trout is present only in a handful of environments related to the Santa Cruz and San Martin basins (Figure 7).

The latter would also be the case for landlocked *Salmo salar* (Figure 7), which was introduced from the US beginning in 1904 into many environments but managed to establish self-supporting populations in only a few localities and is now perceived by sportfishing outfitters as declining even in those environments — once viewed as world class recreational fisheries.

Initial introductions of *Oncorhynchus tschawyscha*, (chinook *salmo*n) from the US in 1904 failed and the species was thought to be absent until the 1980s when fishermen's reports of catching specimens on the Corcovado and Pico Pacific drainage basins (Figure 7) were confirmed. It is quite probable that these specimens are not descendants of the original introductions but escaped specimens of the Chilean aquaculture facilities that have migrated upriver and established self-supporting runs.

Interestingly *salmo*nids are both viewed as a nuisance species for those concerned with preservation of native fish faunas, and as a blessing by those that earn their livelihood from sport fishing. Whatever the impact of *salmo*nids on native assemblages, the lack of previous studies makes assessing impacts difficult. However intensive work on the subject is currently underway by at least two groups (Vigliano and Alonso, in press and unpublished data, and Pascual et al., in press).

Amphibians

To date *Rana catesbiana* Shaw 1802 is the only amphibian to have been reported as an exotic in Argentine continental waters (Luchini, pers comm.) Introduced for the first time in 1935, and later in the 1980s with some sort of government approval for aquaculture purposes, it has found its way into the deltaic system conformed by the rivers Parana and Uruguay (Figure 11); which due to its characteristics makes it an ideal environment for the species. However there are no studies pertaining to the existence and distribution of natural populations. It is also noteworthy that official agencies maintain that because a native frog is hunted for its meat, this frog would also be hunted. No studies about their impact on local biota or systems, or degree of spreading exist.

Mammals

To date three mammal species have had a high impact on aquatic ecosystems of Argentina: the beaver (*Castor Canadensis* Khul 1870), the muskrat (*Ondatra zibethicus*, Linnaeus 1776) and the vison (*Mustela vison* Schreber1777). The first two were introduced into Tierra del Fuego in the 1940s, with no natural predators, and have thrived and colonized the entire Island of Tierra del Fuego both on Chile and Argentina (Figure 11).

Beavers have had a tremendous impact on forest and river dynamics. Before their introduction the forest ecosystem of Tierra del Fuego lacked the typical beaver dikes and flooded forest sectors which are know common and extend through the entire province. Studies related to impacts are scarce (Daciuk 1978). Management of the species is restricted to a kill quota, which is established arbitrarily with out any studies that may support the numbers to be killed. According to unconfirmed reports beavers may have crossed Magellan's straight, on to Chile as recently as a year ago. If this should be true, it would require immediate action to control them before they expand northwards into the Andean Patagonic forest.

The muskrat impacts on the Island are even less studied than those of the beaver and as far as official organizations go they are mostly ignored. There are no reports concerning the possibility that this species may have crossed Magellan's straight.

The vison (*Mustela vison*) was introduced to Chubut and Santa Cruz provinces for pelt production. Escaped or released animals rapidly adapted to the Andean Forest ecosystem, dispersing through interconnecting water bodies. Even thought no actual studies exist, it is considered that they have managed to expand to the entire Andean sector of Patagonia, but have not crossed Magellan's straight into Tierra del Fuego (Figure 11). Their spread has seemingly brought problems for birds, based on perceptions by park rangers and bird watchers of a decline in numbers concurrent with the presence of visons in an area previously free of them. Being excellent swimmers, they also attack fish and it is common from Santa Cruz to Neuquen for them to catch *salmo*nid with their distinctive bight marks (Vigliano unpublished data). This has raised concerns among sport fishing organizations and outfitters in relation to their impact on recreational fisheries.

