**ABSTRACT**

The largemouth bass, *Micropterus salmoides* (Lacepède, 1802), is a centrarchid fish from North America that is now globally distributed because of wide-spread introductions for sport fishing. Its introduction in Brazil dates from the 1920's, primarily in southern regions. *Micropterus salmoides* is already known to have created a series of impacts in the ecosystems in which it is established. However, its parasite fauna in Brazil is unknown. This opens the possibility of new interactions and potential impacts. Therefore, the goal of the present study was to analyze the parasite fauna of *M. salmoides* in four reservoirs in southern Brazil, measuring the prevalence and mean abundance in each reservoir. A total of 59 individuals of *M. salmoides* were analyzed, 15 from each reservoir, except for the Capivari-Cachoeira Reservoir, with 14 individuals. Of the fish analyzed, 91.5% were parasitized by 1567 parasites belonging to four species, three nematodes: larval *Contracaecum* sp. (86.4%), *Procamallanus* (*Procamallanus*) *peraccuratus* Pinto, Fabio, Noronha & Rolas 1976 (6.7 %) and *Hysterothylacium brachyurum* Ward & Magath 1917 (6.7 %), and one species of monogenean flatworm: *Onchocleidus principalis* (Mizelle, 1936) (57.6 %). From these results we can conclude that the process of co-introduction and spillback is still in the early stages, mostly by the low diversity of parasites. Therefore, monitoring and control actions are highly recommended in order to both control the impacts of parasite infections as well as to promote mitigation of activities and prevention campaigns.

**Keywords:** Biological invasion – Largemouthbass – Neotropical Ichthyoparasitology – Nonnative parasites

doi:10.24039/rnh2020141610
INTRODUCTION

Biological invasions leads to novel interactions and negative impacts in native ecosystems (Elton, 1958; Lockwood et al., 2007). Globalization and its routes of transport and commerce plays a role as vectors and pathways in introduction events and large-scale dispersion of many invaders (Hulme, 2009). And this species never comes alone, bringing with them new parasites and pathogens. Which are responsible for changing the balance of the community interactions in its new environment. (Lockwood et al., 2007, 2009; Cassey et al., 2018). The process of parasites co-introduction is not yet contemplated in most of the invasion frameworks, what is justified by the fact that the forces which influence the invasion in free living organisms is different than for parasites (Taraschewski, 2006; Hulme, 2009; Carrete et al., 2012; Blackburn & Ewen, 2017). For example, the stages of introduction and establishment of parasites depends on the prevalence rate in the introduced host and the probability of finding suitable hosts to complete its life cycle in the environment (Hatcher et al., 2012).

Host-parasite interaction can influence community structure in several ways (Price et al., 1986; Dunn & Hatcher, 2015; Calhoun et al., 2018). A parasite can interconnect a series of trophic levels through its life cycle, modulating the population growth of the host species and the apparent level of competition in the ecosystem (Prenter et al., 2004). When successfully co-introduced, a parasite species can spillover to native hosts in the new ecosystem, which may lead to a highly pathogenic interaction due to the lack of co-evolutionary history between the parasite and the new host. Besides that, a nonnative host can also be infected by native parasites, i.e. spillback, which can make this new host a reservoir for the native parasite species, increasing its prevalence in the ecosystem (Kelly et al., 2009; Dunn, 2009; Dunn & Hatcher, 2015). These two possible impacts are influenced by the encounter between susceptible and infected hosts (Telfer & Brown, 2012).

The fish Micropterus salmoides (Lacépède 1802) (Perciformes: Centrarchidae) is a species of great importance in sport fishing because of its characteristics as a top predator, including its large size and voracity (Jackson, 2002; Brown et al.,...
The species is native to North America but is already established in more than 50 countries, and is responsible for changes in ecosystems around the world (Brown, 2009; Van Der Walt et al., 2016; Froese & Pauly, 2016). The impacts caused by *M. salmoides* have led its inclusion in the list of the 100 worst invasive species in the world, which makes its management and control a priority (Lowe et al., 2000). In Brazil, it was introduced in the 1920's and was originally established in the southern region (Schulz & Leal, 2005; Ribeiro et al., 2015; Frehse et al., 2016).

