Invertebrate Zoology, 2018, 15(3): 277–291

An annotated checklist of the freshwater cladocerans (Crustacea: Branchiopoda: Cladocera) of Ecuador and the Galápagos Islands

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ABSTRACT: An annotated checklist of recorded species of Cladocera (Crustacea: Branchiopoda) from inland aquatic habitats in Ecuador (including the Galápagos) is provided. We revised all published records, evaluated the validity of each taxon and provided short taxonomic and biogeographical remarks for each taxon. A total of 34 valid species grouped into 23 genera was found. Presently, all attempts to analyze distributional patterns of cladocerans in Ecuador are premature due to the scarcity of adequate information. Current achievements in the inventory of cladocerans, information gaps and recommendations for future studies on cladoceran taxonomy in Ecuador are discussed.
How to cite this article: López C., Mosquera P.V., Hampel H., Neretina A.N., Alonso M., Van Damme K., Kotov A.A. 2018. An annotated checklist of the freshwater cladocerans (Crustacea: Branchiopoda: Cladocera) of Ecuador and the Galápagos Islands // Invert. Zool. Vol.15. No.3. P.277–291. doi: 10.15298/invertzool.15.3.06

KEY WORDS: checklist, Cladocera, biodiversity, Neotropics, South America, taxonomy.

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Аннотированный список пресноводных ветвистоусых ракообразных (Crustacea: Branchiopoda: Cladocera) Эквадора и Галапагосских островов

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РЕЗЮМЕ: В статье представлен аннотированный список видов ветвистоусых ракообразных (Crustacea: Branchiopoda), отмеченных во внутренних водоемах Эквадора и Галапагосских островов. Мы пересмотрели все опубликованные находки, проанализировали валидность каждого таксона и привели короткие таксономические и биогеографические примечания для каждого таксона. Всего нами было выявлено 34 валидных вида кладоцер, принадлежащих к 23 родам. В настоящее время, любые попытки анализа паттернов распределения ветвистоусых ракообразных в Эквадоре являются преждевременными из-за нехватки надежной информации. Также в статье обсуждены текущие достижения в области инвентаризации кладоцер, информационные пробелы и приведены рекомендации для будущих исследований по систематике кладоцер Эквадора.

Как цитировать эту статью: López C., Mosquera P.V., Hampel H., Neretina A.N., Alonso M., Van Damme K., Kotov A.A. 2018. An annotated checklist of the freshwater cladocerans (Crustacea: Branchiopoda: Cladocera) of Ecuador and the Galápagos Islands // Invert. Zool. Vol.15. No.3. P.277–291. doi: 10.15298/invertzool.15.3.06

КЛЮЧЕВЫЕ СЛОВА: контрольный список, Cladocera, биоразнообразие, Неотропики, Южная Америка, систематика.

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Introduction

Investigations of the cladocerans (Crustacea: Branchiopoda: Cladocera) of the inland freshwater bodies of South America began at the end of the 19th century and were initially carried out by European taxonomists (e.g. Ihering, 1895; Sars, 1901; Stingelin, 1913; Delachaux, 1919; Brehm, 1956). Studies of the freshwater cladocerans of Ecuador began much later. Only at the beginning of the 1980s, some pioneer surveys were carried out as a part of limnological studies on the Galápagos Islands and Andean lakes (e.g. Colinvaux, Steinitz-Kannan, 1980). Since the 1980s only a handful of papers recorded the cladocerans from the inland waters of Ecuador (Gunkel, 2000; Casallas, Gunkel, 2001; Torres, Rylander, 2006; Obando, 2009; Briones, 2012; López-Blanco, Sinev, 2016; Van Colen *et al*., 2017; Alonso *et al*., 2017; Alonso, Kotov, 2017; Alonso, Sinev, 2017) have appeared. Compared to other countries in the tropical zone of South America (Valdivia Villar, 1988; Elmoor-Loureiro, 1998; 2000; Zoppi de Roa, López, 2008; Kotov, Fuentes-Reinés, 2015), the taxonomic knowledge on the cladocerans of Ecuador is limited. Such studies are now just beginning.

