Current status of *Paragonimus* and paragonimiasis in Ecuador

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A review of national and international publications on paragonimiasis in Ecuador, epidemiological records from the Ministry of Public Health and unpublished research data was conducted to summarise the current status of the parasite/disease. The purpose of the review is to educate physicians, policy-makers and health providers on the status of the disease and to stimulate scientific investigators to conduct further research. Paragonimiasis was first diagnosed in Ecuador 94 years ago and it is endemic to both tropical and subtropical regions in 19 of 24 provinces in the Pacific Coast and Amazon regions. Paragonimus mexicanus *is the only known species in the country, with the mollusc* Aroapyrgus colombiensis *and the crabs* Moreirocarcinus emarginatus, Hypolobocera chilensis *and* Hypolobocera aequatorialis *being the primary and secondary intermediate hosts, respectively. Recent studies found* P. mexicanus *metacercariae in* Trichodactylus faxoni *crabs of the northern Amazon. Chronic pulmonary paragonimiasis is commonly misdiagnosed and treated as tuberculosis and although studies have demonstrated the efficacy of praziquantel and triclabendazole for the treatment of human infections, neither drug is available in Ecuador. Official data recorded from 1978-2007 indicate an annual incidence of 85.5 cases throughout the 19 provinces, with an estimated 17.2% of the population at risk of infection. There are no current data on the incidence/prevalence of infection, nor is there a national control programme.*

Key words: *Paragonimus* - paragonimiasis - review - epidemiology - zoonoses - Ecuador

Paragonimiasis, a zoonotic disease caused by several species of *Paragonimus*, is a food-borne trematodiasis considered by the World Health Organization (WHO) to be one of the most neglected tropical diseases (Savioli & Daumerie 2010). *Paragonimus* flukes can infect wild and domestic animals in addition to humans following the ingestion of infective metacercariae found in certain species of freshwater crab and crayfish. Human infections are present in Africa, Asia and the Americas, including United States of America, Mexico, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, Colombia, Peru, Venezuela and Brazil (Acha & Szyfres 2003). Ecuador has the highest prevalence of human paragonimiasis in the Americas and the disease is officially considered a public health problem (Díaz et al. 1991). In 1972, following the analysis of weekly epidemiological reports, the Ministry of Public Health (MSP) made it mandatory to report paragonimiasis as a communicable disease. A 1994 WHO report estimated that 21% of the population was at risk for infection based on an expert opinion on the current prevalence of paragonimiasis in Ecuador (Toscano et al. 1994). Estimates in 1998 indicated that approximately 500,000 Ecuadorians could be infected (WHO 2011); however, official reports from the MSP have estimated an average of 85.5 cases per year (Fig. 1) until 2007. This prevalence is lower than expected, which can be attributed to under-reporting because human infections occur in rural and remote tropical areas, where infected patients are poor and health services are lacking. Furthermore, the data available at the MSP are from passive records, whereas we have demonstrated in several studies that performing active searches in communities reveals higher rates of diagnosis (Calvopiña et al. 1994, 1995).

Geographic distribution and prevalence of human infections - Ecuador is located in the northwestern region of South America and is crossed transversely by the equator line and from north to south by the Andes belt, providing three natural regions: the Pacific coastal area, the Amazon to the east and the Andean region in the centre. The first two regions, which comprise 64% of the country, have tropical and subtropical climates, whereas the higher Andean region is cold with warm inter-Andean valleys (Fig. 2).

Human paragonimiasis in Ecuador was first described in a patient from the coastal region of Chone-Manabí (Heinert 1922). Based on reported clinical cases and epidemiological studies, 511 cases had been documented by 1969 from five coastal and two Amazon provinces (Montalván 1968). From 1972-1976, 316 cases were diagnosed from four coastal provinces (Arzube & Voelker 1978). In 1980, Urrutia reported more than 2,000 cases in the Amazonian provinces (Toscano et al. 1994). Subsequently, foci of infection were identified in the coastal communities of Casacay, Pasaje and Piñas-El Oro, Caluma-Bolívar and Zapallo-Manabí (Palacios et al. 1978, Yokogawa et al. 1983).

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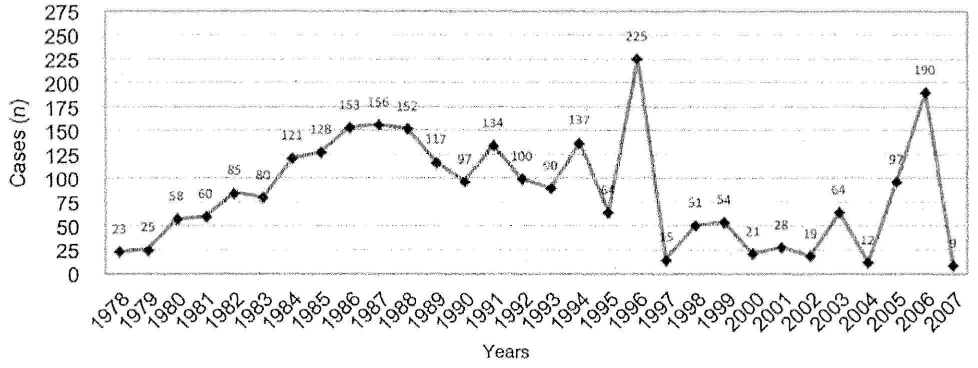

Fig. 1: the number of human cases registered in 30 years by the Ministry of Public Health. There was a marked increase from 23 cases reported in 1978 to 156 in 1987 and then a gradual decline to nine cases in 2007. The peak counts of 1996 and 2006 are due to active searches in communities by research groups.

Two active field searches of indigenous Chachi communities in the coastal province of Esmeraldas documented the presence of *Paragonimus* eggs in 7.1% and 30.3% of the sputum samples examined (Paredes et al. 1978, Guevara et al. 1999). From 1988-1991, the MSP recorded 252 cases from various locations in the above province (Vieira et al. 1992). In the Amazon Region, 124 cases were identified in indigenous Quichua and Shuar and in communities of colonists located along the banks of Napo River (Amunárriz 1991a).

Prospective and retrospective studies relying on active and passive searches have identified new foci of transmission. From 1976-1993, 98 cases of pulmonary paragonimiasis were diagnosed in the regional hospital of Latacunga in the province of Cotopaxi. A subsequent active case search between 1992-1993 documented an additional 189 cases from three subtropical cantons: La Maná, Pangua and Sigchos (Calvopiña et al. 1995). In the coastal province of Manabí, 146 patients from the three cantons of El Carmen, Chone and Pedernales were treated in the regional hospital of El Carmen from 1983-1993 (Calvopiña et al. 1994). According to a clinical review (passive search) of 92 cases admitted to the Eugenio Espejo Hospital in Quito, the patients came from communities in both coastal and Amazonia regions (Peñafiel et al. 1981). In subsequent active studies of some of these communities, 216 new cases of pulmonary paragonimiasis were documented (Calvopiña et al. 1998, 2003). According to the presence of human infection, the endemic foci in Ecuador were thus located in rural tropical and subtropical areas in the six Amazonian and five coastal provinces, with extensions to five Andean provinces (Amunárriz 1991a, Calvopiña et al. 1995).