The parasite fauna of *M. salmoides* is well known in its native area, although there are few studies where it has been introduced. Of those, none was concerning the ecological impacts of co-introduced parasites in the new environment (Costa et al., 2018). Information concerning the possible direct and indirect impacts of *M. salmoides* in Brazil's native communities is essential to ensure effective management and control. The fact that *M. salmoides* is well established and can be found in great abundance in the south of Brazil increases the probability of co-introduction and spillover of parasites, leading to possible secondary impacts related to the invasion by *M. salmoides* (Taraschewski, 2006). Therefore, the present study aimed to provide an evaluation of the helminth parasite fauna of *M. salmoides* in Brazil and the possible impacts it may have on the invaded ecosystems.

**MATERIAL AND METHODS**

We sampled four reservoirs in South Brazil, on the metropolitan region of Curitiba, Parana, Brazil. The reservoirs were chosen primarily by its abiotic similarities, are in the same basin, and have a small distance between each other. In the environmental matter they are all categorized as moderately degraded and are localized in the same basin with a maximum distance of 78 km by each other (Rodrigues et al., 2005; Brunkow et al., 2009; Xavier et al., 2009; Seara, 2010; Da Conceição et al., 2014).

The reservoirs sampled were: Piraquara I (25°29'48.1"S 49°01'05.0"W), Passaúna (25°27'41.2"S 49°22'58.4"W), Capivari-cachoeira (25°11'39.1"S 48°52'35.2"W) and Vossoroca (25°50'32.6"S 49°04'31.8"W).

The sampling effort was thought in a way that maintained the same number of hosts (15 hosts by reservoir) with similar average life stage, all adults. Samples were all collected in the spring of 2015, to decrease the influence of seasonality on the parasite diversity between the reservoirs. All individuals of *M. salmoides* were captured using rod, hook, and artificial baits, in the period necessary to reach the number of samples previous stipulated (Parana, 2005). The fishes sampled were anesthetized, killed by spinal section and taken to the Zoology Laboratory of the Federal University of Parana (Underwood et al., 2013). There, they were numbered, measured (cm) (total and standard length) and weighed (g). The gastrointestinal tract and viscera were collect for endoparasite samples and gills were separated for ectoparasite analyzes, both were fixed in formol 5%. The parasites were collected, quantified and preserved in ethyl alcohol 70% and prepared for identification following the methods and protocols for which taxa described in Eiras et al. (2006). The species of parasites were identified using the classical studies of Margolis & Kabata (1984), Moravec (1998) and Hoffman (1999).

The parasite variables calculated were the parasite richness of each reservoir class. Abundance, prevalence and mean abundance of which parasite species followed by Bush et al. (1997).

Ethic aspects: The authors point out that they fulfilled all national and international ethical aspects.

**RESULTS**

A total of 59 individuals of *M. salmoides* were analyzed, 15 from each reservoir, except for Capivari-Cachoeira Reservoir, with 14 individuals. The mean and SD of the hosts total length analyzed was 31.41 ± 3.50 cm in Passaúna reservoir, 28.7 ± 7.03 cm in Piraquara I reservoir, 31.75 ± 2.58 cm in Vossoroca reservoir and 31.94 ± 7.19 cm in Capivari-cachoeira reservoir. All the
reservoirs sampled had 100% of the fishes parasitized by some species of helminth, with exception of Capivari-Cachoeira reservoir, that had only 66.67 % of infected hosts. The parasites sampled belong to four species, three nematodes: Contracaecum sp. in their larval stage according to Moravec, Kohn & Fernandes, 1993 found encysted in the stomach external wall; Procamallanus (Procamallanus) peraccuratus Pinto, Fabio, Noronha and Rolas, 1976, and Hysterothylacium brachiurum Ward & Magath, 1917, both found inside the intestine of the hosts; and one species of monogenean infecting the host’s gills: Onchocleidus principalis (Mizelle, 1936). Of these, Contracaecum sp. and O. principalis were recorded in all the reservoirs sampled, while P. peraccuratus and H. branchiurum were found in only one reservoir each. All the parasite variables of prevalence, mean abundance, number of parasite sampled by reservoir and number of infected fish can be seen in Table 1.

