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Alien crustacean species recorded in Ecuador

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ABSTRACT

Alien species are organisms introduced into an area outside of their natural range and are considered a major cause of biodiversity loss in the marine environment. The aim of this work is to report on the alien crustacean species observed in Ecuador. A bibliographic review was conducted using a digital search in the scientific literature. A total of ten alien species of crustaceans, representing eight genera in seven families, were encountered in Ecuador. The only crab, *Cardisoma crassum* Smith, 1870, was observed in the Galapagos Islands. The other species include barnacles, crayfishes, and freshwater prawns. Native ranges of the alien crustaceans include the Indo-Pacific region, North America, Asia, and Australia. Major introduction pathways are aquaculture and transport by ship. *Procambarus alleni* (Faxon, 1884) was reported recently as an aquarium species, but its presence in the natural environment is currently unknown. One alien species has been introduced each decade since the 1960s. Some species (the barnacles *Amphibalanus improvisus* (Darwin, 1854), *Amphibalanus reticulatus* (Utinomi, 1967), and the copepod *Lernaea cyprinacea* Linnaeus, 1758) were reported as alien species for Ecuador but need verification regarding their current status. Additionally, the barnacle *Dosima fascicularis* (Ellis and Solander, 1786) presented an occasional record in the Galapagos Islands, but due to its dispersal ability and open ocean habitat it is not possible to conclude that this really is an alien species. The list of alien crustacean species recorded in Ecuador is considered incomplete due to both scarce published work regarding this topic and taxonomic problems. Therefore, it is necessary to carry out more research to establish a complete list of the alien species present in Ecuador and assess their impact on aquatic ecosystems.

KEYWORDS

Aquaculture, biodiversity loss, invasive species, South America, transport on ships

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INTRODUCTION

Alien species are non-native organisms introduced to an area outside of their natural biogeographic range. The presence of alien species is mostly attributable to human actions of artificially transporting species beyond their usual distributional barriers (Richardson *et al.*, 2010; Blackburn *et al.*, 2014). When an introduced species successfully colonizes a natural or semi-natural environment where it lacks natural enemies, it often becomes a potential threat to native biodiversity (*e.g.*, species, ecosystem), and can be defined as an “alien invasive species” (Howard, 2004). Alien invasive species have been considered as a major cause of biodiversity loss and reduction (by at least one-fifth) in the average abundance of native organisms, across many ecosystems, including in the marine environment (Brockerhoff and McLay, 2011; Moodley *et al.*, 2020).

The subphylum Crustacea is the most successful taxon of alien species in aquatic ecosystems around the world due to characteristics of their life history, physiology, and behavior (Hänfling *et al.*, 2011). The most recent reports include 73 alien crab species, of which 52 spp. can be found in seas and countries across the globe. Most species are either swimming crabs (Portunidae), shore crabs (Grapsidae), or spider crabs (Majidae) (Brockerhoff and McLay, 2011; McLay, 2015). Other taxa contributing to reported exotic crustacean species include crayfish, barnacles, copepods, and mysids (Castilla and Neill, 2009; Carlton, 2011; Carlton *et al.*, 2011; Hänfling *et al.*, 2011).

Three general questions arise in relation to alien species: (i) which species are involved, (ii) which habitats do they occupy, and (iii) how can we manage this problem? (Pyšek and Richardson, 2010). In Ecuador, the first two issues have been considered for marine Cnidaria, Bryozoa, Arthropoda, Rhodophyta, Chlorophyta (Cárdenas-Calle *et al.*, 2019), phanerogams, and terrestrial animals (Donoso *et al.*, 2014; Sandoya *et al.*, 2017; Espinoza-Amén *et al.*, 2021). However, information related to alien crustaceans in Ecuador is scarce, and it is necessary to assess their environmental impact and management. The objective of this work is to report on the alien crustacean species observed in Ecuador.

MATERIAL AND METHODS

A bibliographic review of the alien crustacean species in Ecuador was performed by a digital search. The starting point was the web page “GRIIS Checklist of Introduced and Invasive Species — Ecuador” (Herrera *et al.*, 2020a). This literature search was complemented with direct observations made by the authors on mainland Ecuador since 2011. The information was processed through the analytic-synthetic method (Cellucci, 2013). This method aims to solve a problem based on prime premises, which are considered as true by an “intuition” (*i.e.*, previous knowledge) and demonstrated with deductions (Cellucci, 2013). In our case, the prime premise was that the analyzed species are aliens as demonstrated by reports in the literature.