National and regional checklists are crucial for a basic knowledge on the biodiversity and such efforts allow a firm taxonomical basis for derived studies. Recently, several comprehensive checklists with taxonomical notes have been compiled for different countries where cladocerans are under intense study, e.g. India (Chatterjee *et al*., 2013), China (Korovchinsky, 2013; Ji *et al*., 2015; Xiang *et al*., 2015) and Korea (Jeong *et al*., 2014) in Asia; Colombia (Kotov, Fuentes-Reinés, 2015), Chile (De los Ríos Escalante, Kotov, 2015) and Brazil (Elmoor-Loureiro, 1998, 2018) in South America. At the same time, large revisions and checklists in Cladocera genera have helped to tackle taxonomical challenges (e.g. Van Damme *et al*., 2010).

The aims of the present paper are to provide a formal list of the Ecuadorian (including the Galápagos Archipelago) cladocerans based on all available literature, to evaluate the validity of all recorded species and to discuss some taxonomic and biogeographical issues. Moreover, we identify information gaps and provide recommendations for future investigations of taxonomy and biogeography of the cladocerans of Ecuadorian inland waters.

Material and methods

The list of the cladocerans of Ecuador compiled herein is based on data from literature, a revision of all published papers we could find to date. Species listed for Ecuador are discussed with special attention to their taxonomic status. Current valid species names and combinations are based on the FADA checklist (Kotov *et al*., 2013), with some exclusions specified below. The species are attributed to three geographic and physiographic provinces of the continental territory of this country: Andean Region, Coastal Region, Amazonian Region according to Steere (1950) and to the Galápagos Islands (Fig. 1).

Results

In total, 34 valid species of Cladocera have been reported in literature from inland water bodies of Ecuador. These species belong to seven families and 23 genera. The family Chydoridae, as expected, includes the largest number of genera (13 genera) followed by the Daphniidae (3 genera). The remaining families each contain two or one genera. Chydoridae includes 15 species, followed by Daphniidae (12 species), Macrothricidae (2 species), Ilyocryptidae (2 species), Sididae (2 species), Bosminidae (2 species) and Moinidae (1 species).

Order Ctenopoda Sars, 1865

Family Sididae Baird, 1850

(1) *Diaphanosoma brachyurum* (Liévin, 1848)

Records. Coastal Region: Chongón Reservoir (02º13′09″S 80º07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Fig. 1. Map of Ecuador showing main geographical regions, number of recorded species and number of sampled locations in each region.

Рис. 1. Карта Эквадора с обозначенными основными биогеографическими районами, число выявленных видов и число обследованных водоемов приведено для каждого региона.

Taxonomical remarks. *D. brachyurum* has been originally described from Europe and constitutes a complex of cryptic species with several related taxa in the Nearctic and Neotropical regions (Korovchinsky, 1992, 2004). Often, existing reports of this taxon refers to other species, even in Europe (Korovchinsky, 2000). In the Neotropics, this name is used incorrectly because this species in absent in South America (Korovchinsky, 2004). The Ecuadorian populations need to be revised and all Neotropical records of this species must be critically evaluated. As a result, this common and diverse tropical species group remains unresolved in Ecuador.

(2) *Sarsilatona serricauda* Sars, 1901

Records. Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro, identified on remains in lake sediments (López-Blanco, Sinev, 2016).

Taxonomical remarks. *S. serricauda* was described from Brazil (see Korovchinsky, 2004). It is distributed from the southern U.S.A. to northern Argentina (Korovchinsky, 2004; Kotov, Fuentes-Reinés, 2015).