Table 1. Helminth parasites of Micropterus salmoides by reservoir sampled, all located in the metropolitan region of Curitiba, Paraná, Brazil. IF: Number of Infected Fish; NP: Number of Parasites; P%: Prevalence; MA±SD: Mean Abundance ± Standard Deviation.

| Reservoir               | Parasites         | IF | NP  | P%  | MA ±SD    |
|-------------------------|-------------------|----|-----|-----|-----------|
| Passaúna (N=15)         | P. peraccuratus   | 1  | 1   | 6.7 | 0.07 ±0.3 |
|                         | O. principalis    | 2  | 5   | 13.3| 0.33 ±0.9 |
|                         | Contracaecum sp.  | 15 | 149 | 100 | 9.9 ±11.8 |
|                         | H. branchiurum    | 1  | 1   | 6.7 | 0.07 ±0.3 |
| Piraquara (N=15)        | O. principalis    | 15 | 237 | 100 | 15.8 ±15.3|
|                         | Contracaecum sp.  | 15 | 394 | 100 | 26.7 ±15.2|
| Capivari-cachoeira (N=14) | O. principalis  | 2  | 4   | 14  | 0.3 ±0.8  |
|                         | Contracaecum sp.  | 7  | 70  | 50  | 5 ±11.07  |
| Vossoroca (=15)         | Contracaecum sp.  | 14 | 387 | 93  | 21.7 ±19.7|
|                         | O. principalis    | 15 | 319 | 100 | 25.8 ±14.2|
|                         | H. branchiurum    | 1  | 1   | 6.7 | 0.07 ±0.3 |
|                         | P. peraccuratus   | 1  | 1   | 6.7 | 0.07 ±0.3 |
|                         | O. principalis    | 34 | 565 | 57.6| 16.6 ±15.18|
| Total                   | Contracaecum sp.  | 51 | 1000| 86.4| 19.6 ±16.83|

DISCUSSION

The invasion of M. salmoides is responsible for several disturb in places where it was introduced, although the impacts related to its parasite community in Brazil were not known until the present study (Ribeiro et al., 2015; Costa et al., 2018). The native helminth fauna of the fish M. salmoides is well studied, with more than 50 species of parasites recorded in its native region (Hoffman, 1999; Costa et al., 2018). The nematodes Contracaecum sp. and H. branchiurum observed during the present study have also been noted parasitizing M. salmoides in its native environment (Hoffman, 1999; Tavakol et al., 2015). The same is true for the monogenean O. principalis (Galaviz-Silva et al., 2016). However, the nematode P. peraccuratus is a parasite native to South America, which makes its infection in M. salmoides a possible instance of parasite spillback (Azevedo et al., 2006; Takemoto et al., 2009).

The helminth parasite fauna observed in the present study showed low species diversity in comparison with studies conducted in the native region (Costa
et al., 2018). It is known that most of the parasite community are introduced with its host, although is probably lost on the initial stages of introduction. Mainly by its difficulty of adaptation in the nonnative environment (MacLeod et al., 2010; Carrete et al., 2012; Lymbery et al., 2014, Blackburn & Ewen, 2017). Yet, highly stress situation in the capture and transportation of nonnative hosts can influence its immunologic conditions, selecting more resistant propagules (Carrete et al., 2012). The introduction of *M. salmoides* in the reservoirs sampled during the present investigation is still recent (the reservoirs were constructed from the 1960's to the 1980's). So, once *M. salmoides* are constantly introduced in reservoir by multiple fonts (mostly fishermen) of several distinguish life stage and local fonts, the richness and prevalence of nonnative parasite may increase with time, as its chances to establish in a nonnative environment (e.g. Vitule et al., 2009; Ribeiro et al., 2015).