The incidence of paragonimiasis from 1978-2007 according to the records of the MSP is provided in Figs 1, 3, with the incidence from 1998-2007 shown by region. It is important to note that these data represent only patients diagnosed in MSP clinics and hospitals who sought medical assistance (passive search); cases diagnosed in private clinics and hospitals and active cases that were specifically found in remote areas are not considered. Cases are still being diagnosed in hospitals within the endemic areas, with rare migrant cases observed in referral hospitals in non-endemic areas, such as Quito and Guayaquil. Without an official notification, the MSP stopped the obligatory recording of clinical cases of paragonimiasis in 2007.

Life cycle - The parasite - Prior to 1971, it was believed that the infectious *Paragonimus* species in Ecuador was *Paragonimus westermani* (Rodríguez 1963).

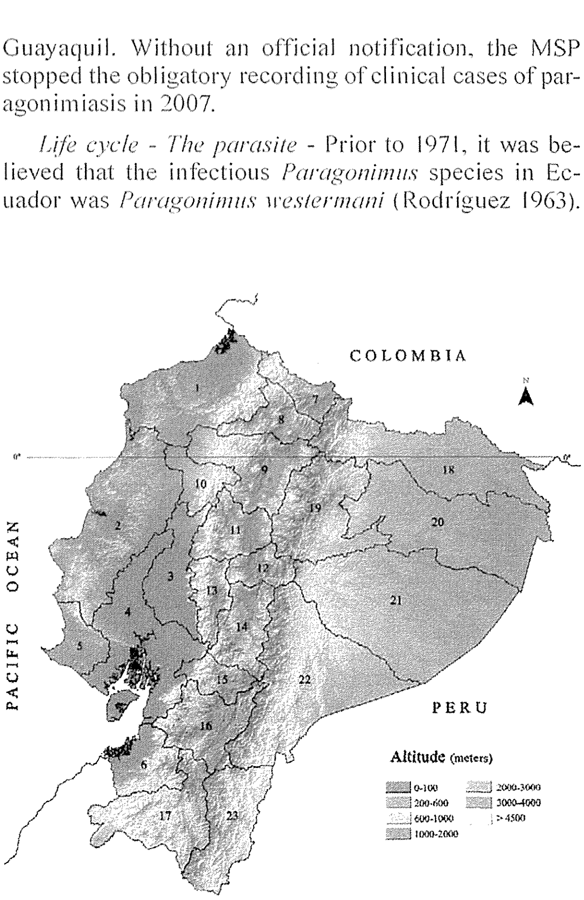

Fig. 2: map of Ecuador. The central brown Andes belt marks the Andean region. The Pacific coastal and eastern Amazon regions with tropical climate are in green. The yellow colour corresponds to the foothills of the mountains with subtropical climate. Cases of human paragonimiasis have been reported in all provinces except Galapagos Islands (not showed). Santa Elena (5), Carchi (7), Imbabura (8) and Tungurahua (12). The total country's area is 283.560 km². According to 2010 census, there is a total population of 14.483.499 of which 7,236,822 live in the coastal region, 6.449,355 in the Andean, 739.814 in the Amazon and the rest in the Galapagos Islands (INEC 2010). 1: Esmeraldas; 2: Manabí; 3: Los Rios; 4: Guayas; 6: El Oro; 9: Pichincha; 10: Santo Domingo de los Tsáchilas; 11: Cotopaxi; 13: Bolivar; 14: Chimborazo; 15: Cañar; 16: Azuay; 17: Loja; 18: Sucumbios; 19: Napo; 20: Orellana; 21: Pastaza; 22: Morona Santiago; 23: Zamora Chinchipe.

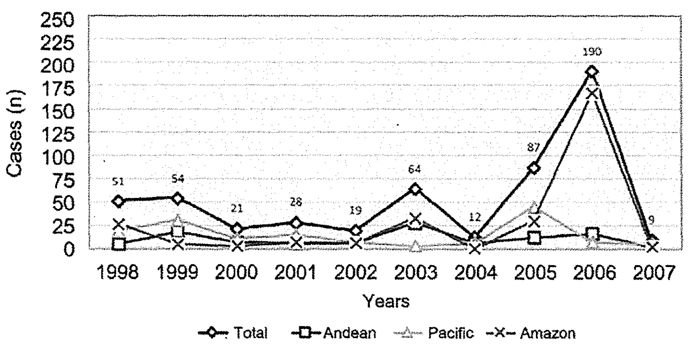

Fig. 3: the number of overall cases from 1998-2007 in the three geographical regions as registered by the Ministry of Public Health. There was an annual national average of 53.5 (range 9-190) cases. Based on the size of the population distribution, the highest incidence of cases was in the Amazon Region. In 2006, 166 of the 190 patients came from the province of Sucumbios.

However, a different species was described in 1971 when non-encysted metacercariae were observed in crabs from a coastal subtropical area, Caluma-Bolivar (Yokogawa et al. 1971). These metacercariae were similar to those described in Peru by Miyazaki et al. (1969) and in Mexico by Miyazaki and Ishii (1968). In 1979, Voelker and Arzube (1979) described a new species, *Paragonimus ecuadoriensis*, after having observed ovary and testis morphologies and egg size and shape that varied from those described for *Paragonimus inca*, *Paragonimus mexicanus* and *Paragonimus peruvianus*. Further comparative studies, however, revealed that *P. ecuadoriensis* and *P. peruvianus* were identical to *P. mexicanus* (Brenes et al. 1980, Miyazaki et al. 1980) and *P. ecuadoriensis* and *P. peruvianus* are described as part of *P. mexicanus* in subsequent publications (Acha & Szyfres 2003). Adult parasites obtained from rats, dogs and cats experimentally infected with metacercariae obtained from *Hypolobocera chilensis* in Nalpe-Manabí exhibited similar morphological and morphometric characteristics to those of *P. mexicanus* (Waikagul et al. 2003). A molecular phylogenetic study conducted by sequencing the cytochrome c oxidase subunit 1 and the second internal transcribed spacer genes revealed that isolated metacercariae from *Hypolobocera aequatorialis* from Concordia-Esmeraldas belonged to *P. mexicanus*. This finding was later confirmed in adult worms obtained from experimentally infected cats (Iwagami et al. 2003). In the Amazon, studies of metacercariae from *Moreirocarcinus emarginatus* confirmed the presence of *P. mexicanus*. A recent publication studying *Paragonimus* species from Mexico using morphological and molecular approaches identified three distinct species following comparisons with the DNA sequences from the species found in Ecuador (López-Caballero et al. 2013). The authors of the publication therefore suggested resurrecting the name *P. ecuadoriensis* for species in South America. However, further studies using molecular, scanning electron microscopy and morphological techniques are required before accepting this suggestion.

Additionally, a small encysted metacercariae, which was tentatively named *Paragonimus napensis*, was found in the northern Amazon Region (Amunárriz 1991b). Future molecular taxonomy studies are also needed to clarify the identity of this species.

First intermediate host - A study performed in 1984 on the snail *Aroapyrgus colombiensis* captured in the Amazon Region revealed it to be the first intermediate host of *Paragonimus*. A total of 2,350 specimens were microscopically examined using two techniques. The first 1,000 specimens were placed in Petri dishes with water and observed microscopically every 12 h for released rediae and cercariae. The remaining specimens were compressed between two glass plates and then examined microscopically. Rediae and cercariae were observed, indicating an infection rate of 0.042% in the snails (Amunárriz 1991b) and the rediae exhibited characteristic morphological features of *P. mexicanus* (Malek et al. 1985). In contrast, none of the *Hemisinus maculatus* molluscs captured in a subtropical region of the province of Bolívar were found to be infected (Yokogawa et al. 1971).