Order Anomopoda Sars, 1865

Family Daphniidae Straus, 1820

(1) *Ceriodaphnia* cf. *cornuta* Sars, 1885

Records. Coastal Region: Chongón Reservoir (02º13′09″S 80º07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. This taxon was initially described from Australia (Sars, 1885) and then found in other tropical regions. Now it is considered as a complex of closely related species, specific for each continent (Sharma, Kotov, 2013). According to DNA-barcoding data, the *C. cornuta* species complex harbors cryptic species in tropical regions of the Neotropics as well (Elías-Gutiérrez *et al*., 2008). *C. cornuta*, sometimes listed under the name of its African congener, *C. rigaudi* Richard 1894, is commonly recorded in the region (Valdivia Villar, 1988; Elmoor-Loureiro, 2000; Zoppi de Roa, López, 2008; Kotov, Fuentes-Reinés, 2015). Although nowadays taxonomists consider this species as a complex of sibling taxa, *C.* cf. *cornuta* can be easily distinguished from other *Ceriodaphnia* species based on its prominent rostrum. Neotropical populations need to be revised in detail as part of a global revision of this group.

(2) *Ceriodaphnia dubia* Richard, 1894

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. *C. dubia* is initially described from Indonesia, but then found in different regions of the world with tropical and temperate climate (see Chatterjee *et al*., 2013). It has been reported from Andean lakes in nearby countries (Zoppi de Roa, López, 2008; De los Ríos Escalante, Kotov, 2015; Kotov, Fuentes-Reinés, 2015). This taxon needs a global revision, as it is apparently a group of closely related species (e.g. Sharma, 2014).

(3) *Daphnia* (*Daphnia*) *ambigua* Scourfield, 1947

Records. Andean Region: Lakes of Reserva Ecológica Cayambe-Coca (Páramo de Guamaní) (0°21′00″S 78°12′00″W) (Torres, Rylander, 2006). Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l. Province of Azuay (Alonso *et al*., 2017). Lake Colta (1°45′00″S 78°44′33″W), 3.288 m a.s.l. (Villalobos, 1994).

Taxonomical remarks. The taxon was initially described from the United Kingdom, but the description was based on an exotic population occurring out of its main distribution range in the New World (see Benzie, 2005). This small-sized species of *Daphnia* is distributed throughout the Americas (Matsumura-Tundisi, 1984, Adamowicz *et al*., 2004; Benzie, 2005) and invaded Europe. South American populations form a distinct clade (Hebert *et al*., 2003). It could be confused with *D. parvula*, which has been also recorded from Ecuador.

(4) *Daphnia* (*Daphnia*) *laevis* Birge, 1879

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W). 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. This taxon was initially described from U.S.A. (see Benzie, 2005). It represents a group of cryptic species distributed in North and South America and Africa (Taylor *et al*., 1998; Adamowicz *et al*., 2004; Benzie, 2005).

(5) *Daphnia* (*Daphnia*) *longispina* (O.F. Müller, 1776)

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Labaj *et al*., 2017; Van Colen *et al*., 2017).

Taxonomical remarks. *D. longispina* was initially described from Denmark (see Kotov, 2015). This morphological confusing species complex has a wide geographical distribution in Africa, Europe and Asia (Benzie, 2005, Kotov *et al*., 2013). Its taxonomy is confused even in Europe (Petrusek *et al*., 2008; Kotov, 2015). As *D. longispina* s.str. does not occur in South America (Adamowicz *et al*., 2004), this is most likely a misidentification.

(6) *Daphnia* (*Daphnia*) cf. *obtusa* Kurz, 1875

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. *Daphnia obtusa* was initially described from Czech Republic (see Benzie, 2005). It is considered now a nearly cosmopolitan complex of species with numerous species (Benzie, 2005). Populations assigned to *D. obtusa* s.l. have been reported from high altitude regions of different tropical countries (Villalobos, 1994; Kotov, Taylor, 2010; Van Damme, Eggermont, 2011). Populations are known from the Neotropics (Villalobos, 1994). In South America this species needs to be revised, it is apparently represented by a series of taxa even on this continent (Kotov, Taylor, 2010).

(7) *Daphnia* (*Daphnia*) *parvula* (Fordyce, 1901)

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. *D. parvula* has been described for North America, but has a wide geographical range in the western hemisphere, especially latitudinal (Benzie, 2005; Popova, Kotov, 2013), and widely distributed in Europe (Alonso, 1996; Flössner, 2000). This taxon could be confused with *D. ambigua*, which is also present in our checklist.

