Ecto- and endo-parasitic monogeneans (Platyhelminthes) on cultured freshwater exotic fish species in the state of Morelos, South-Central Mexico

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Abstract
An extensive parasitological study of 365 freshwater exotic fish specimens belonging to 13 species of seven families (Cichlidae, Cyprinidae, Osphronemidae, Pangasidae, Poeciliidae, Characidae, and Loricariidae) collected from 31 Aquaculture Production Units (APU) from Central Mexico revealed the occurrence of 29 ecto- and endo-parasitic monogeneans found on gills and stomachs: Cichlidogyrus sclerosus, C. thurstonae, C. tilapiae, Cichlidogyrus sp. 1, Cichlidogyrus sp. 2, Enterogyrus coronatus, E. malmbergi, Gussevia spiralcirra, Sciadicleithrum iphthimum, Sciadicleithrum sp., Scutogyrus longicornis (all Dactylogyridae), Gyrodactylus cichlidarum, and G. yacatli on Oreochromis niloticus, Pterophyllum scalare and Hemichromis sp. (Cichlidae); Dactylogyrus baueri, D. formosus, D. intermedius, D. vastator, D. extensus, Dactylogyrus sp. (all Dactylogyridae), and G. kobayashii on Carassius auratus, Cyprinus carpio and Ctenopharyngodon idella (Cyprinidae); Trianchonorus acleithrium and T. trichogasterium (Dactylogyridae) on Trichogaster trichopterus (Osphronemidae); Thaparocleidus caece, T. siamensis (Dactylogyridae), and Dactylogyridae sp. on Pangasianodon hypophthalmus (Pangasidae); G. poecilae on Poecilia reticulata (Poeciliidae); Diaphorocleidus armillatus (Dactylogyridae) on Gymnocorymbus ternetzi (Characidae); Unilatus unilatus (Dactylogyridae) and Gyrodactylidae sp. on Hypostomus sp. (Loricariidae). The paramount importance of the establishment of these monogeneans due to the importation/exportation of non-native ornamental and other exotic host fish species cultured for food in Mexico is briefly discussed. Quarantine is recommended for all transferred host species.
Keywords
characids, cichlids, cyprinids, fish introductions, loricariids, Monogenea, Morelos state, non-native ornamental fish, osphronemids, pangasids, parasites, poeciliids, quarantine, tilapia

Introduction
At a global level, increasing attention is being paid to generate useful ecological indicators that favor invasiveness and geographic range expansion by introduced species (Lavergne and Molofsky 2007, Blackburn and Ewen 2017). Conjointly, introductions of species are rising sharply because of increased trade, transport, travel, and tourism associated with globalization (IPPC Secretariat 2005). Within this context, trade of the non-native ornamental fish industry and/or fish farms for food production, has been the main cause of introductions of fish and their parasites around the world (Barroso de Magalhães and Jacobi 2013, Mendoza et al. 2015). Furthermore, the same industries pose a growing threat to native wildlife if non-native fishes are later released into the wild (see Mendoza-Franco et al. 2012). Culture of non-native ornamental and food fishes represents major activities in the state of Morelos (south-central Mexico) since these fishes are commercially distributed within and outside of Mexico in large quantities (Martínez et al. 2010).

Although non-native aquatic organisms are important to Morelos aquaculture and the economy of the state of Morelos, the aquaculture industry should be made aware of the considerable local, state, and national concern over the potential ecological or economic problems arising from non-native fish introductions and their parasites in natural environments (i.e., parasite transfer and/or fish competition with native species) (Barroso de Magalhães and Jacobi 2013). Recently, a total of 44 helminth species on introduced freshwater fishes were listed for Mexico, of which five are invasive species, i.e., *Cichlidogyrus sclerosus* Paperna & Thurston, 1969 *Dactylogyrus extensus* Muel ler & Van Cleave, 1932 and *Gyrodactylus cichlidarum* (Paperna 1968) García-Vasquez & Hansen, 2007 (Monogenea); *Centrocestus formosanus* (Nishigori 1924) Price, 1932 (Digenea) and *Schyzocotyle acheilognathi* Yamaguti, 1934 (Cestoda), all of them introduced with their Asian and African hosts (Tapia Osorio et al. 2014). The present study was conducted to identify the most common ecto- and endo-parasitic monogeneans inhabiting commercially important ornamental and/or food fish species that have been imported into Mexico.