Legislation and Policies

The review of existing laws and policies regarding the issue of aquatic alien invaders fall, at best, short of the mark. Argentina is among the first of Latin American countries to legislate in relation to the threat of ballast water stowaways in general, and of the golden mussel in particular, by having its Coast Guard issue specific legislation concerning the prevention of the introduction of new alien aquatic invaders in the Plata basin (DPMA 1998). However, it has not made this legislation applicable to maritime ports outside this basin.

Also we may consider that a national law establishing the rules for purposeful introduction of alien species to aquatic systems exists. However this law (RESOLUCION 987) is general in nature establishing the need for an official permit in order to introduce an alien species into water bodies. The same law establishes that a particular government section is in charge of giving permits, prohibiting the introduction of species, and establishing contingency measures to avoid the settling and growth of unwanted species. However, we have been unable to locate protocols or contingency plans to follow in case such an introduction is requested, or the spreading of a particular nuisance species is to be eradicated. Also there are no specific funding provisions to deal with the different aspects that relate to the subject. Furthermore, local and provincial legislation commonly overlap and are in conflict with one another. Thus meanwhile one local agency may authorize an introduction, it may be prohibited at the national level by another agency or vice versa.

Discussion

When we reviewed the available information it became clear from even the earliest stages that the major problem in relation to handling aquatic alien invasions in Argentina was not the existing lack of specific knowledge. The country has the necessary facilities and human resources to quite rapidly generate any necessary information. The biggest problem has been the lack of awareness among politicians and decision makers of the importance and extent of the threats posed by alien aquatic invaders. Only those industries directly under threat from an alien invader, as is the case with hydroelectric power plants and *Limnoperna fortunei*, take any action to try to control a specific problem. This lack of awareness is linked to the lack of economic development in Argentina, which has not only taken the country towards an actual economic collapse, but has also diverted attention and funds from basic research, and issues such as aquatic invaders. If one looks at the history of Argentina during the past 30 years, one finds out that is has been characterized by political and economic instability. Within that context it is not surprising that alien aquatic invaders have never been an official issue. It is doubtful that the situation will change unless the economic situation of the country changes. We have to understand that in any country where the main problem has become how to secure a minimum income for most of the people, aquatic invaders and the problems they cause are outside political agendas. This has caused us to believe that alien aquatic invaders find in Argentine freshwater environments a wonderland were they can thrive and for the most part pass unnoticed. It is only when a particular invader has a profound effect, like hydroelectric power generation, that a fast response occurs.

Within this context it should be obvious that unless the economic situation changes radically, political goals and funds will be focused elsewhere. This being the case, and also considering that the information that we managed to collect and present during this conference is at best sketchy, and that many of the basic data for the species mentioned here can be summarized as unknown, we therefore considered that the best step we can take is to start a low cost project having as a goal the creation of geo-referenced GIS-associated database of confirmed reports of alien species in freshwater environments. This would allow us to produce absence/presence matrixes and up-to-date distribution maps, and if possible in the long run a free access database to all those interested on the subject. Information gathering will be primarily through e-mail electronic censuses to all subject related research, academic and monitoring agencies and individuals. Target species will be all potential alien plant or animal species related to freshwater systems. The database will be initially structured in five modules: wildlife, fish, crustaceans, molluscs and aquatic plants. Each module will be the direct responsibility of a researcher who works on the specific taxonomic field and meanwhile all will use the same data structure, GIS gathering strategy and analysis procedures. Each module will be allowed to grow independently according to their own possibilities in terms of available information and funding sources. Furthermore, each module may be subdivided into taxonomic groups if the information gathered allows it. Maps produced will be available to contributors and eventually a free access Web site will be established.