(8) *Daphnia* (*Daphnia*) cf. *pulex* Leydig, 1860

Records. Andean Region: Lake San Pablo (0°12′00″N 78°13′00″E), 2.660 m.a.s.l., Province of Imbabura (Gunkel, 2000; Labaj *et al*., 2017). Cajas National Park (2°50′00″S 79° 10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. It was initially described from unknown locality in Europe (Benzie, 2005). This taxon is a complex of species and a revision of the group is needed (Kotov, Taylor, 2010; Kotov, 2016), in particular for populations from South America (Crease *et al*., 2012) and may be confused with *D. pulicaria*.

(9) *Daphnia* (*Daphnia*) *pulicaria* Forbes, 1893

Records. Andean Region: Lake San Pablo (0°12′00″N 78°13′00″E), 2.660 m a.s.l., Province of Imbabura (Villalobos, 1998; Casallas, Gunkel, 2001). Lake Coicochoa (0°18′00″N 78°21′00″W), 3.246 m a.s.l. (Villalobos, 1994). Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. This taxon was initially described from U.S.A. (see Benzie, 2005). According to Adamowicz *et al*. (2004) some records of *D. pulex* in South America may refer to *D. pulicaria*, and both taxa are easily confused also in Europe (see also in Crease *et al*. (2012)).

(10) *Simocephalus acutifrons* Johnson, 1953

Records. Coastal Region: Chongón Reservoir (02º13′09″S 80º07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. This species was described from the Republic of South Africa (see Orlova-Bienkowskaja, 2001). Then it was considered as a junior synonym of *S. brehmi* Gauthier, 1939 (Orlova-Bienkowskaja, 2001; Kotov *et al*., 2013). Both taxa were described from the African continent (Gauthier, 1939; Johnson, 1953) and populations of *S*. cf. *brehmi* have been reported from Brazil (Orlova-Bienkowskaja, 2001; Van Damme, Dumont, 2010). This is a very easily recognizable taxon, yet the status in South American populations needs revision (Van Damme, Dumont, 2010). The Ecuadorian record needs revision in comparison to other Neotropical populations of *S.* cf. *brehmi.*

(11) *Simocephalus exspinosus* (De Geer, 1778)

Records. Galápagos Islands: Lake El Junco (0°53′42″S 89°28′48″W), 675 m a.l.s., San Cristóbal Island (Obando, 2009).

Taxonomical remarks. The species was initially described from Europe, now it is considered as cosmopolitan taxon (Orlova-Bienkowskaja, 2001) which needs a global revision.

(12) *Simocephalus* cf. *vetulus* (O.F. Müller, 1776)

Records. Coastal Region: Chongón Reservoir (02º13′09″S 80º07′32″W), 54 m a.s.l., Prov-

ince of Guayas (Briones, 2012). Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. *S. vetulus* is a Palearctic species initially described from Denmark (see Orlova-Bienkowskaja, 2001; Huang *et al*., 2014). Unfortunately, Orlova-Bienkowskaja (2001) did not analyze material from South America. According to Kotov *et al*. (2010), *S. vetulus* or a very closely related species is present in this continent. Neotropical populations of this taxon need to be checked morphologically and genetically, keeping in mind the existence of numerous *vetulus*-like species in other regions of the world (Huang *et al*., 2014).

Family Moinidae Goulden, 1968

(1) *Moina micrura* Kurz, 1874

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. The species was initially described from Czech Republic (see Petrusek *et al*., 2004). This taxon represents a cosmopolitan group which needs a detailed global revision (Elías-Gutiérrez *et al*., 1999; Petrusek *et al*., 2004; Bekker *et al*., 2016).

Family Ilyocryptidae Smirnov, 1976 sensu Smirnov, 1992

(1) *Ilyocryptus spinifer* Herrick, 1882

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. This species was initially described from U.S.A. (see Kotov, Dumont, 2000). It is a common tropicopolitan taxon, usually found in different localities in South America (Kotov, Dumont, 2000).

(2) *Ilyocryptus spinosus* (Štifter, 1988)

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (recorded by Alonso *et al*., 2017).