Materials and methods
Ornamental fish species were collected from 2010 to 2014 from different municipalities (Axochiapan, Ayala, Cuautla, Jiutepec, Jojutla, Tlaltizapan, Tlaquiltenango, Xochitepec, and Zacatepec) located in the state of Morelos. Live fish were examined thoroughly externally under a stereo-microscope before opening the visceral cavity.
Fish were sacrificed by puncturing the brain region and the gills of each fish were removed and placed in vials containing hot 4–5% formalin solution to fix any of the ectoparasites that might be present and labeled with data of each collection site. The internal cavity of each fish was exposed by an incision made along the venter from the anus to mouth. The entire alimentary canal was removed; the interior of the gut was thoroughly examined in situ, then placed in a Petri dish containing hot formalin solution 4–5%, where it was searched for monogeneans (Salgado-Maldonado et al. 2014). Subsequently, all monogeneans specimens were isolated and stained with Gomori’s trichrome and mounted in Canada balsam. In addition, some specimens were mounted in a mixture of lactic-acid (LA) and glycerin- ammonium picrate (GAP) and then re-mounted in Canada balsam as permanent preparations (Mendoza-Franco et al. 2013). Parasite identifications were made using a Leica microscope DM2500 with Nomarski interference contrast and based on descriptions provided in the following references: García-Vásquez et al. 2007, 2015, Jogunoori et al. 2004, Kritsky et al. 1989, Lim 1996, Mendoza-Palmero et al. 2012, Pariselle and Euzet 1995, Yamaguti 1963. Reference specimens were deposited in the National Helminthological Collection of Mexico (CNHE). Prevalence (percent of hosts infected), mean abundance (mean number of parasites per examined fish), and intensity range for each monogenean species follows Bush et al. (1997). Host species and common names follow those in the FishBase (Froese and Pauly 2017).

**Results**

A total of 365 fish specimens of 13 species belonging to 7 families was examined for monogeneans: Cichlidae, Characidae, Cyprinidae, Loricariidae, Osphronemidae, Pangasidae, and Poeciliidae. Twenty-nine monogenean species infecting gills and/or stomachs were identified from hosts species of all families mentioned above from a total of 31 Aquaculture Production Units (APU) from different municipalities located in the state of Morelos (see Table 1 and Figure 1). The prevalence, mean abundance, and mean intensity of infections at each APU of individual species from different hosts are provided in Tables 2–4.

**Discussion**

Currently, 31 species of exotic monogeneans have been registered in the state of Morelos due to the introduction of their hosts that are cultured either for food or aquariums (present data; Caspeta-Mandujano et al. 2009). This current study on cultured exotic fish species revealed that cichlids (i.e., species of *Oreochromis*, *Hemichromis*, and *Pterophyllum*), harbored the highest number of monogeneans (14 species) followed by cyprinids with seven species of which *Dactylogyrus baueri* Gussev, 1955, *Dactylogyrus formosus* Kulwieć, 1927, *Dactylogyrus intermedius* Wegener, 1909, and
Table 1. Ecto- and endo-parasitic monogeneans (Platyhelminthes) on cultured exotic fish from several Aquaculture Production Units (APU) in the state of Morelos, South-Central Mexico.