Second intermediate hosts - On the coast, non-encysted metacercariae found in captured *H. aequatorialis* from Jipijapa in the province of Manabí were initially named *P. ecuadoriensis* (Arzube & Voelker 1978). In Caluma within the province of Bolívar, non-encysted metacercariae identified as *P. mexicanus* were isolated from *Strengeria eigenmanni* (after referred as *Pseudotelphusa chilensis*) (Yokogawa et al. 1971). Among *H. aequatorialis* specimens collected from 45 different rivers in four cantons of the province of Esmeraldas, 42.6% of the crabs were found to be infected with *P. mexicanus* (Vieira et al. 1992). In *P. chilensis* (at present referred as *H. chilensis*) captured in Nalpe-Manabí and *H. aequatorialis* collected in Concordia-Esmeraldas, 16.1% and 68.5% specimens, respectively, were found to be harbour *P. mexicanus* (Iwagami et al. 2003, Waikagul et al. 2003).

In the Amazon, *P. mexicanus* metacercariae were found in 96.1% of the *M. emarginatus* (formerly referred to as *Zilchiopsis ecuadoriensis*) individuals examined. These crabs were caught in the same streams where infected *A. colombiensis* molluscs were found. Conversely, none of the *Trichodactylus faxoni* (formerly referred to as *Trichodactylus maytai*) crabs captured were parasitised (Amunárriz 1991b).

Metacercariae have been found in various organs of crabs. Among the *Hypolobocera* species examined, *P. mexicanus* metacercariae infested the hepatopancreas in 14.4% (Vaca et al. 1989). In *H. chilensis* from

Nalpe-Manabí, metacercariae also showed a preference for the hepatopancreas (Waikagul et al. 2003). However, although *H. aequatorialis* from Quinindé-Esmeraldas showed a preference for the hepatopancreas, metacercariae were also found in muscle and other organs (Vieira et al. 1992). The metacercariae in crabs from Caluma-Bolívar were found to prefer the hepatopancreas over muscle (Yokogawa et al. 1971). It is unknown whether these locations are associated with the parasite or host intermediate species, as in Asia, where various families of molluscs determine which subspecies of *P. westermani* is present (Blair et al. 1997). Crabs, both male and female, were found to be infected without any existing predilection, although a higher infection rate was reported in male crabs from Nalpe-Manabí (Waikagul et al. 2003).

In 2013, the authors (HS, MC and DR) studied 35 *T. faxoni* crabs captured from a small stream in the northern Amazon Region: Nuevo Rocafuerte, in the province of Orellana. Of these 35 crabs, 13 (37.1%) were positive for *P. mexicanus*. However, in the coastal region, none of the 153 *Hypolobocera* spp of crabs captured in areas previously considered to be endemic were found to be parasitised by *P. mexicanus*. Metacercariae that have not yet been identified have also been found (unpublished data). In Ecuador, infected crabs have been found at elevations ranging from 150-2,000 m.

Several patients from both the coast and the Amazon regions reported no clinical history of ingesting raw crab, but did eat crayfish (Fernández 1990). Freshwater crayfish could also be a secondary host in Ecuador, as documented in other countries (Acha & Szyfres 2003). Confirmatory studies on these crustaceans are needed.

Definitive hosts - In captured wild mammals from the coastal region, adult *Paragonimus* flukes were recovered from the lungs of a *Nasua nasua* (coati or *tejón*), whereas no flukes were found in examined *Didelphis marsupialis* or *marmosas* (Arzube & Voelker 1978). In the Amazon, pulmonary cysts containing adult *Paragonimus* were found in captured *D. marsupialis*, *Felis pardalis* (ocelot or *tigrillo*), *N. nasua* and *Tayassu pecari* (*pécaris*) (Vaca et al. 1989, Amunárriz 1991b). Cats experimentally infected with metacercariae from *H. aequatorialis* captured in the coastal provinces of El Oro and Esmeraldas developed lung nodules containing *P. mexicanus* flukes (Palacios et al. 1978, Vieira et al. 1992). Infection in cats, dogs and *Rattus rattus*, but not in hamsters, was achieved with metacercariae obtained from *H. chilensis* in Nalpe-Manabí (Waikagul et al. 2003).

Human infections - Age and gender - In Ecuador, paragonimiasis is generally diagnosed in adolescents and young adults, but clinical cases have been documented in individuals ranging from four-67 years of age (Calvopiña et al. 1998, 2003). Among patients treated at hospitals in Latacunga and Guayaquil, most affected individuals ranged from 11-30 years of age (Fernández 1990, Calvopiña et al. 1995). In the Chachi indigenous groups from Canandé-Esmeraldas River, most affected individuals were 11-30 years of age (Guevara et al. 1999). During active field searches, infections were found more frequently in children from six-12 years of age (Calvopiña et al. 1998).

Regarding gender, no significant differences have been found. However, variations exist depending on the geographical location of the patients. In the indigenous Quichua and Shuar groups and colonists in the Amazon Region, alongside Napo River, women exhibited infection rates of 51.2% (Amunárriz 1991a) and 52.8% (Calvopiña et al. 2003), respectively. In patients treated in hospitals of Latacunga-Cotopaxi and Quito-Pichincha (non-endemic areas), males exhibited infection rates of 52% and 57.7%, respectively. Of the 45 patients admitted to the hospital in the coastal city of Guayaquil, there were 21 males and 24 females (Fernández 1990). The greatest gender differences were observed in patients treated in a coastal regional hospital in El Carmen-Manabí and those of the indigenous Chachi (province of Esmeraldas), where the infection rates of females reached 66.4% and 90%, respectively (Calvopiña et al. 1994, Guevara et al. 1999). The variation in age and gender ratio of infection depends not only on the specific locality and geographical region, but also on the local customs and habits related to the preparation of crustaceans.

Clinical forms - Based on all publications, reports, clinical records and available studies, 3,822 cases were documented in Ecuador since 1921, of which 99.7% were pulmonary infections. There were 12 cases of cutaneous paragonimiasis in the same family, presenting signs of migratory inflammation, localised pain and the presence of adult worms confirmed using histopathology (Carvajal et al. 1979). A hepatic form of the disease presented with a tumour lesion in the left lobe of the liver (Peñafiel et al. 1981).

The pulmonary symptoms included a productive cough with rust-coloured sputum in 70-100% of the cases, followed by chest pain in 80%. Symptoms were periodic and mild in patients with a short clinical evolution and/or low egg counts in their sputum (Peñafiel et al. 1981, Calvopiña et al. 1994). Most patients showed good general health and nutritional status. However, in the indigenous ethnic group Chachi of Canandé-Esmeraldas River, weight loss and diaphoresis were documented in 60% of cases with a 30% prevalence of fever (Guevara et al. 1999). Complicated cases involving pleural effusion, exudative pleuritis and emphysaema were reported in 19% of patients referred to the Eugenio Espejo Hospital in Quito (Peñafiel et al. 1981). Among 124 patients in the hospital of Nuevo Rocafuerte in the Amazon Region, 12.5% presented with fever and dyspnoea and were in poor health (Amunárriz 1991a). The duration of disease ranged from three months to 12 years one case lasted 14 years before a diagnosis was made (Peñafiel et al. 1981).