Taxonomical remarks. This species was initially described from Germany (see Kotov, Štifter, 2006). *I. spinosus* has been reported from the Northwest of U.S.A, Northeast of Canada and the North of Europe (Kotov, Štifter, 2006). Ecuadorian populations should be compared morphologically and genetically with Neartic and Paleartic populations. The former could belong to a described taxon related to *I. spinosus* s.str.

Family Macrothricidae Norman and Brady, 1867

(1) *Macrothrix* cf. *hirsuticornis* (Norman and Brady, 1867)

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. This species was initially described from the United Kingdom (see Kotov, 2007). According to Smirnov (1992), only Palearctic populations could be regarded as *M. hirsuticornis* s.str., yet this taxon was recorded from North and South America as well. Kotov (2007) concluded that all populations from southern South America belong to *M. oviformis* Ekman, 1900. The record from Ecuador and others from the Neotropics must be revised because its identity with *M. oviformis* is not obvious.

(2) *Drepanothrix dentata* Eurén, 1861

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. This species was initially described from Sweden (Smirnov, 1992). It is distributedin the Palearctic region only (Alonso, 1996; Flössner, 2000). This taxon may also be present in the Neartic region (Kotov *et al*., 2013). *Drepanotrix dentata* was considered by Kotov (2016) as a complex of species which needs to be revised taxonomically. Only Iglesias *et al*. (2016) recorded this species in South America previously. There is a high chance that populations from South America belong to a new species if it is not a misidentification.

Family Bosminidae Baird, 1845 sensu Sars, 1865

(1) *Bosmina* (*Bosmina*) *longirostris* (O.F. Müller, 1776)

Records. Andean Region: Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. This taxon was initially described from Denmark; preliminary genetic data suggests that this is a really cosmopolitan taxon (Chatterjee *et al*., 2013).

(2) *Bosmina* (*Liederobosmina*) *huaronensis* Delachaux, 1918

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Remarks. This species is initially described from Peruvian Andes; it is widely distributed in the Americas (De los Ríos Escalante, Kotov, 2015).

Family Chydoridae Dybowski and Grochowski, 1894

(1) *Acroperus tupinamba* Sinev & Elmoor-Loureiro 2010

Records. Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro, based on remains in lake sediments (López-Blanco, Sinev, 2016).

Remarks. *A. tupinamba* was described from Brazil; it has a wide distribution in Brazil and likely in other areas in the Neotropics (Sinev, Elmoor-Loureiro, 2010).

(2) *Alona* cf. *affinis* (Leydig, 1860)

Records. Andean Region: Lakes of Reserva Ecológica Cayambe-Coca (Páramo de Guamaní) (0°21′00″S 78°12′00″W) (Torres, Rylander 2006).

Taxonomical remarks. The species was initially described from Germany (see Sinev, 1997). Any records from the New World are unlikely belong to European *A. affinis* s.str. To date, several New World populations have been assigned to existing as well as new names (Sinev, 1997; Van Damme *et al*., 2010). In Lake Titicaca (high altitudes of Peru), an *A. affinis*-like population has been given a name yet needs a formal redescription (see Van Damme *et al*., 2010). The record from Ecuador needs a revision; it probably refers to *A. ossiani* (Sinev, 1998). In this checklist *A. affinis* is considered a dubious record.

(3) *Alona glabra* Sars, 1901

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso et al., 2017).

Taxonomical remarks. The taxon was initially described from Argentina; this is a widespread Neotropical species (Sinev, 2001). But it deserves close attention, because there are at least two different phylogroups in the region (Elías-Gutiérrez *et al*., 2008). Sinev (2015a) recently revised this group (including Neotropical taxa) and suggested to move all *A. pulchella*-related species to the genus *Ovalona*, proposing a new combination *Ovalona glabra* (Sars, 1901).

(4) *Alona guttata* Sars, 1862

Records. Andean Region: Lakes of Reserva Ecológica Cayambe-Coca (Páramo de Guamaní) (0°21′00″S 78°12′00″W) (Torres, Rylander, 2006). Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Labaj *et al*., 2017).