| Host species/Family | Monogeneans/CNHE | APU | Municipalities |
|---------------------|------------------|-----|----------------|
| Oreochromis niloticus (Cichlidae) | **Cichlidogyrus sclerosus†/10743** | Acuícola Jaloxtoc | Ayala |
| | | El Cifón | Zacatepec |
| | | 7 Hermanos | Cuautla |
| | | La cascada | Tlaltizapan |
| | | Acuícola Ayala | Ayala |
| | | Maricultura Argos | Zacatepec |
| | **Cichlidogyrus thurstonae†/10744** | La Cascada | Tlaltizapan |
| | **Cichlidogyrus tilapia†/10745** | Acuícola Ayala | Ayala |
| | | Maricultura Argos | Zacatepec |
| Oreochromis niloticus | *Cichlidogyrus sp. 1 †/10746* | Acuícola Ayala | Ayala |
| | *Cichlidogyrus sp. 2 †/10747* | | |
| | **Hemichromis sp.** | **Enterogyrus coronatus‡/10748** | Maleny | Zacatepec |
| | | | | |
| Oreochromis niloticus | **Enterogyrus malmbergi†/10749-10750** | San Tilapia | Tlaltizapan |
| | | La buena Fortuna | Jojutla |
| | **Oreochromis niloticus** | **Gyrodactylus cichlidarum§/10756** | Acuícola Jaloxtoc | Ayala |
| | | Centro Zacatepec | Zacatepec |
| | | El Invernadero | Ayala |
| | | Los Huajes | Ayala |
| | | Linda Vista | Ayala |
| | | Platanar | Ayala |
| | | Grupo Carsal | Ayala |
| | | | |
| | | **Gyrodactylus yacatli§/10757** | Jesus Madariaga | Zacatepec |
| | | | | |
| | | **Pterophyllum scalare** | **Gussevia spiralocirra†/10752** | | |
| | | *Sciadicleithrum iphthimum†/10753* | | |
| | | *Sciadicleithrum sp. †/10754* | | |
| | | **Scutogyrus longicornis†/10755** | La Cascada | Tlaltizapan |
| | **Carassius auratus** (Cyprinidae) | **Dactylogyrus baueri†/10758** | Centro de acopio La Perla | Tlaltizapan |
| | | **Dactylogyrus formosus†/10759** | El Invernadero | Ayala |
| | | **Dactylogyrus intermedius†/10760** | Los Huajes | Ayala |
| | | **Dactylogyrus vastator†/10761-10762** | Linda Vista | Ayala |
| | | **Dactylogyrus kobayashii†/10765-10767** | Platanar | Ayala |
| | | **Cyprinus carpio** (Cyprinidae) | **Dactylogyrus extensus†/10763** | Ornapez | Ayala |
| | | **Ctenopharyngodon idella** (Cyprinidae) | **Dactylogyrus sp.†/10764** | Centro Zacatepec | Zacatepec |
| | | *Trichogaster trichopterus* (Osphronemidae) | *Trichanthurus alechthrum†/10768* | Consorcio Lugo-Galeana | Juijtepec |
| | | | | Granja Acuícola Foras | Xochitepec |
| | | *Trichanthurus trichogasterium†/10769* | | |
| | | **Pangasianodon hypophthalmus** (Pangasidae) | **Thaparocleidus caecus†/10770** | Betta Fish | Xochitepec |
| | | *Thaparocleidus siamensis†/10771-10772** | Betta Fish | Xochitepec |
| | | *Dactylogyrus sp.†/10761-10762** | La buena Fortuna | Juijtepec |
| | | | | Exopec | Jojutla |
| | | | | Agua Fría | Tlaltizapan |
| | | **Poeclia reticulata** (Poeciliidae) | **Gyrodactylus poeciliae§/10773** | Huertas de Cuatla | Ayala |
| | | | | Exopec | Tlaltizapan |
| | | | | Agua Fría | Tlalpuente |
| | | **Gymnocorymbus ternetzi** (Characidae) | *Diaphorocleidus armillatus†/10774-10775** | Aquafrío | Zacatepec |
| | | | | Tropipex | |
| | | **Hypostomus sp.** (Loricariidae) | *Gyrodactylus sp.†/10777** | Consorcio Lugo-Galeana | Juijtepec |
| | | *Unilatus unilatus†/10776** | Consorcio Lugo-Galeana | Juijtepec |