Eating habits in relation to paragonimiasis - Indigenous groups in Ecuador and migrants to tropical regions practice hunting and fishing, including freshwater crayfish and crabs, for their basic food supply. Certain beliefs and practices are likely to increase infection rates, such as the idea that eating raw crabs is beneficial for hangovers and freshly prepared juice from raw crabs (made from internal organs) is used as a traditional medicine to treat fevers (Vieira et al. 1992). Certain Amazon communities prepare the "juice" of raw crabs to increase breast milk production in nursing mothers. It is customary for families or groups of neighbours to fish the rivers for crabs and crayfish and then consume them in soup, fried, baked or raw. Children play and fish in the rivers during their free time and eat baked, fried or raw crabs and crayfish (Fernández 1990). In endemic areas, 94% of patients reported eating crabs and 99% reported eating crayfish (Calvopiña et al. 1994). As these eating habits involve the entire family, several members of the same family can become infected, as observed in Chachi (Paredes et al. 1978), in the Amazon (Amunárriz 1991b) and among coastal settlers (Calvopiña et al. 2003).

Diagnosis - In Ecuador, a case of pulmonary paragonimiasis is defined as a person presenting with a productive cough with rusty-brown or blood-stained sputum, accompanied by a history of eating raw or improperly cooked freshwater crabs or crayfish and the presence of the characteristic ova of *Paragonimus* in sputum and/or stool samples (Díaz et al. 1991). The diagnostic method recommended and utilised is the microscopic observation of eggs in sputum and faeces. No concentration methods are used and no serological and/or molecular methods are available. Eggs of *Paragonimus* in sputum have been identified following Ziehl Neelsen staining (Calvopiña et al. 2003). The detection of eggs in faecal material can reach up to 13.6%, especially in children because of their habit of swallowing sputum (Fernández 1990). Faecal detection can also occur during intestinal paragonimiasis, a disease that is undiagnosed in Ecuador and rarely occur worldwide (Liu et al. 2012). More than 50% of hospitalised patients showed hypereosinophilia or leucocytosis (11,000-15,000/μL) with normal haemoglobin and haematocrit levels (Peñafiel et al. 1981). Microscopy is specific, but the sensitivity depends on the amount and frequency of expectoration, which is inconsistent in patients with mild and moderate disease. Using soluble antigens obtained from adult *Paragonimus*, elevated levels of IgG and IgM were found in patients with pulmonary paragonimiasis according to the presence of eggs in sputum, with the subclass IgG4 antibody being the most dominant (Guevara et al. 1995, 1999). In 43 patients, the levels of IgG and IgE determined by ELISA and indirect haemagglutination remained elevated after six months of being treated with praziquantel (PZQ) (Knobloch et al. 1984). These tests were performed only for research purposes.

Crude antigens of *P. westermani* and *Paragonimus heterotremus* were used to test for dermal delayed hypersensitivity in residents of endemic areas, with reactive cases found in children and adolescents (Palacios et al. 1978); however, the test was discontinued because of severe sensitivity reactions and low specificity (Díaz et al. 1991). Immunoblot assays were performed using antigens of *P. heterotremus*, with four of seven children who presented with chronic cough, but were negative for eggs in their sputum exhibiting positive results (Waikagul et al. 2003). Studies using crude antigens from various species carry the risk of false negative results.

Imaging studies - Radiological imaging was performed only on referred hospitalised patients from rural health centres because of the unavailability of diagnostic methods and/or drugs or because of disease severity. In patients referred to the Eugenio Espejo Hospital in Quito, the most common radiological finding was diffuse and nodular infiltrates (54%), with 11% presenting pleurisy, emphysaema and pleural effusion and 11% presenting normal radiographs (Peñafiel et al. 1981). Of the patients treated at hospitals in Nuevo Rocafuerte-Orellana and in Guayaquil, 77% and 85.2% exhibited normal radiological imaging (Fernández 1990, Amunárriz 1991a). In the former hospital, 13% showed exudative pleuritis, hilar lymphadenopathy and caverns (Amunárriz 1991a). In patients identified during active searches, 46% presented with diffuse and nodular infiltrates, whereas 39% did not exhibit any radiographic abnormalities (Calvopiña et al. 1998, 2003). Infiltrative images were found to resolve after treatment, but no radiological changes were noted in patients with nodular lesions, pleural effusion or cavities (Calvopiña et al. 1998). There were no pathognomonic radiological lesions associated with paragonimiasis. No reports are available using computed tomography or magnetic resonance imaging studies.

Differential diagnosis and association with tuberculosis (TB) and/or pulmonary mycosis - Overall, 10.8% of the referred patients treated at the Eugenio Espejo Hospital presented with pulmonary TB (Peñafiel et al. 1981), whereas only one (1.5%) patient with TB was found in the hospital of Nuevo Rocafuerte-Orellana (Amunárriz 1991a). No association was found in patients referred to hospitals in El Carmen-Manabí and Francisco de Orellana (Vaca et al. 1989, Calvopiña et al. 1994). During active search studies in La Maná-Cotopaxi communities, 12.9% of patients had or were in treatment for pulmonary TB.

Patients with pulmonary paragonimiasis generally exhibited good health and nutritional status. Episodes of cough were periodic and rust-coloured sputum with haemoptysis, as in TB, rarely occurred (Calvopiña et al. 2003). None of the cases were associated with pulmonary mycoses despite the fact that paracoccidioidomycosis is endemic in these tropical regions (Severo & Fernández 2004).

Treatment - According to the Manual for Paragonimiasis Control in Ecuador, issued in 1991 by the MSP (Díaz et al. 1991) and by the WHO (2011), PZQ is the drug of choice for treating pulmonary paragonimiasis. The recommended dosage for treating paragonimiasis is three administrations totalling 75 mg/kg/day for two days. The treatment of patients from the coast and Amazon regions with PZQ was effective in 95-100% of cases, with minimal and transient adverse effects (Calvopiña et al. 1998). A 100% cure rate was observed in patients treated with PZQ at 50 mg/kg/day for three days (Fernández 1990). In the 1970s and 1980s, treatment with bithionol was effective in 80% of patients, but treatment abandonment was common due to severe adverse effects, especially gastrointestinal. Bithionol was effective in treating 62 of 64 patients at the Amazon regional hospital of Nuevo Rocafuerte, with tolerable/manageable adverse effects under an inpatient regimen (Amunárriz 1991a). A combination of emetine plus chloroquine was effective in only 18.2% of patients treated (Peñafiel et al. 1981). Currently, there are no official guidelines in Ecuador, which has led to a lack of medical knowledge regarding current management and recommended therapy.

In two clinical-therapeutic trials, 216 patients with pulmonary paragonimiasis from the coast and Amazon were treated using triclabendazole (TCB). An efficacy of 100% was obtained, even in patients resistant to PZQ (Calvopiña et al. 1993). Using three distinct dose regimens: 5 mg/kg once per day for three days, a single dose of 10 mg/kg or two doses of 10 mg/kg during a single day, all 62 patients were cured, both clinically and parasitologically. In a second study, 154 patients were treated with either 10 mg/kg twice a day or a single dose of 10 mg/kg, with efficacies of 90.9% and 84.4%, respectively, and all patients were cured following retreatment (Calvopiña et al. 2003). TCB is now recommended as the alternative drug of choice for treating paragonimiasis and the first drug of choice for fascioliasis (WHO 2011). Currently, PZQ and TCB are not available in Ecuador despite their recommendation in the 2013 national therapeutic manual.