Taxonomical remarks. This taxon was initially described from Norway; it represents a cosmopolitan complex of species, widely distributed, which needs to be revised worldwide (Van Damme *et al*., 2010). Neotropical populations show differences from North American species in this complex, *A. barbulata*, and from the European *A. guttata* (Sousa *et al*., 2016).

(5) *Alona ossiani* (Sinev, 1998)

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. The taxon was described from Brazil (Sinev, 1998). *A. ossiani* is a Neotropical congener of the truly Palearctic *A. affinis* (Leydig, 1860) (Sinev, 1998; Van Damme *et al*., 2010; Sinev, 2013). The previous record of *A. affinis* from Ecuador reported by Torres and Rylander (2006) most likely belongs to *A. ossiani* or to another related species, not to *A. affinis* s.str., and should be checked in detail.

(6) *Alpinalona cajasi* Alonso & Sinev, 2017

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso, Sinev, 2017).

Taxonomical remarks. Recorded initially by Alonso *et al*. (2017), as *Alona* sp. related to

Alona manueli Sinev et Zawisza, 2013 (*Alona* sp. gr. *manueli*) (Sinev, Zawisza, 2013). It was described the same year as a new species in a new genus *Alpinalona* Alonso et Sinev, 2017.

(7) *Alonella hampelae* Alonso & Kotov 2017

Records. Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l. (Alonso, Kotov, 2017).

Taxonomical remarks. This taxon was recently described from Lakes of Cajas National Park (Ecuador) by Alonso and Kotov (2017). It belongs to the *A. excisa*-group. All records of *A.* cf. *excisa* of South America need revision because other taxa could be present there (Alonso, Kotov, 2017).

(8) *Alonella nana* Baird, 1843

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (in Briones (2012) as "*Alona nana*").

Taxonomical remarks. This taxon was initially described from the United Kingdom (see Smirnov, 1971). Briones (2012) recorded "*Alona nana* Baird 1843" which is an erroneous combination, the author apparently meant *Alonella nana*. However, *A. nana* does not occur in the Neotropics (Smirnov, 1996) and it is possible that the record of Briones (2012) has been confused with a small Neotropical taxon *A. dadayi*, which is recognizable by a long rostrum. This record in the lowlands of Ecuador may be invalid.

(9) *Camptocercus dadayi* (Stingelin, 1913)

Records. Andean Region: Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017).

Taxonomical remarks. *C. dadayi* is a well-defined Neotropical taxon initially described from Colombia (see Sinev, 2015b).

(10) *Chydorus* cf. *sphaericus* (O.F. Müller, 1776)

Records. Andean Region: Lakes of Reserva Ecológica Cayambe-Coca (Páramo de Guamaní) (0°21′00″S 78°12′00″W) (Torres, Rylander, 2006). Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro (López-Blanco, Sinev, 2016). Andean Region: Lakes of Cajas National Park (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso *et al*., 2017; Labaj *et al*., 2017).

Taxonomical remarks. The species was initially described from Denmark (Smirnov, 1971). This is a very difficult cosmopolitan species complex with many taxa, as revealed by genetic methods (Belyaeva, Taylor, 2009; Kotov *et al*., 2016). The name "*C. sphaericus*" is used for nearly every *Chydorus* around the world, and it is not certain that all these records belong to the *C. sphaericus* group. Any records of this difficult genus should be accompanied by drawings or photos for confirmation.

(11) *Ephemeroporus acanthodes* Frey, 1982

Records. Andean Region: Lakes of Reserva Ecológica Cayambe-Coca (Páramo de Guamaní) (0°21′00″S 78°12′00″W) (Torres, Rylander, 2006, misspelled as "*E. acanthoides*").

Remarks. The species was initially described from souther U.S.A., in South America, it have been found in the Peruvian Andes (Valdivia Villar, 1988), a Venezuelan Andean lake (López, 1993) and more recently in different water bodies in Brazil (Serafim *et al*., 2003, Van Damme, Dumont, 2010) and Paraguay (Debastiani-Júnior *et al*., 2015). Several species of *Ephemeroporus* are present in the Neotropics, identifications should be checked thoroughly.