* = new record in Mexico. Site of infection on host: † = gills lamellae; ‡ = stomach; § = fins.
Figure 1. Map of the state of Morelos, Mexico showing position of each APU: 1 7 Hermanos (18°51'49.82132"N; 98°58'01.20211"W) 2 Acuícola Ayala (18°45'11.59525"N; 98°56'58.87989"W) 3 Acuícola de Jiutepec (18°52'29.84116"N; 99°09'24.49751"W) 4 Acuícola Jaloxtoc (18°43'56.72740"N; 98°55'20.14003"W) 5 Adilene Marisol (18°35'43.94208"N; 99°01'43.49419"W) 6 Agua Fría (18°33'22.41096"N; 99°00'57.44948"W) 7 Aquafish (18°38'53.20757"N; 99°13'13.80019"W) 8 Betta Fish (18°46'15.00012"N; 99°12'05.44263"W) 9 Centro Zacatepec (18°39'22.70079"N; 99°12'02.36030"W) 10 Centro de Acopio La Perla (18°38'18.23968"N; 99°00'32.15165"W) 11 Consorcio Lugo-Galeana (18°53'48.34681"N; 99°11'13.92251"W) 12 El Chino (18°54'03.35178"N; 99°12'10.27438"W) 13 El Cifón (18°40'42.68111"N; 99°11'26.16448"W) 14 El Invernadero (18°37'11.86468"N; 98°59'37.85120"W) 15 Exopez (18°41'41.78829"N; 99°06'07.81780"W) 16 Granja Acuícola Foras (18°31'07.09460"N; 98°47'54.39963"W) 17 Grupo Carsal (18°37'21.23567"N; 99°00'54.9462"W) 18 Huertas de Cuatla (18°45'41.45252"N; 98°54'57.10516"W) 19 Jesús Madariaga (18°39'59.91903"N; 99°12'05.85187"W) 20 La Buena Fortuna (18°38'07.31312"N; 99°10'58.58424"W) 21 La Cascada (18°41'06.91860"N; 99°09'05.97650"W) 22 Linda Vista (18°38'11.27728"N; 98°59'41.36454"W) 23 Los Huajes (18°38'01.06064"N; 98°59'39.86312"W) 24 Maleny (18°39'43.43675"N; 99°11'52.86078"W) 25 Maricultura Argos (18°35'50.18775"N; 99°12'16.44262"W) 26 Olascoaga (18°55'43.93946"N; 99°10'40.92078"W) 27 Ornapec (18°45'06.02177"N; 98°59'14.37030"W) 28 Platanar (18°43'30.25259"N; 98°54'30.22690"W) 29 Pliego (18°37'45.93123"N; 98°59'53.99321"W) 30 San Tilapia (18°39'09.51796"N; 99°11'36.53955"W) 31 Tropipez (18°46'10.83544"N; 99°12'05.47184"W).
Table 2. Parameters of infection of monogeneans on cichlids (APU: Aquaculture Production Unit; P%: Prevalence; MA: mean abundance; RI: range of infection; MI: mean intensity; IH: infected hosts).