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Figure 1. Introduction of crustacea with culture purposes *C.q.*: *Cherax quadricarinatus*, *C.t*: *Cherax tenuimanus*, *M.r. Macrobrachium rosenbergii*. Date and exact location of introduction unknown

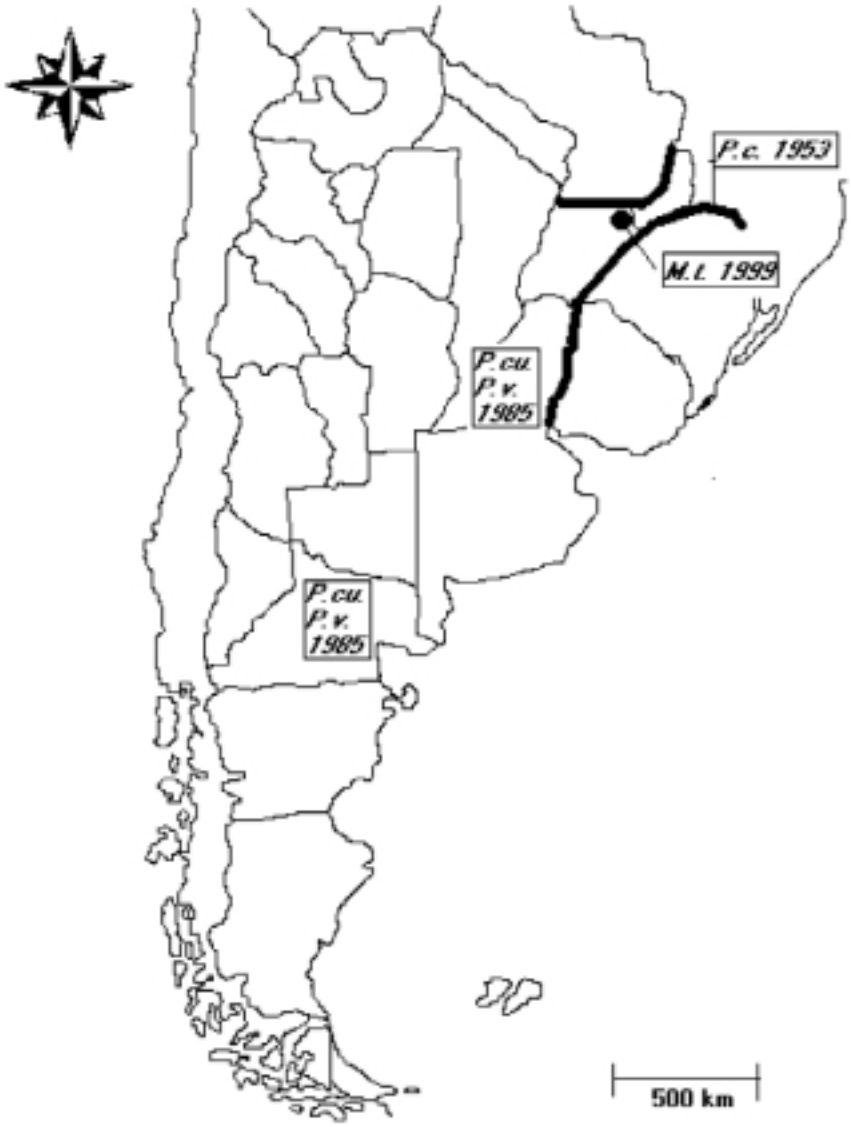

Figure 2. Report of presence of alien gastropoda on river systems *M.t.*: *Melanoiddes tuberculata*, *P.c.* : *Pseudosuccinea columnella*, *P. cu.*: *Physella cubensis*, *P.v.*: *Physella venustula*. *1953* : year of first detection.

Figure 3. Known distribution of *C.f.*: *Corbicula fluminea*, *C.l.*: *C. largillierti*. *1980* year of first detection.