In the present study only one specimen of both *H. brachyurum* and *P. peraccuratus* was found. The nematode *H. brachyurum* is commonly found parasitizing the genus *Micropterus*. It has been registered previously in the species *M. dolomieu*, in Michigan, and in *M. salmoides*, also in the USA (Amin & Minckley, 1996; Gopar-Merino et al., 2005); this paper represents the first record of the species in Brazil. As for *P. peraccuratus*, it has only been recorded in Brazil, parasitizing primarily cichlids (Moravec et al., 1993; Azevedo et al., 2006; Takemoto et al., 2009). According to standard practice, a host-parasite relationship is only considered to be effective if it results in at least one other case of parasite infection, *i.e.* when the rate of the parasite reproduction in the new host is greater than one (Hatcher et al., 2012, Blackburn & Ewen, 2017), or if the prevalence of infection is greater than 10% (Bush et al., 1990). Although more studies need to be done to confirm both infections, we cannot discard the possibility of a co-introduction event in the case of *H. brachyurum* and a spillback event for *P. peraccuratus* (Kelly et al., 2009). In relation to *Contracaecum sp.*, its larval stage is very generalist and are globally distributed, once its final host are mainly piscivorous birds (Madi & Silva, 2005; Takemoto et al., 2009; Tavakol et al., 2015). This parasite has a complex life cycle, and *M. salmoides*, among other intermediary host, has its infection influenced by its trophic level; *i.e.* top predators typically have a higher probability of parasite infection (Lafferty & Morris, 1996; Poulin & Leung, 2011; Chen et al., 2008).

The species *O. principalis* has a high level of specificity to the genus *Micropterus*, what makes it presence an event of co-introduction (Maitland & Price, 1969; Margolis & Kabata, 1984; Collins & Janovy, 2003). Although, over the several monogenean species that parasite *M. salmoides* (Hoffman, 1999; Galaviz-Silva et al., 2016; Costa et al., 2018), only one was found in this study. This shows a clear example of enemy release, still the high abundance of *O. principalis* in two of the reservoirs sampled could be a compensation of the poor parasite richness (Colautti et al., 2004; Roche et al., 2010).

This study shows only a preliminary sample of the parasite community of *M. salmoides* in Brazil, what may increase in studies in other regions that include seasonal samples. This allied to a constant monitoring of the impacts made by these parasites on the nonnative environments of *M. salmoides*. However, we presented important information for the introduction management and control for nonnative hosts and its parasites. The parasite fauna of *M. salmoides* can lead to multiple scenarios of indirect impact. For example, the increase in the prevalence of native parasites caused by *M. salmoides* serving as a reservoir for infection can facilitate the invasion success of the host. The presence of *M. salmoides* can also lead to a decrease in the prevalence and intensity of native parasites in the cases where *M. salmoides* does not serve as a proper host that can be included in the parasite's life cycle. Furthermore, the co-introduction of parasites may lead to emergent diseases in the new environment because of the lack of co-evolutionary history in the host-parasite relation, or because of the occurrence of apparent competition, which may decrease the population of native fishes in the ecosystem (Strauss et al., 2012; Blackburn & Ewen, 2017; Young et al., 2016). Finally, more than that, the parasite community dynamics in a nonnative host may suffer temporal variations (tend to increase its richness over time), increasing the links of connectance and nestedness in trophic networks, or changing its patterns of predation and competition; primordially in the early stages of the host.
introduction. The current paper represents a first record of the *M. salmoides* parasite fauna in Brazil. From the results cited we can conclude that the process of co-introduction and spillback is still in the early stages and that management actions are highly recommended in order to both control the impacts of parasite infections as well as to promote mitigation activities.

**ACKNOWLEDGMENTS**

We are grateful CAPES and CNPq. JRSV received productivity grants from CNPq (numbers 310850/2012-6 and 303776/2015-3).

**BIBLIOGRAPHIC REFERENCES**

Amin, OM & Minckle, WL. 1996. *Parasites of some fish introduced into an Arizona reservoir; with notes on introductions*. Journal of the Helminthological Society of Washington, vol. 63, pp. 193–200.

Azevedo, RK, Abdallah VD & Luque, JL. 2006. *Ecologia da comunidade de metazoários metazoários parasitos do acará Geophagus brasiliensis (Quoy e Gaimard, 1824) (Perciformes: Cichlidae) do rio Guandu, Estado do Rio de Janeiro, Brasil*. Acta Scientiarum. Biological Sciences, vol. 28, pp. 403–411.

Blackburn, TM & Ewen, JG. 2017. *Parasites as drivers and passengers of human-mediated biological invasions*. Ecolhealth, vol. 14, pp. 61–73.

Brown, TG, Runciman, B, Pollard, S & Grant, ADA. 2009. *Biological synopsis of Largemouth Bass (Micropterus salmoides)*. Canadian manuscript report Fisheries and aquatic sciences, vol. 2884, pp. 1-16.