| APU             | Hosts             | Monogeneans            | Inds. | P%  | MA    | RI      | MI    | IH   |
|-----------------|-------------------|------------------------|-------|-----|-------|---------|-------|------|
| Maleny          | Hemichromis sp.   | Enterogyrus coronatus  | 36    | 50  | 5.14  | 1–13    | 3.6   | 10/20|
| 7 hermanos      | Oreochromis niloticus | Cichlidogyrus sclerosus | 12    | 57  | 1.71  | 2–4     | 3.0   | 4/7  |
| Acuícola de Jiutepec | Oreochromis niloticus | Enterogyrus malmbergi | 18    | 50  | 2.57  | 2–5     | 3.6   | 5/10 |
| Acuícola Jaloxtoc | Oreochromis niloticus | Cichlidogyrus cichlidarum | 18    | 20  | 2.57  | 18      | 1.5   | 1/5  |
| Acuícola Jaloxtoc | Oreochromis niloticus | Cichlidogyrus sclerosus | 13    | 100 | 2.60  | 1–7     | 2.6   | 5/5  |
| Adilene Marisol | Oreochromis niloticus | Enterogyrus malmbergi  | 53    | 100 | 7.57  | 2–13    | 5.3   | 10/10|
| Centro Zacatepec | Oreochromis niloticus | Gyrodactylus yacatli   | 15    | 10  | 2.14  | 15      | 15    | 1/10 |
| El Cifón        | Oreochromis niloticus | Cichlidogyrus sclerosus | 7     | 40  | 1.00  | 3–4     | 3.5   | 2/5  |
| A cúcola Ayala  | Oreochromis niloticus | Dactylogyrus tilapiae  | 159   | 100 | 22.71 | 3–37    | 15.9  | 10/10 |
| A cúcola Ayala  | Oreochromis niloticus | Enterogyrus malmbergi  | 6     | 50  | 0.86  | 1–2     | 1.2   | 5/10 |
| Pliego          | Oreochromis niloticus | Enterogyrus malmbergi  | 2     | 25  | 0.29  | 2       | 2.0   | 1/4  |
| San Tilapia     | Oreochromis niloticus | Enterogyrus malmbergi  | 34    | 100 | 4.86  | 1–17    | 8.5   | 4/4  |
| La Buena Fortuna | Oreochromis sp.   | Enterogyrus malmbergi  | 23    | 60  | 3.29  | 1–7     | 3.83  | 6/10 |
| Jesús Madariaga | Pterophyllum scalare | Gussevia spiralocirra  | 5     | 10  | 0.71  | 5       | 5.0   | 1/10 |
| El Chino        | Pterophyllum scalare | Sciadicleithrum spp.   | 6     | 83.3| 1.00  | 1–2     | 1.2   | 5/6  |
| Olascoaga       | Pterophyllum scalare | Sciadicleithrum sp.    | 9     | 75  | 1.29  | 1–4     | 3.0   | 3/4  |

Table 3. Parameters of infection of monogeneans on hosts of the Cyprinidae (APU: Aquaculture Production Unit; P%: Prevalence; MA: mean abundance; RI: range of infection; MI: mean intensity; IH: infected hosts).

| APU                     | Hosts             | Monogeneans          | Inds. | P%  | MA    | RI      | MI    | IH   |
|-------------------------|-------------------|----------------------|-------|-----|-------|---------|-------|------|
| Consorcio Lugo-Galeana  | Carassius auratus | Dactylogyrus sp.     | 520   | 100 | 52.0  | 13–154  | 86.7  | 10/10|
| El invernadero          | Carassius auratus | Gyrodactylus kohayashii | 525   | 100 | 87.5  | 5–314   | 87.5  | 6/6  |
| Grupo Carsal            | Carassius auratus | Dactylogyrus formosus | 1     | 17  | 0.17  | 1–8     | 1.0   | 1/6  |
| Linda vista             | Carassius auratus | Gyrodactylus kohayashii | 28    | 100 | 20    | 0.3–54  | 26.7  | 3/3  |
| Los Huajes              | Carassius auratus | Dactylogyrus vastator | 5     | 33  | 1.7   | 5       | 5.0   | 1/3  |
| Los Huajes              | Carassius auratus | Dactylogyrus baueri   | 1     | 20  | 0.2   | 1       | 1.0   | 5/5  |
| Los Huajes              | Carassius auratus | Dactylogyrus spp.    | 38    | 100 | 7.6   | 2–25    | 7.6   | 5/5  |
| Los Huajes              | Carassius auratus | Gyrodactylus kohayashii | 102   | 100 | 20.4  | 2–58    | 20.4  | 5/5  |
| Centro Zacatepec        | Ctenopharyngodon idella | Dactylogyrus sp.   | 100   | 14  | 14.3  | 100     | 100.0 | 1/7  |
| Ornapec                 | Cyprinus carpio   | Dactylogyrus extensus | 5     | 20  | 0.5   | 2–3     | 2.5   | 2/10 |
Table 4. Parameters of infection of monogeneans on characids, loricariids, osphronemids, pangasids, and poeciliids (APU: Aquaculture Production Unit; P%: Prevalence; MA: mean abundance; RI: range of infection; MI: mean intensity; IH: infected hosts).