The scientific names of the species analyzed, their corresponding authorities, and the names of their families were validated through the World Register of Marine Species (WoRMS Editorial Board, 2021). The taxonomy of observed freshwater crayfish was checked using an updated classification (Crandall and De Grave, 2017). The native range of freshwater species was verified initially using the web page “NAS-Nonindigenous Aquatic Species” (USGS, 2017) and then subsequently verified through the scientific literature.

RESULTS

A total of ten alien crustacean species, belonging to nine genera in eight families have been recorded from Ecuador, including two species considered alien only in the Galapagos Islands (Tab. 1). The native ranges of the alien species analyzed are the Indo-Pacific region, North America, Asia, and Australia. The introduction pathways were mostly through aquaculture attempts or transport by ship for trade or tourism.

The crayfish *Procambarus alleni* (Faxon, 1884) has been recently reported as an aquarium species (US\$ 10 per unit), and its presence in natural environments of Ecuador is currently unknown. The woodlouse *Porcellionides pruinosus* (Brandt, 1833) was reported in Colombia, and its presence was mentioned in Ecuador (Tab. 1). On average, one alien species was introduced per decade since the 1960s.

Table 1. Alien species of crustaceans recorded in Ecuador, period of introduction, and native region.

Family	Species	Observations	Native region
Balanidae	<i>Amphibalanus amphitrite</i> (Darwin, 1854)	Reported for South American Pacific since 1999; introduced by ship transport, attached to hulls (Carlton <i>et al.</i> , 2011). A cosmopolitan species on tropical coasts, and its presence is considered unlikely on the west coast of America (Darwin, 1854; Bishop, 1950).	Indo-Pacific region (Carlton <i>et al.</i> , 2011)
	<i>Megabalanus coccopoma</i> (Darwin, 1854)	Native species in mainland Ecuador, but alien in the Galapagos since 1964-1966; introduced by ship transport, attached to hulls (Henry and McLaughlin, 1986; Carlton <i>et al.</i> , 2019).	Indo-Pacific region (Carlton <i>et al.</i> , 2011)
Cambaridae	<i>Procambarus clarkii</i> (Girard, 1852)	Observed in Ecuador since 1986–1989; introduced for aquaculture purposes (Hobbs <i>et al.</i> , 1989; Romero, 1997; Riascos <i>et al.</i> , 2018).	The southern and central United States of America, northeastern Mexico (Hobbs <i>et al.</i> , 1989).
	<i>Procambarus alleni</i> (Faxon, 1884)	Reported as an aquarium species in Guayaquil in 2020 (Herrera <i>et al.</i> , 2020b). Presence in the natural environment unknown.	Florida, United States of America (Hobbs, 1984).
Cymothoidae	<i>Artystone trysibia</i> Schioedte, 1866	Reported since 2016, as a fish parasite in the loricariid <i>Chaetostoma dermorhynchum</i> (Boulenger, 1887), Tena River, Amazon (Junoy, 2016). The fish is a native species in Ecuador.	Atlantic coast of the Americas (Junoy, 2016).
Gecarcinidae	<i>Cardisoma crassum</i> Smith, 1870	Native in mainland Ecuador, alien in the Galapagos since 1993 when the individuals were carried in as food (Hickman and Zimmerman, 2000; Keith <i>et al.</i> , 2016).	West coast of the Americas (Bright, 1966).
Limnoriidae	<i>Limnoria tripunctata</i> Menzies, 1951	Alien species in Galapagos since 1960s (Carlton <i>et al.</i> , 2019). Reached the Galapagos from the continent by oceanic drift, including populated driftwood, wooden ships, and water ballast (Quayle, 1992; Gillespie <i>et al.</i> , 2012).	Circumtropical/warm-temperate species; in the eastern Pacific, from British Columbia (Canada) to Ecuador (Brusca and Iverson, 1985).
Palaemonidae	<i>Macrobrachium rosenbergii</i> (de Man, 1879)	Observed in Ecuador since 1978; introduced for aquaculture purpose (Alvarez-Galvez, 1984).	South and southeastern Asia (Wowor and Ng, 2007; 2008).
Parastacidae	<i>Cherax quadricarinatus</i> (von Martens, 1868)	Observed in Ecuador since 1994; introduced for aquaculture purposes (Romero, 1997; Romero and Jiménez, 2002).	Australia and southern New Guinea (Austin, 1996).
Porcellionidae	<i>Porcellionides pruinosus</i> (Brandt, 1833)	Reported from Colombia and Ecuador (Preciado and Martínez, 2015).	Europe (Preciado and Martínez, 2015).