Brunkow, RF, Dias, LN, Wosiack, AC & Xavier, CF. 2009. *Monitoramento da qualidade das águas: Reservatório do Estado do Paraná 2005 a 2008*. Brasil: IAP- Instituto Ambiental do Paraná.

Bush, AO, Aho, JM & Kennedy, CR. 1990. *Ecological versus phylogenetic determinants of helminth parasite community richness*. Evolutionary Ecology, vol.4, pp. 1-20.

Bush, AO, Lafferty, KD, Lotz, JM & Shostak, A. 1997. *Parasitology meets ecology on its own terms: Margolis et al. revisited*. Journal of Parasitology, vol. 83, pp. 575-583.

Calhoun, DM, McDevitt-Galles, T & Johnson, PTJ. 2018. *Parasites of invasive freshwater fishes and the factors affecting their richness*. Freshwater Science, vol. 37, pp. 134-146.

Carrete, M, Edelaar, P, Blas, J, Serrano, D, Potti, J, Dingemanse, NJ & Tella, JL. 2012. *Don't neglect pre-establishment individual selection in deliberate introductions*. Trends Ecology and Evolution vol. 27, pp. 67–68.

Cassey, P, Delean, S, Lockwood, JL, Sadowski, J & Blackburn, TM. 2018. *Dissecting the null model for biological invasions: A meta-analysis of the propagule pressure effect*. Plos biology, vol. 16, e2005987.

Chen, HW, Liu, WC, Davis, AJ, Jordán, F, Hwang MJ & Shao, KT. 2008. Network position of hosts in food webs and their parasite diversity. Oikos, vol. 117, pp. 1847–1855.

Colautti, RI, Ricciardi, A, Grigorovich, IA & Maclsaac, HJ. 2004. *Is invasion success explained by the enemy release hypothesis?* Ecology Letters, vol. 7, pp. 721–733.

Collins, MR & Janovy, J. 2003. *Host specificity among Ancyrocephalinae (Monogenoidea) of Nebraska sunfish*. Journal of Parasitology, vol. 89, pp. 80–83.

Costa, APL, Takemoto, RM & Vitule, JRS. 2018. *Metazoan parasites of Micropterus salmoides (Lacépède 1802) (Perciformes, Centrarchidae): a review with evidences of spillover and spillback, (Lacepède)*. Parasitology Research, vol. 117, pp.1671-1681.

Da Conceição, JR, Vitola, CRR, Barros, ACR & Scheer, MB. 2014. *Plano para o uso e a conservação da água e do entorno do reservatório Piraquara I*. Curitiba: Sanepar.

Dunn, A. 2009. *Chapter 7: Parasites and Biological Invasions*. Advances in parasitology, vol. 68, p. 161-184.

Dunn, AM & Hatcher, MJ. 2015. *Parasites and biological invasions: Parallels,
interactions, and control. Trends Parasitol, vol. 31, pp. 189–199.

Eiras, JC, Takemoto, RM & Pavanelli, GC. 2006. Métodos de estudo e técnicas laboratoriais em parasitologia de peixes. EDUEM, Maringá, PR.

Elton, CS. 1958. The ecology of invasions by animals and plants. University of Chicago Press, Chicago, EUA.

Estes, JA, Terborgh, J, Brashares, JS, Power, ME, Berger J, Bond, WJ, Carpenter SR, Essington, TE, Holt, RD, Jackson JBC, Marquis RJ, Oksanen L, Oksanen T, Paine RT, Pikitch EK, Ripple WJ, Sandin SA, Scheffer M, Schoener TW, Shurin, JB, Sinclair ARE, Souël ME, Virtanen R & Wardle DA. 2011. Trophic downgrading of planet Earth. Science, vol. 333, pp. 301–306.

Frehse, FA, Braga, RR, Nocera, GA & Vitule, JRS. 2016. Non-native species and invasion biology in a megadiverse country: scientometric analysis and ecological interactions in Brazil. Biological Invasions, vol. 18, pp. 3713–3725.

Froese, R & Pauly, D. (Eds.). 2016. FishBase. World Wide Web electronic publication. www.fishbase.org, Accessed in June 2016.