Prevention and control measures - At present, there are no strategies for diagnosis, updated patient management or preventive measures in Ecuador. A national control or elimination programme of the disease is non-existent.

Concluding remarks - Paragonimiasis is endemic to tropical and subtropical regions of Ecuador. Although the disease is known to be present in several locations, epidaemiological studies remain incomplete. Furthermore, the lack of recent active field search and nationwide seroepidemiological studies prevent making an estimate of the current infected population. Knowledge of the intermediate hosts and reservoirs is limited and there is no comparative molecular characterisation of the parasites. To identify possible new species in the Amazon, DNA identification methods are needed. In addition, investigations are recommended to determine the impact that ecological and environmental changes, such as farming, chemical application in oil palm and banana plantations, dam construction and deforestation with the disappearance of animal reservoirs and intermediate hosts, may have on the disease. Preventive programmes to educate and implement changes in the eating habits of residents (only eating well-cooked crabs or crayfish) are of the utmost importance. A continued health education programme for professional personnel, together with ensuring the availability of medication for treatment, is necessary to care for those affected by *Paragonimus*. The lack of drugs recommended for treatment is of great concern because it causes patients to remain infected, with epidaemiological consequences, complications and suffering. The MSP should acquire the drugs and then make them readily available in the health centres of endemic areas.

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帝京平成大学紀要 第25巻

Some Freshwater Crabs from Ecuador, South America

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南米エクアドル産サワガニ類数種の記録

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Abstract

Freshwater crabs that were collected in Ecuador during the field survey for lung flukes were identified as 9 species of 2 families. The species collected from the west of the Andean Cordilleras are *Hyplobocera aequatorialis* (Ortmann, 1897), *H. delsolari* Pretzmann, 1978, *H. exuca* Pretzmann, 1977, and *H. guayaquilensis* Bott, 1967 of the family Pseudothelphusidae, while the species collected from the Ecuadorian Amazon Basin are *Moreirocarcinus chacei* (Pretzmann, 1968), *M. emarginatus* (H. Milne-Edwards, 1853), *Rotundovaldivia latidens* (A. Milne-Edwards, 1869), *Sylviocarcinus devillei* H. Milne-Edwards, 1853, and *Trichodactylus faxoni* Rathbun, 1905 of the family Trichodactylidae.

Keywords: Freshwater crabs, Pseudothelphusidae, Trichodactylidae, *Hyplobocera, Moreirocarcinus, Rotundovaldivia*, *Sylviocarcinus*, *Trichodactylus*, Ecuador.

要 約

2012年および2013年、南米エクアドルにおける肺吸虫に関する現地調査の際に採集されたカニ類は以下の２科９種に同定された。アンデス山系の西部で採集されたのは Pseudothelphusidae の *Hypolobocera*属４種、*H. aequatorialis*（Ortmann, 1897）、*H. delsolari* Pretzmann, 1978、*H. exuca* Pretzmann, 1977、*H. guayaquilensis* Bott, 1967、東部のアマゾン水系で採集されたのは Trichodactylidae の *Moreirocarcinus chacei*（Pretzmann, 1968）、*M. emarginatus*（H. Milne-Edwards, 1853）、*Rotundovaldivia latidens*（A. Milne-Edwards, 1869）、*Sylviocarcinus devillei* H. Milne-Edwards, 1853、*Trichodactylus faxoni* Rathbun, 1905の５種であった。

Introduction

During two years, 2012 and 2013, the junior authors participated in the field research of lung flukes from Ecuador, South America. In the first year, sampling of crabs as intermediate host was made in the west areas of the Andean Cordilleras, and at the Amazon Basin in the east of the Andean Dividing Range in the second year. Most of the specimens collected during the survey were dissected and examined for lung fluke larvae, but some crabs were kept in alcohol for identification of the species.

The crabs from Ecuador were well studied and many new species and subspecies were described by Pretzmann (1968a, b, 1971, 1972, 1977, 1978, 1983a-d), Smalley & Rodríguez (1972), Rodríguez (1982, 1992), and Rodríguez & Von Sternberg (1998). Two monographs dealing with the families Pseudothelphusidae and Trichodactylidae completed by Rodríguez (1982, 1992) are then the monuments for the knowledge of the South American freshwater crabs. The complex pentanomial nomenclature introduced by Pretzmann (1978, 1983a, b) was readjusted to binominal nomenclature by Rodríguez & Von Sternberg (1998), and the generic system of the Trichodactylidae was revised by Magalhães & Türkay (1996a). Even if the taxonomic studies were advanced as briefly noted above, there are still many problems for the identification of the critical and variable species, with geographical distribution around the Andean Cordilleras and the Amazon Basin.

As recorded in the following lines, the specimens from Ecuador collected by the authors were identified as four species of the family Pseudothelphusidae from the west of the Andean Cordilleras and five species of the family Trichodactylidae from the upper reaches of the Amazon Basin. All the specimens are preserved in the collections of the National Museum of Nature and Science, Tsukuba (NSMT).

Family Pseudothelphusidae

Genus ***Hypolobocera*** Ortmann, 1897

Hypolobocera aequatorialis (Ortmann, 1897)

(Figs. 1, 3C, D)

Potamocarcinus aequatorialis Ortmann, 1897, pp. 317 (in key), 319, pl. 17 fig. 5.

Pseudothelphusa aequatorialis: Rathbun, 1905, p. 285.

Potamocarcinus (Hypolobocera) aequatorialis aequatorialis: Bott, 1967, p. 368, fig. 3.

Hypolobocera (Hypolobocera) aequatorialis nigra Pretzmann, 1968a, p. 6; 1972, p. 44, figs. 167-169, 262-264.

Hypolobocera (Hypolobocera) aequatorialis aequatorialis: Pretzmann, 1972, p. 43, figs. 186-189, 265-267.

Hypolobocera aequatorialis: Rodríguez, 1982, p. 61 (pt), fig. 33e, f ; Rodríguez & Von Sternberg, 1998, p. 113, fig. 1.

Hypolobocera (Hypolobocera) [aequatorialis] aequatorialis aequatorialis: Pretzmann, 1983d, p. 351, figs. 4, 18, 26, 39, 54, 56, 71.

Hypolobocera (Hypolobocera) [aequatorialis] aequatorialis nigra: Pretzmann, 1983d, p. 352, figs. 3, 17, 25, 35, 52, 55, 72.

Material examined. Pucayacu, Cotopaxi Province, Ecuador, 5 Oct. 2012, 2 ♂♂ (37.5 × 24.0 mm; 35.8 × 23.0 mm), 1 ♀ (46.5 × 28.9 mm); Guassaganda, Cotopaxi Province, 1 ♂ (33.9 × 21.5 mm), 2 ♀♀ (40.5 × 25.7 mm; 32.0 × 20.5 mm).

Remarks. This species is medium to large in size for the genus *Hypolobocera* from Ecuador, exceeding 6 cm in carapace breadth, together with *H. delsolari* Pretzmann and *H. exuca* Pretzmann.