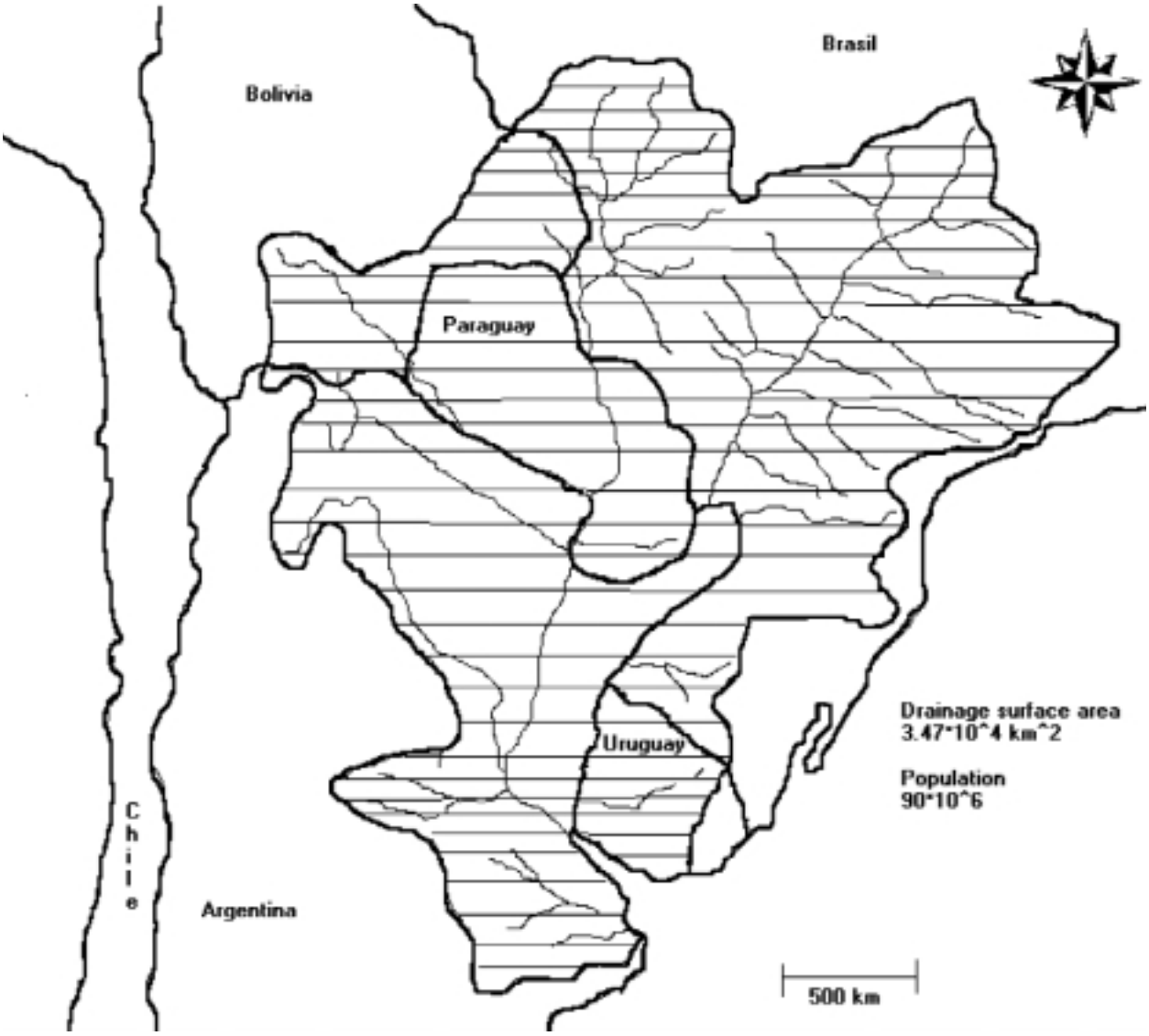

Figure 4. Expected spread of *Limnoperna fortunei* into La Plata basin.

Figure 5. Know distribution of *C.c.: Cyprinus carpio, C.i.: Ctenopharingodon idella.*

Figure 6. Known distribution of *C.a.: Carasius auratus, A.n.: Aristichthys nobilis, H.m.: Hypopthalmichthys molitrix A.b.: Acipenser baerii, C.g.: Clarias gariepinus, M. s :Morone saxatilis, O.n.: Oreochromis niloticus.* ? :Date and exact location of introduction not known. (Modified from Baigun & Quiros, 1985, Pascual et al. in press, Vigliano & Alonso in press.).