| APU             | Host                              | Monogeneans               | Inds. | P%  | MA  | RI   | MI   | IH   |
|-----------------|-----------------------------------|---------------------------|-------|-----|-----|------|------|------|
| Aquafish        | Gymnocorymbus ternetzi            | Diaphorocleidus armillatus| 131   | 100 | 13.1| 2–24 | 13.1 | 10/10|
| Tropipez        | Gymnocorymbus ternetzi            | Diaphorocleidus armillatus| 698   | 100 | 69.8| 7–217| 69.8 | 10/10|
| Consorcio Lugo-Galeana | Hypostomus sp. | Unilatus unilatus         | 15    | 60  | 1.5 | 1–11 | 2.5  | 6/10 |
|                 | Hypostomus sp. | Gyrodactylus sp.          | 14    | 60  | 1.4 | 1–8  | 2.3  | 6/10 |
|                 | Trichogaster trichopterus         | Trianchoratus spp.        | 80    | 75  | 20  | 03–54| 26.7 | 3/4  |
|                 | Trichogaster trichopterus         | Trianchoratus trichogasterium | 250  | 80  | 25  | 16–61| 31.3 | 8/10 |
| Granja Acuícola Foras | Trichogaster trichopterus     | Trianchoratus trichogasterium | 564  | 90  | 56.4| 1–262| 62.7 | 9/10 |
| Betta fish      | Pangasianodon hypophthalmus       | Thaparocleidus spp.       | 536   | 40  | 26.8| 1–125| 67.0 | 8/20 |
| La Buena Fortuna | Pangasianodon hypophthalmus       | Thaparocleidus siamensis  | 1000  | 100 | 200 | 130–300| 200.0| 5/5  |
|                 | Pangasianodon hypophthalmus       | Dactylogyridae sp.        | 10400 | 100 | 2080| 1000–3000| 1733.3| 5/5  |
| Exopez          | Poecilia reticulata              | Gyrodactylus poecilia     | 4     | 33  | 0.67| 2    | 2.0  | 2/6  |
| Agua fría       | Poecilia reticulata              | Gyrodactylus poecilia     | 75    | 90  | 7.5 | 1–37 | 8.3  | 9/10 |
| Huertas de Cuautla | Poecilia reticulata            | Gyrodactylus poecilia     | 1     | 12.5| 0.125| 1    | 1.0  | 1/8  |

*Gyrodactylus kobayashii* Hukuda, 1940 are new geographical records in Mexico (see Tables 1 and 3). Despite the great number of parasitological studies on native and/or introduced species of Cichlidae in Mexico (Vidal-Martínez et al. 2001), studies on the parasite fauna of other exotic freshwater fishes, especially on their monogeneans, are relatively scarce. Exceptionally, there have been many reports of species of *Cichlidorhysis* on species of *Oreochromis* (often called tilapia) (see Kritsky et al. 1994, Jiménez-García et al. 2001). Even so, intensity of infection is comparatively high as well as the number of new records of these monogeneans, the latter which continues to grow each year (see Table 3, Mendoza-Franco et al. 2015b). In the present study, the angelfish *P. scalare* (Schultze) and *Hemichromis* sp. were studied for the first time and are shown to be parasitized with *G. spiralocirra* Kohn & Paperna, 1964, *S. iphthimum* Kritsky, Thatcher & Boeger, 1989, *Sciadicleithrum* sp. (new geographical records), and *E. coronatus* Pariselle, Lambert & Euzet, 1991.