The carapace (Fig. 1A) is typically elliptical, with the anterolateral margin regularly convex and minutely serrated along whole length and the posterolateral margin moderately retreats toward to its posterior end; the proportion of breadth to length of the carapace is 1.56-1.61. The dorsal surface of the carapace is uneven, with a prominent median depression and a pair of long oblique furrow from the gastro-cardiac separation. The male right and left chelipeds (Fig. 1C) are distinctly different in size, the fingers being sharply toothed; the outer surface of the palm is smooth, without tubercle.

The male abdomen (Fig. 1B) is narrow and seven-segmented. The thoracic trench (Fig. 1D) is deeply excavated, especially at the distal part of the fifth sternite, to accommodate the distal part of the first pleopods. The male first pleopod (Figs. 1D, 3C, D) is stout, with the gently developed lateral lobe along its whole length; its outer distal end of the apical lobe is sharply pointed and nearly perpendicular to the shaft or directed weakly forward. The female abdomen is remarkably large, completely covering the whole thoracic surface. Each female genital pore occupies whole length of the sixth thoracic sternite, being longitudinal for its anterior half and directed obliquely outward for its posterior half.

It may be right that Rodríguez & Von Sternberg (1998) synonymized the subspecies *nigra* described by Pretzmann (1968) with the present species. Considering that even in the specimens examined there is a dark colored, almost black, male among the dark brown specimens, with the quite similar pleopods, the coloration of the specimens is not

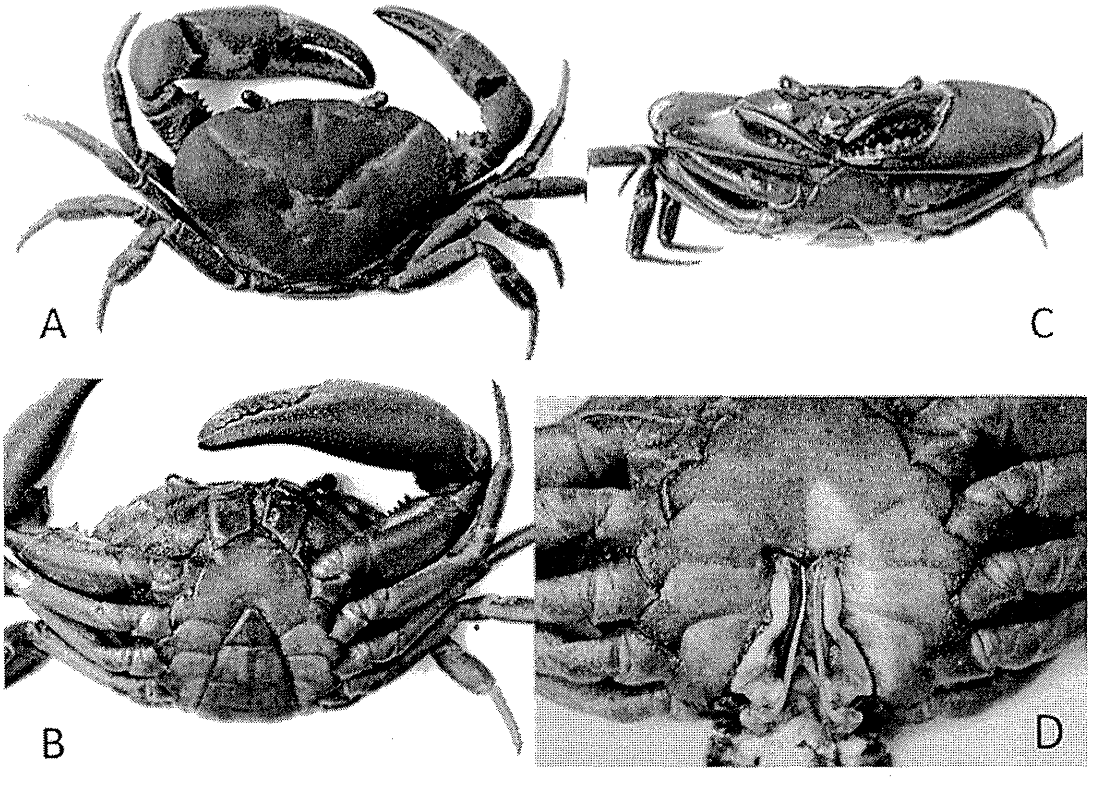

Fig. 1. *Hypolobocera aequatorialis* (Ortmann), ♂ (35.8 × 23.0 mm). Dorsal and ventral views (A, B), chelae (C), and pleopods (D).

considered to be the diagnostic character.

The general characters are close to those of *H. delsolari* Pretzmann. The distinguishing characters are referred to the remarks on the species.

Distribution. Widely distributed in the eastern and western slopes of the Eastern Cordillera of Ecuador.

Hypolobocera delsolari Pretzmann, 1978

(Figs. 2, 3G, H)

Hypolobocera (Hypolobocera) [aequatorialis] delsolari delsolari Pretzmann, 1978, p. 163, fig. 1; 1983d, p. 350, pl. 13 fig. 58.
Hypolobocera (Hypolobocera) delsolari: Pretzmann, 1983a, p. 304, pls. 11, 12.
Hypolobocera (Hypolobocera) [aequatorialis] delsolari isabella Pretzmann, 1978, p. 163, fig. 2; 1983d, p. 350.
Hypolobocera (Hypolobocera) delsolari isabella: Pretzmann, 1983a, p. 304, pls. 13, 14.
Hypolobocera aequatorialis: Rodríguez, 1982, p. 61 (pt), fig. 1a-d.
Hypolobocera delsolari: Rodríguez & Von Sternberg, 1998, p. 116, fig. 2.

Material examined. Guassaganda, Cotopaxi Province, Ecuador, 5 Oct. 2012, 1 ♂ (45.0 × 29.0 mm).

Remarks. Size and general shape of the carapace are close to those of *H. aequatorialis* (Ortmann) as represented in Figs. 1A and 2B. However, in this species both chelipeds (Fig. 2A) are not so much different in size and shape as in *H. aequatorialis* (Fig. 1C), with a big swelling at the distal part of the outer surface of the palm, or the bases of both fingers. The male abdomen is narrow, and the abdominal trench is not always specially deep, as seen in Fig. 2C. The male first pleopod (Figs. 2D, 3G, H) is rather slender, with the weakly developed lateral lobe not angled at the basal