DISCUSSION

The total number of alien crustacean species observed in Ecuador to date is relatively low compared to the numbers reported in Mexico (39 alien crustacean species), but close to the eight alien crustacean species reported for Colombia (Gracia *et al.*, 2011; Gutierrez *et al.*, 2012; Rodríguez-Almaraz and García-Madrigal, 2014). There are records of marine alien species in Peru, which include algae and mollusks, but no crustaceans (Castilla and Neill, 2009; Brockerhoff and McLay, 2011). The number of alien crustacean species mentioned in the current literature, however, should be considered with some caution because of the scarcity of studies in Latin America.

Due to a strong increase in tourism activities and transport by ship in the 1990's, it was expected that some alien barnacles would invade the Galapagos Islands, *Amphibalanus amphitrite* (Darwin, 1854), *Amphibalanus improvisus* (Darwin, 1854), and *Amphibalanus reticulatus* (Utinomi, 1967) for example (see Carlton, 1988; Zullo, 1991). Surprisingly, no alien

species of barnacle has been reported so far from the Galapagos Islands (Carlton *et al.*, 2011). Currently, *A. amphitrite* has been recorded from mainland Ecuador (Cárdenas-Calle *et al.*, 2019), but the presence of *A. reticulatus* has not yet been confirmed (Carlton *et al.*, 2011).

Amphibalanus improvisus was reported as an invasive species in Ecuador (Rodríguez-Almaraz and García-Madrigal, 2014), but this may require confirmation as its presence was last recorded in the mid-1800's (Darwin, 1854; Carlton *et al.*, 2011). Distribution patterns of *A. improvisus* are principally determined from museum collections but we could not find local registers for Ecuador. In 2016, the arrival of the stalked barnacle *Dosima fascicularis* (Ellis and Solander, 1786) on floating plastic marine litter, was mentioned for Santa Cruz Island, Galapagos. However, it has been considered to be an alien crustacean species without invasive capacity (Keith *et al.*, 2019).

We found the presence of the parasitic copepod *Lernaea cyprinacea* (Linnaeus, 1758) in Ecuador, associated with aquarium fish species (Lema, 2015).

It is naturally distributed in Africa, Asia, and the southeast of Siberia, and it has been introduced into North and South America by the living fish market (Plaul *et al.*, 2010). We could not confirm the presence of *L. cyprinacea* in Ecuador, but it is assumed that there are species of *Lernaea* in this country (Antonio Torres, pers. comm.).

The commercial marine shrimp species, *Penaeus monodon* Fabricius, 1798, is naturally distributed in Asia, Africa, and Australia, but adult individuals were reported in Ecuadorian waters in 1993 (Barragán, 1993; Giménez *et al.*, 2014). However, we have not found more recent evidence related to its presence in Ecuador. It is not possible to conclude that it is currently an alien species existing in Ecuador.

There are also doubts in relation to the presence of the freshwater prawn, *Macrobrachium* species, in Ecuador. The FAO (1975) reported *Macrobrachium carcinus* (Linnaeus, 1758) as an alien species, but mentioned that the species could also be *Macrobrachium americanum* (Spence Bate, 1868) or *Macrobrachium inca* Holthuis, 1950. Additionally, they reported *Macrobrachium acanthurus* (Wiegmann, 1836), however, it remains doubtful that this species occurs in Ecuador. We found no other records about these freshwater shrimp species in Ecuador.

The shore crab *Pachygrapsus transversus* (Gibbes, 1850), originally an Atlantic species, has been mentioned to occur in Ecuador (Martínez-Macías, 2016; Limón, 2019; Cárdenas-Calle *et al.*, 2020). However, Schubart *et al.* (2005) demonstrated that the material from the eastern Pacific corresponds to another species, *Pachygrapsus socius* Stimpson, 1871.

The record of alien crustacean species in Ecuador is considered incomplete due to taxonomic problems and limited studies focusing on invasive species (Korshunova *et al.*, 2019). It is necessary to consider the possibility of cryptic species being present in Ecuador, including alien crustacean species. In this sense, the museums and their biological collections are a valuable source for different studies, including biological invasion and functional ecology research. The information may even be used to answer future questions not yet posed (Suarez and Tsutsui, 2004; Castillo-Figueroa, 2018; Bakker *et al.*, 2020). In Ecuador, however, the development and maintenance of biological collections have not been a priority,

which limits the study of locally collected species. Therefore, additional research is necessary to update the list of alien species present in Ecuador and assess their impact on aquatic ecosystems.

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