Monogeneans usually exhibit high host specificity in comparison with other parasite groups, parasitizing a single or few closely related host species. The only zoogeographic range expansion of exotic monogeneans on native hosts is the discovery of species of *Cichlidorhysis* and *G. cichlidarum* from tilapia on native cichlids and poeciliids, respectively, in natural environments of Mexico (Jiménez-García et al. 2001, García-Vásquez...
et al. 2007, 2017). The present study revealed the highest intensity of infection with *G. cichlidarum* (identified as a tilapia pathogen by García-Vásquez et al. 2017) and *Cichlidogyrus* spp. on *Oreochromis* spp. (see Table 2). Therefore, preventing escape of these tilapia from culture systems due to their monogeneans’ ability to infest and persist on other non- or related wild fish is urgently required. Another example of the persistence of monogeneans is seen with the dactylogyrid *Urocleidoides vaginoclaustrum* Jogunoori, Kritsky & Venkatanarasaiah 2004. This monogenean was originally described from fishes introduced to India via the aquarium trade. Its type host, the green swordtail *Xiphophorus hellerii* (Heckel) (Poeciliidae), is naturally distributed in southern Mexico and Central America, where the native profundulid *Profundulus labialis* (Günther) also hosts *U. vaginoclaustrum*. The problem is that *X. hellerii* has been artificially introduced along with *U. vaginoclaustrum* to other hydrological systems such as India and northern Mexico (Jogunoori et al. 2004, Mendoza-Palmero and Aguilar-Aguilar 2008, Mendoza-Franco et al. 2015a) from which other cyprinodontiform hosts could potentially become infected with this parasite. Additionally, in the present study the black tetra *G. ternetzi* (Boulenger) (Characidae) was studied for the first time and is revealed to be highly infested with *D. armillatus* Jogunoori, Kritsky & Venkatanarasaiah, 2004 (Dactylogyridae) (see Table 4). *Gymnocorymbus ternetzi* is native to South America and has been introduced via the aquarium trade to India and Mexico. Currently, there are nine species of *Diaphoroceleidus* dispersed on native bryconid and characid (Characiformes) hosts in the neotropics (South and Central America) (Santos et al. 2018). The transfer and/or evidence of extensive cryptic speciation of other monogenean groups from exotic to native or vice versa on closely related hosts in Mexico remains unknown, but that potential exists.

Similarly to the introduced tilapia in Mexico, cyprinids (i.e., *C. idella*) are also widely distributed in the country including habitats located within areas protected for conservation (see Salgado Maldonado et al. 2014). These fishes were introduced to Central America (i.e., Mexico and Honduras) for aquaculture purposes from 1965-1980s (Salgado-Maldonado and Rubio-Godoy 2014, Salgado-Maldonado et al. 2015) and the presence of species of *Dactylogyrus* and *G. kobayashii* (see Table 1, 3) in Morelos might be originally related to these introductions. Poeciliids (known as guppies, mollies, platies, and swordtails) have been studied for ectoparasitic monogeneans in Mexico and mainly gyroactylids have been reported on the skin and/or gills on these fishes (García-Vásquez et al. 2015). Currently, there are 11 gyroactylid species described and/or reported from poeciliids. Only species of *Urocleidoides* (Dactylogyridae) have been reported on the gills of the poeciliids of the two-spot livebearers *Pseudoxiphophorus bimaculata* (Heckel), *X. hellerii*, and *Poeciliopsis retropinna* (Regan) from Mexico and Panama (Mendoza-Franco et al. 2015). In the present study, *G. poeciliae* Harris & Cable, 2000 was found for the first time on the guppy *Poecilia reticulata* Peters from Mexico (see Tables 1, 4). This monogenean species has been reported on *Poecilia caucana* (Steindachner) and *P. reticulata* from their natural ranges of distribution (Venezuela and Trinidad, respectively). Among all species of *Gyrodactylus* mentioned above, only *G. bullatarudis* Turnbull, 1956 and *G. turnbulli* Harris, 1986 have been reported on six poeciliid host species (*Gambusia*...
holbrooki Girard, Poecilia sphenops Valenciennes, P. reticulata, P. bimaculata, Poeciliopsis sp., and X. bellerii) from Mexico, Canada, Costa Rica, Peru, Trinidad, Australia, and Singapore (see García-Vásquez et al. 2015). Given the low host specificity of both gyro-
dactylid species and the invasive characteristic of poeciliids, the potential transfer of these
 gyro dactylids to native poeciliids and other ecologically-associated hosts in Mexico is
 high (see García-Vásquez et al. 2017, Mendoza-Franco et al. 2015).