(12) *Euryalona occidentalis* Sars, 1901

Records. Galápagos Islands: Lake El Junco (0°53′42″S 89°28′48″W), 675 m a.s.l., San Cristóbal Island (Obando, 2009).

Taxonomical remarks. It is a clearly recognizable Neotropical taxon initially described from Brazil (Paggi, 1980).

(13) *Kurzia* cf. *latissima* (Kurz, 1875)

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. It was initially described from Czech Republic, its distribution is restricted to the Afrotropics and the Palearctic (Hudec, 2000). South American records have been shown to belong to *K. polyspina* (Hudec, 2000; Elmoor-Loureiro, 2002). It is most likely

that identification of Briones 2012 is erroneous, and the author dealt with *K. polyspina.*

(14) *Leydigiopsis brevirostris* Brehm, 1938

Records. Coastal Region: Chongón Reservoir (02°13′09″S 80°07′32″W), 54 m a.s.l., Province of Guayas (Briones, 2012).

Taxonomical remarks. This is a well-defined Neotropical species initially described from Brazil (Sinev, 2004; Van Damme, Sinev, 2013), and other species in this genus can be expected in Ecuador.

(15) *Magnospina dentifera* (Sars, 1901)

Records. Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro, listed in the bottom sediments (López-Blanco, Sinev, 2016).

Taxonomical remarks. This taxon was initially described from Brazil (Sinev et al., 2004). Recently, the *Alona dentifera* group was moved to the genus *Magnospina* Sousa, Elmoor-Loureiro et Santos, 2016. However, it was separated from *Coronatella,* with unclear diagnosis, and the combination may change again. This Neotropical taxon ("*Alona*" *dentifera*) is well defined and occurs from U.S.A to Argentina (Sinev *et al*., 2004; Sousa *et al*., 2016).

(16) *Notoalona sculpta* (Sars, 1901)

Records. Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro, listed based on based on fragments found in lake sediments (López-Blanco, Sinev, 2016).

Taxonomical remarks. This is a clearly recognizable Neotropical taxon initially described from Brazil (Rajapaksa, Fernando, 1987; Van Damme *et al*., 2013).

(17) *Oxyurella longicaudis* (Birge, 1910)

Records. Coastal Region: Lake Tembladera (3°29′29″S 79°59′40″W), 17 m a.s.l., Province of El Oro based on fragments found in lake sediments (López-Blanco, Sinev, 2016).

Remarks. *O. longicaudis* is a common Neotropical species initially described from unknown localities in South America (Elmoor-Loureiro, 1998; Van Damme, Dumont, 2010).

(18) *Paralona pigra* (Sars, 1862)

Records. Andean Region: Lakes of National Park Cajas (2°50′00″S 79°10′00″W), 3.160–4.450 m a.s.l., Province of Azuay (Alonso et al., 2017).

Taxonomical remarks. *P. pigra* was initially described from Norway; it is a cosmopolitan species (Dumont, Smirnov, 1996; Smirnov, 1996) and needs to be revised worldwide.

Discussion

The checklist of recorded species of Ecuadorian cladocerans contains 34 valid species. The number of cladoceran species of Ecuador recorded to date is significantly lower when compared to those in checklists for other countries in South America, such as Peru (88 taxa), Colombia (101 taxa), Brazil (116 taxa) and Venezuela (115 taxa) (Valdivia Villar, 1988; Elmoor-Loureiro, 2000; Zoppi de Roa, López, 2008; Kotov, Fuentes-Reinés, 2015). The comparably "low" biodiversity of the cladocerans in Ecuadorian water bodies is herein considered an artifact resulting from insufficient past efforts in sampling and identification. However, there is a benefit from the low number of studies on Cladocera in Ecuador: the taxonomical confusion is small and has not accumulated over decades (or even centuries). It is possible to start from a firm and modern taxonomical basis and conduct new studies in the region.