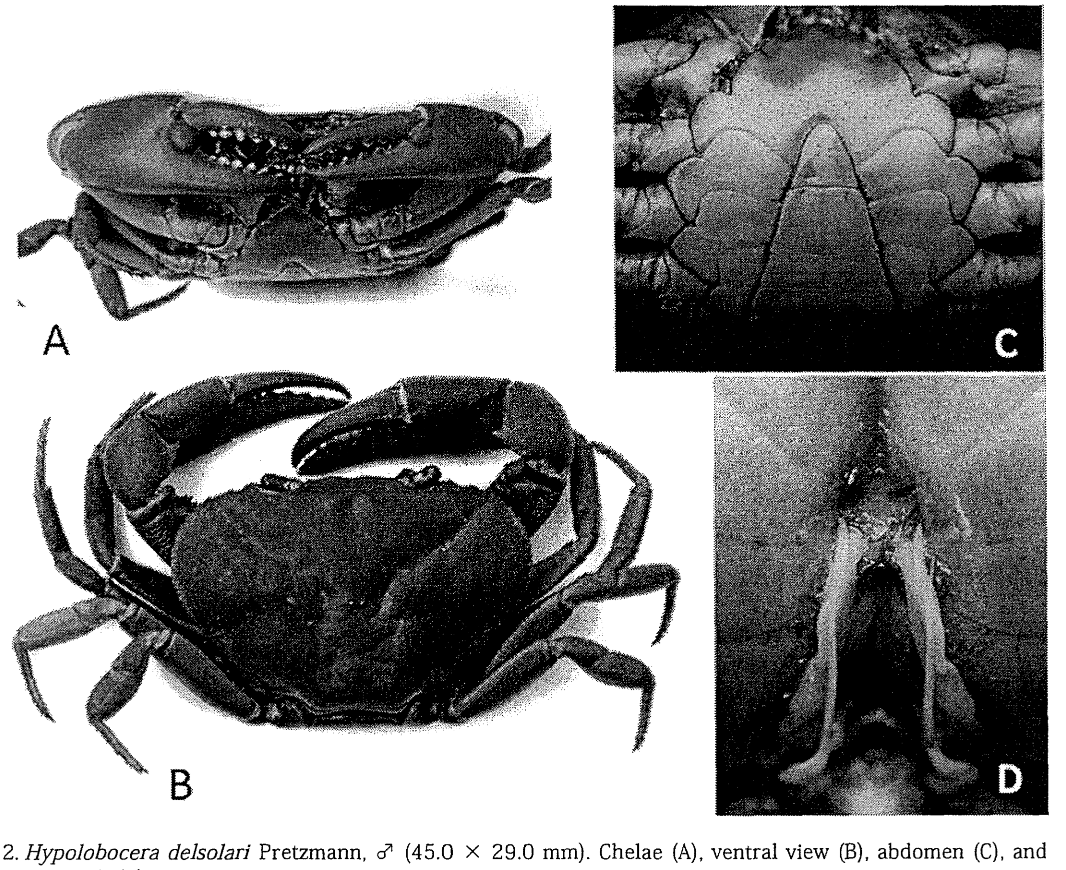

Fig. 2. *Hypolobocera delsolari* Pretzmann, ♂ (45.0 × 29.0 mm). Chelae (A), ventral view (B), abdomen (C), and pleopods (D).

and distal ends; the distal lobe is strongly developed forward and sharp at its tip as extension of the outer margin of the shaft; no special trench to accommodate the distal part of the first male pleopod as in *H. aequatorialis* (Fig. 1D).

Distribution. Known from several localities in Azuay Province, Ecuador.

Hypolobocera exuca Pretzmann, 1977

(Figs. 3A, B, 4)

Hypolobocera (Hypolobocera) [conradi] exuca Pretzmann, 1977, p. 437, fig. 8; 1983b, p. 357, pl. 20.

Hypolobocera riveti Rodríguez, 1980, p. 891; 1982, p. 49, figs. 19b, 20e, j, 23b, 25.

Hypolobocera exuca: Rodríguez & Von Sternberg, 1998, p. 117, fig. 4.

Material examined. Pucayacu, Cotopaxi Province, Ecuador, 5 Oct. 2012, 1 ♂ (carapace and abdomen with pleopods), (86.0 × 53.0 mm).

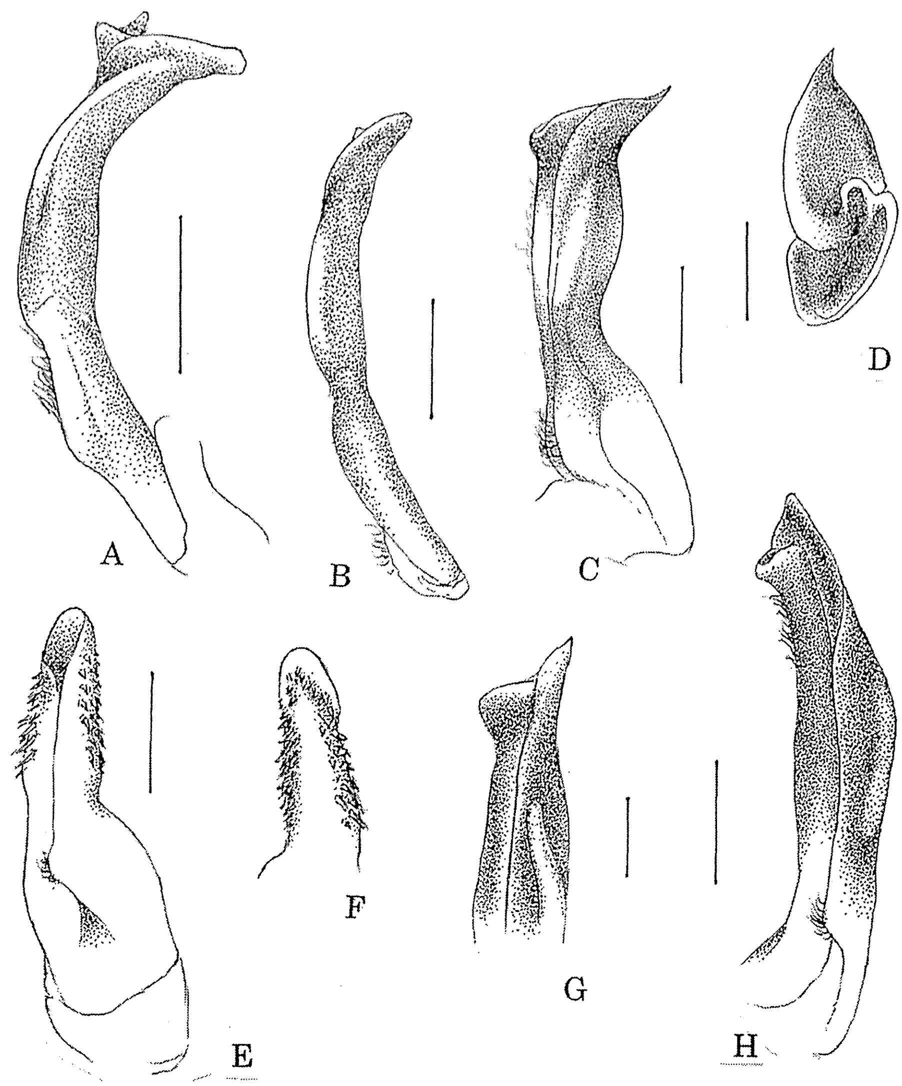

Fig. 3. Male first pleopod. A, B: *Hypolobocera exuca* Pretzmann, lateral (A) and sternal (B) views. C, D: *Hypolobocera aequatorialis* (Ortmann), ventral view (C) and distal part in upper view (D). E, F: *Trichodactylus faxoni* Rathbun, ventral view (E) and distal part in sternal view (F). *Hypolobocera delsolari* Pretzmann, distal part in lateral view (G) and ventral view (H). Scales for A = 5 mm, B, C = 3 mm, D-G = 1 mm, H = 2 mm.