The African tilapia (Cichlidae) and the Asian catfish (Pangasiidae) are both freshwater whitefish aquaculture species that potentially compete for similar markets. In
 fact, in 2013 Mexico was recognized as the second largest importer of pangasius fillet
 in the world (Martínez et al. 2016). No analysis concerning the environmental im-
pact of the introduction of these latter fishes and their parasites from Vietnam into
 Mexican aquaculture and/or in wild habitats (Martínez et al. 2016) has been made. Pangasianodon hypophthalmus (Sauvage) was studied for the first time in the present
 study and it revealed to be parasitized with three monogenean species: Thaparocleidus
caeus (Mizelle & Kritsky, 1969) Lim 1996, T. siamensis (Lim 1990) Lim, 1996, and
 Dactylogyridae sp. (Table 4). Finally, Loricariids, otherwise known as plecos (species
 of Hypostomus) are very popular ornamental freshwater fish naturally found in tropical
 South America, Panama, and Costa Rica. In Mexico, Hypostomus plecostomus (L.) was
 introduced into the Balsas Basin (see geographic position in Figure 1) to control macro-
 phytes and algae, and are now established in multiple water bodies (Ramírez-Morales
 and Ayala-Pérez 2009). The only report of a gill monogenean species on an introduced
 pleco to Mexico is that of Heteropriapulus sp. (Dactylogyridae) on the Amazon sail-
 fin Pterygoplichthys pardalis Castelnau from the Reserva de la Biosfera Montes Azules
 (BRMA) in the state of Chiapas (Mendoza-Franco et al. 2012). The present study
 provides two new monogenean records for Mexico, Gyrodactylidae sp. and Unilatus
 unilatus, the latter belonging to the Dactylogyridae which was previously reported on
 the snow pleco P. anisitsi Eigenmann and Kennedy and on Plecostomus sp., from Brazil
 and Peru, respectively (Mendoza-Palmero et al. 2012).

The fish examined in the present study are ornamental and/or for food production
 that are commercialized in Mexico. Results clearly show that importation of these fish
 can carry several monogeneans, both ecto- and endo-parasitic species, which could
 infect other related fish in systems they invade. Therefore, determining the occurrence
 of parasitic species will help provide better aquaculture conditions and will help to
 solve some of the problems faced by fish farmers. In the literature, there are a number
 of reports dealing with the introduction of parasites by ornamental fish from which
 the consequences of parasite introduction can be detrimental to native fish. For ex-
 ample, epizootics that may lead to extensive mortality (i.e., D. vastator on cyprinids,
 see Cone 1999) as shown for several species of monogeneans introduced into farms or
 aquariums, and from there to natural populations (Bakke et al. 2002, 2007; García-
 Vásquez et al. 2017). In addition to the identification of invasive host fish species, it is
 recommended that all freshwater fish imported into the country for food (farmed) or
 ornamental purposes must comply, at least, with quarantine regulations.
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