Galaviz-Silva, L, Iruegas-Buentello, FJ, Escobar-González, B & Molina-Garza, ZJ. 2016. Infection levels and seasonality of monogeneans in the largemouth bass Micropterus salmoides (Perciformes: Centrarchidae) from Nuevo León, México. Journal of helminthology, vol. 90, pp. 685–692.

Gopar-Merino, L, Osorio-Sarabia, D & García-Prieto, L. 2005. A New Species of Hysterothylacium (Nematoda: Anisakidae) Parasite of Ariopsis guatemalensis (Osteichthyes: Ariidae) From Tres Palos Lagoon, Mexico. Journal of Parasitology, vol. 91, pp. 909–914.

Hatcher, MJ, Dick, JTA & Dunn, AM. 2012. Disease emergence and invasions. Functional Ecology, vol. 26, pp. 1275–1287.

Hoffman, GL. 1999. Parasites of North American freshwater fishes. Cornell University Press, London, UK.

Hulme, PE. 2009. Trade, transport and trouble: Managing invasive species pathways in an era of globalization. Journal of Applied Ecology, vol. 46, pp. 10–18.

Jackson, DA. 2002. Ecological effects of Micropterus introductions: the dark side of Black Bass. American Fish Society Symposium, vol. 31, pp. 221–232.

Kelly, DW, Paterson, RA, Townsend, CR, Poulin, R & Tompkins, DM. 2009. Parasite spillover: a neglected concept in invasion ecology?. Ecology, vol. 90, pp. 2047-2056.

Lafferty, KD & Morris, AK. 1996. Altered behavior of parasitized killfish increases susceptibility to predation by bird final hosts. Ecology, vol. 77, pp. 1390–1397.

Lockwood, JL, Hoopes, MF & Marchetti, MP. 2007. Invasion ecology. John Wiley & Sons, Oxford, UK.

Lockwood, JL, Cassey, P & Blackburn, TM. 2009. The more you introduce the more you get: the role of colonization pressure and propagule pressure in invasion ecology. Diversity and Distribution, vol. 15, pp. 904–910.

Lowe, S, Browne, M, Boudjelas, S & De Poorter, M. 2000. 100 of the world’s worst invasive alien species. A selection from the Global Invasive Species Database. Species Survival Commission of the World Conservation Union (IUCN). pp. 12.

Lymbery, AJ, Morine, M, Kanani, HG, Beatty, SJ & Morgan, DL. 2014. Co-invaders: The effects of alien parasites on native hosts. International Journal of Parasitology: Parasites and Wildlife, vol. 3, pp. 171–177.

MacLeod, CJ, Paterson, AM, Tompkins, DM & Duncan, RP. 2010. Parasites lost - do invaders miss the boat or drown on arrival? Ecology Letters vol. 13, pp. 516–527.

Madi, RR & Silva, MSR. 2005. Contracaecum Railliet & Henry, 1912 (Nematoda, Anisakidae): o parasitismo relacionado à biologia de três espécies de peixes piscívoros no reservatório do Jaguari, SP. Revista Brasileira de Zoociências, vol. 7, pp. 15–24.

Maitland, PS & Price, CE. 1969. Urocleidus principalis (Mizelle, 1936). A North American monogenetic trematode new to the British Isles, probably introduced with the Largemouth Bass Micropterus salmoides (Lacepede, 1802). Journal of Fish Biology, vol. 1, pp. 17-18.
Margolis, L & Kabata, Z. 1984. Guide to the parasites of fishes of Canada. Part 1: General introduction (by Margolis, L & Kabata, Z.); Monogenea and Turbellaria (by Beverley-Burton, M.). Department of Fisheries & Oceans.

Moravec, F, Kohn, A & Fernandes, BMM. 1993. Nematode parasites of fishes of the Parana River (Brazil) Part 2: Seuratoidea, Ascaridoidea, Habronematoida and Acuarioidea. Folia Parasitologica, vol. 40, pp. 115-134.

Moravec, F. 1998. Nematodes of Freshwater Fishes of the Neotropical Region. Academia: Praha.