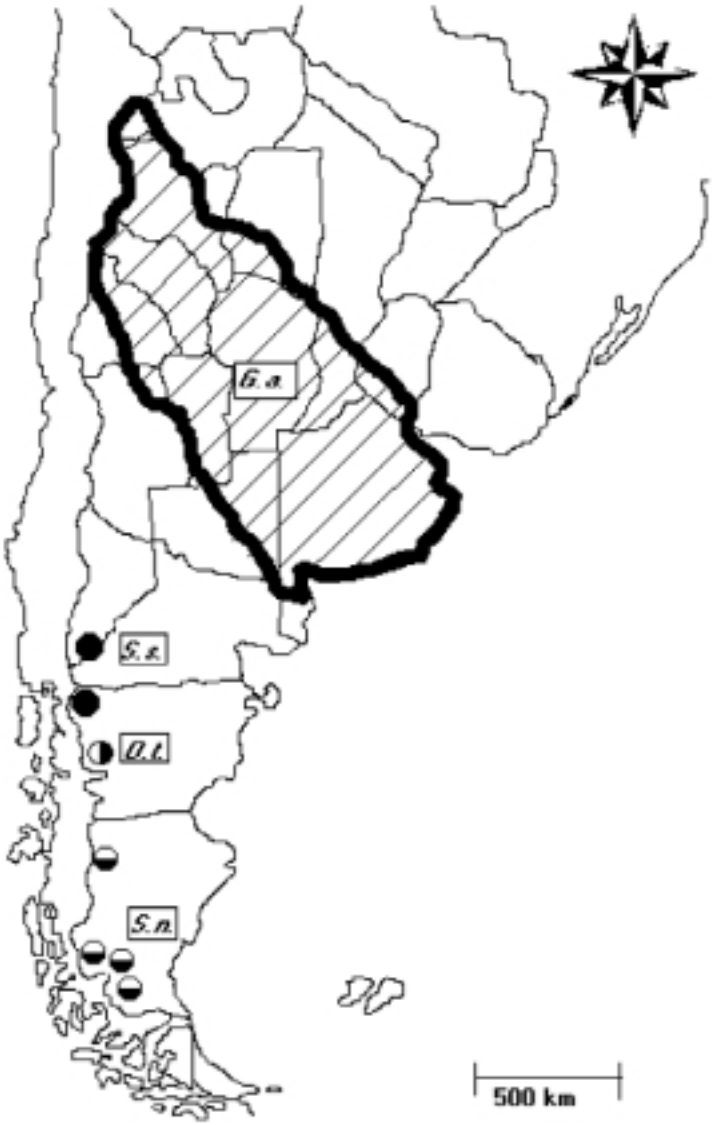

Figure 7. Known distribution of *G.a.: Gambusia affinis, S.s.: Salmo salar, O.t.: Oncorhynchus tshawytscha, S.n.: Salvelinus namaycush.* (Modified from Baigun & Quiros 1985; Pascual et al. in press; Vigliano & Alonso in press.).

Figure 8. Known distribution of *Oncorhynchus mykiss*. (Modified from Baigun & Quiros 1985; Pascual et al. in press; Vigliano & Alonso in press.)

Figure 9. Known distribution of *Salmo trutta*. (Modified from Baigun & Quiros 1985; Pascual et al. in press; Vigliano & Alonso in press.)

Figure 10. Known distribution of *Salvelinus fontinalis*. (Modified from Baigun & Quiros 1985; Pascual et al. in press; Vigliano & Alonso in press.)

Figure 11. Known distribution of *R.c.: Rana catesbiana*, *M.v.: Mustela vison*, *C.c.: Castor Canadensis* and *O.z.: Ondatra zibethicus*.