Several taxa in this checklist may belong to undescribed species, or to groups of which the taxonomy needs to be resolved in detail in the Neotropics or worldwide. The checklist illustrates that we should be careful to apply "Holarctic" names to Neotropical populations in Ecuador, including in high altitudes. However, we should be realistic that also "Löffler Islands" — tropical high altitude aquatic habitats harboring relict populations originating from northern latitudes (Van Damme, Eggermont, 2011) — could be found in Ecuador. In addition, the possibility of true human-mediated introductions should not be excluded. It is clear however, that the majority of records deserve a closer look and a morphological and genetic comparison to populations from the *terra typica*.

Taxonomical studies of freshwater Cladocera in Ecuador are just starting and most of the

efforts have been carried out in the limnetic zones of lakes and ponds in the Andean Region. Habitats important for cladoceran biodiversity, such as littoral zones, temporary pools and swamps, as well as several areas such as the low and medium altitudes of Ecuador, should be explored. The water bodies of the lowlands of the Coastal Region and Galápagos Islands have been scarcely studied and those of the Amazonian Region remain unexamined (Fig. 1). According to Green (1995), high altitude lakes have lower biodiversity than water bodies from lowlands (but see Van Damme, Eggermont, 2011), yet a high endemism can be expected in the Andes (Kotov *et al*., 2010). Therefore, more extensive studies of cladocerans, including the unexplored lowlands, and further explorations in the mountains with unique taxa, are necessary to improve such a situation. In addition, it will be interesting to learn what the volcanic Galápagos really harbor of cladoceran faunas. Despite a relatively small country in comparison to its neighboring countries, Ecuador has also an enormous biodiversity as a result of the heterogeneity of existing environments and the notorious altitudinal gradients. The diversity in habitats is currently not reflected in the Cladocera.

Presently, any attempts to analyze the distributional patterns of Cladocera in Ecuador would be uninformative due to the scarcity of adequate information. The occurrence of Cladocera species that are common in the Neotropics and that are known for example in Colombia and Peru, as well as new species, can be expected, especially in the diverse family Chydoridae. The description of new chydorids from Ecuador (Alonso, Kotov, 2017; Alonso, Sinev, 2017) clearly point in that direction, yet new taxa in other families cannot be excluded.

Recommendations

The low number of Cladocera species reported from Ecuador could be attributed to the insufficient number of cladoceran surveys and studies. More taxonomical and biogeographical studies of Ecuadorian cladocerans are needed, especially in regions which are poorly studied, such as the Amazonian Region, Coastal Region and Galápagos Islands (Fig. 1). These field surveys must encompass littoral zones of large lakes and ponds, particularly where macrophytes are present. Special attention should be paid to sampling in the bottom layers and in-shore areas and among macrophytes in order to survey the species that live in these zones. Also, it is necessary to sample a greater variety of aquatic habitats, such as artificial reservoirs, wetlands, swamps, "albarradas" (cisterns), inundated rice fields, temporary pools, moss, flooded forest, hyporheic/phreatic zones and phytotelmata communities. The efforts of local specialists should be combined with taxonomical training under the leadership of trained experts in order to provide knowledge transfer on taxonomy of cladocerans. The analysis of biodiversity of resting eggs from sediments using the Sars' Method (Van Damme, Dumont, 2010) may be used complementary to obtain a better estimation of biodiversity of cladocerans, to describe different life stages (e.g. males) and provide material for molecular studies.

In concordance with recent advances in the field, these studies must be reinforced by genetics, in order to accurately explore the genetic isolation between populations from different regions of the world, and within the region.

Acknowledgements

Corrections and suggestions from anonymous referees greatly improved an early version of the manuscript. Special thanks to Dr F.D.R Sousa for his valuable comments on some species and help with some bibliographical references and Dr A.Y. Sinev for some critical comments. Thanks for M. Belén López for help with the figure and L. Dávalos-Lind for revision of the English spelling and grammar in earlier draft.

Manuscript writing (remarks on taxonomic status of some tropical taxa revealed in Ecuador, general text editing) for ANN was funded by RFBR according to the research project 18-34-00389 мол_а. AAK was supported by Russian Government Program of Competitive Growth of Kazan Federal University.

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Responsible editor K.G. Mikhailov