Paraná. State Decree n. 4742, May 3rd, 2005. Vedada a pesca e outras atividades correlatas nos lagos e no entorno das barragens sob a responsabilidade da companhia de saneamento do Paraná. Curitiba, may 2005. Available in <http://www.leisestaduais.com.br/pr/decreto-n-4742-2005-parana-vedada-a-pesca-e-outras-atividades-correlatas-nos-lagos-e-no-entorno-das-barragens-sob-a-responsabilidade-da-companhia-de-saneamento-do-parana-saneamento-destinadas-ao-abastecimento-publico> Accessed in February 2019

Poulin, R & Leung, TLF. 2011. Body size, trophic level, and the use of fish as transmission routes by parasites. Oecologia, vol. 166, pp.731–738.

Prenter, J, MacNeil, C, Dick JTA & Dunn, AM. 2004. Roles of parasites in animal invasions. Trends in Ecology and Evolution, vol. 19, pp. 385–390.

Price, PW, Westoby, M, Rice, B, Atsatt, PR, Fritz, RS, Thompson, JN & Mobley, K. 1986. Parasite Mediation in Ecological Interactions. Annual Review of Ecology and Systematics, vol. 17, pp. 487–505.

Ribeiro, VM, Braga, RR, Abilioha, V & Vitule, JRS. 2015. Evaluation of three capture techniques for invasive Micropterus salmoides (Lacepède, 1802) in a Neotropical reservoir: Implications for population control and management. Journal of Applied Ichthyology, vol. 31, pp. 1127–1129.

Roche, DG, Leung, B, Mendoza Franco, EF & Torchin, ME. 2010. Higher parasite richness, abundance and impact in native versus introduced cichlid fishes. International Journal of Parasitology, vol. 40, pp. 1525–1530.

Rodrigues, L, Thomaz, SM, Agostinho, AA & Gomes, LC. 2005. Biocenoses em reservatórios: padrões espaciais e temporais. Editora Rima, São Paulo, Brazil.

Seara, RW. 2010. Avaliação do desempenho da barragem da Usina Governador Parigot de Souza (Capivari-Cachoeira). Master Dissertation, Federal University of Uso Preto, Brazil.

Schulz, UH & Leal, ME. 2005. Growth and mortality of black bass, Micropterus salmoides (Pisces, Centrarchidae; Lacepède, 1802) in a reservoir in southern Brazil. Brazilian Jounal of Biology, vol.65, pp. 363–369.

Strauss, A, White, A & Boots, M. 2012. Invading with biological weapons: The importance of disease-mediated invasions. Functional Ecology, vol. 26, pp. 1249–1261.

Takemoto, RM, Pavanelli, GC, Lizama, MAP, Lacerda, ACF, Yamada, FH, Moreira, LHA, Ceschini, TL & Bellay, S. 2009. Diversity of parasites of fish from the Upper Paraná River floodplain, Brazil. Brazilian Journal of Biology, vol. 69, pp. 691-705.

Taraschewski, H. 2006. Hosts and parasites as aliens. Journal of Helminthology, vol. 80, pp. 99–128.

Tavakol, S, Smit, WJ, Sara, JR, Halajian, A & Luus-Powell, WJ. 2015. Distribution of Contracaecum (Nematoda: Anisakidae) larvae in freshwater fish from the northern regions of South Africa. African Zoology, vol. 50, pp. 133-139.

Telfer, S & Brown, K. 2012. The effects of invasion on parasite dynamics and communities. Functional Ecology, vol. 26, pp. 1288–1299.

Underwood, W, Anthony, R, Gwałtney-Brant, S, Poison, ASPCA & Meyer, R. 2013. AVMA guidelines for the euthanasia of animals: 2013 ed. Schaumburg: IL. American Veterinary Medical Association.

Van Der Walt JA, Weyl OLF, Woodford DJ & Radloff FGT. 2016. Spatial extent and consequences of black bass (Micropterus sp.) invasion in a Cape Floristic Region river basin. Aquatic Conservation of
Introduction of non-native freshwater fish can certainly be bad. Fish and Fisheries vol. 10, pp. 98–108.

Xavier, CF, Wosiack, AC, Dias, LN & Brunkow, RF. 2009. Qualidade das águas: Reservatórios do Estado do Paraná 2005 a 2008. Curitiba: IAP.

Young, HS, Parker, IM, Gilbert, GS, Guerra AS & Nunn CL. 2016. Introduced species, disease ecology, and biodiversity–disease relationships. Trends in Ecology and Evolution, vol. 2164, pp. 1–14.

Received November 2, 2019.
Accepted January 14, 2020.