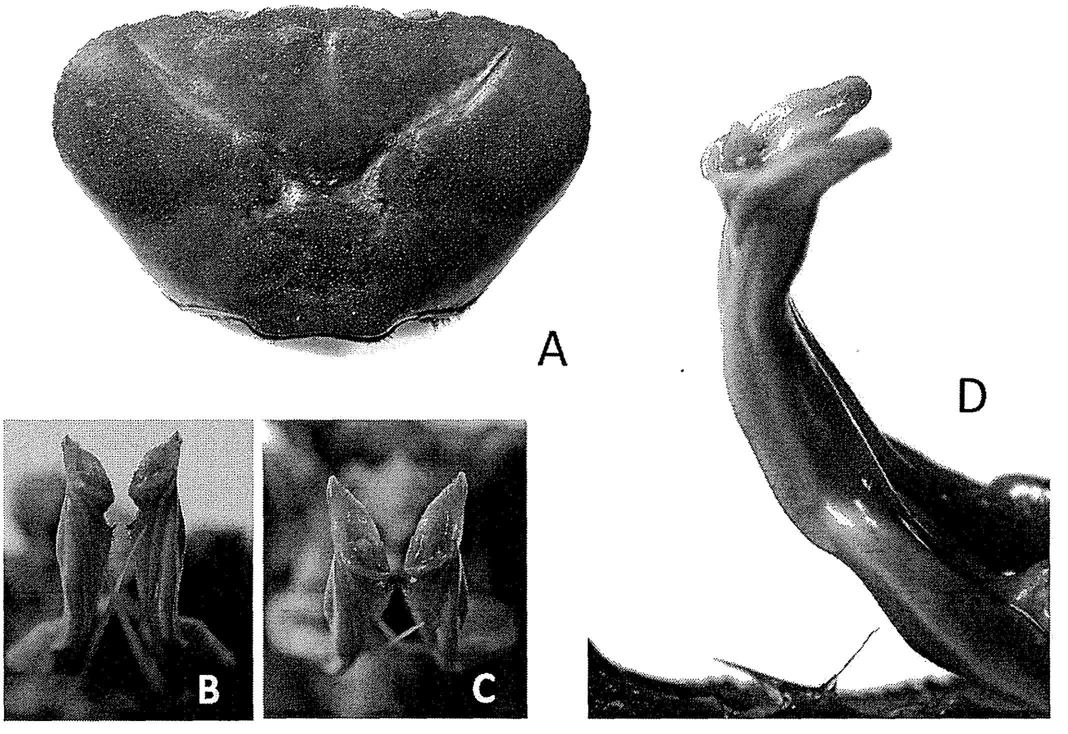

Fig. 4. *Hypolobocera exuca* Pretzmann, ♂ (86.0 × 53.0 mm). Carapace (A), and pleopods in ventral (B) and lateral (C) views.

Remarks. This species attains to large size in the genus *Hypolobocera*, having the broad carapace (Fig. 3A); in the male examined, the proportion of breadth to length of carapace is 1.62; anterior half of the lateral margin of the carapace is strongly convex and regularly serrated, while posterior half the lateral margin is rather concave and retreats strongly toward its posterior end. The dorsal surface is not convex, with a pair of prominent oblique furrow from the lateral end of the mesogastric region toward the anterior one third of the anterolateral margin of the carapace.

The male first pleopod (Figs. 3A, B, 4B-D) is slender and curved dorsally, without lateral lobe, but with distinct subapical ridge on mesial side; a prominent triangular papilla on the abdominal side of the distal truncated tip.

Distribution. According to Rodríguez & Von Sternberg (1998), this species is distributed between the provinces of Cañar and Cotopaxi, Ecuador.

Hypolobocera guayaquilensis Bott, 1967

(Fig. 5)

Potamocarcinus (Hypolobocera) aequatorialis guayaquilensis Bott, 1967, p. 368, fig. 4.

Hypolobocera (Hypolobocera) caputii guayaquilensis: Pretzmann, 1971, p. 17.

Hypolobocera (Hypolobocera) guayaquilensis: Pretzmann, 1972, p. 42, figs. 173-175.

Hypolobocera guayaquilensis: Rodríguez, 1982, p. 64; Rodríguez & Von Sternberg, 1998, p. 118, fig. 5.

Hypolobocera (Hypolobocera) [aequatorialis] guayaquilensis: Pretzmann, 1983b, p. 353, pl. 2 fig. 5, pl. 5 fig. 16, pl. 8 fig. 28, pl. 10 fig. 37, pl. 12 fig. 53, pl. 13 fig. 57, pl. 15 fig. 69.

Material examined. Jana River, Jana, Manabi Province, Equador, 12 Aug. 2013, 2 ♂♂ (carapaces and abdomens with pleopods) (35.2 × 14.0 mm; 31.4 × 11.5 mm), 1 ♀ (carapace and abdomen with pleopods) (40.5 × ca. 17.0

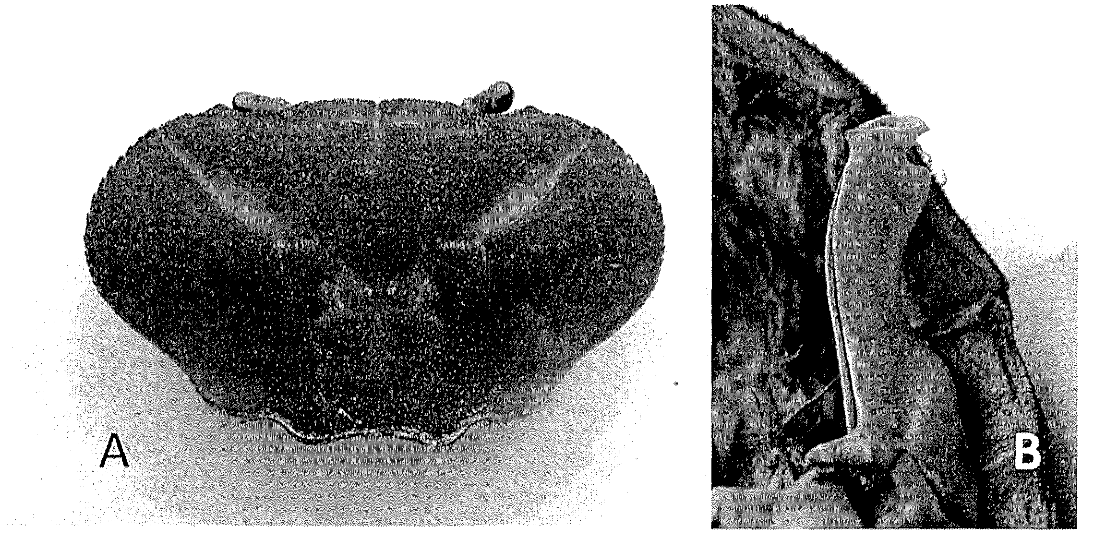

Fig. 5. *Hypolobocera guayaquilensis* Bott, ♂ (31.4 × 11.5 mm), Carapace (A) and left first pleopod (B).

mm)

Remarks. This species attains medium to large size for the genus. The carapace (Fig. 5A) is typical for the genus, but proportionally wider than the others, posterior part of the lateral margin being rather concave. Anterior half of the anterolateral margin of the carapace is regularly and strongly convex, and distinctly serrulated. The male first pleopod (Fig. 5B) is stout, and arcuate in lateral view; the outer lobe is strongly developed, increasing in width distally and ending as an obtuse or rather rounded summit.

Distribution. Ecuador.

Family Trichodactylidae

Genus ***Moreirocarcinus*** Magalhães & Türkay, 2008

Moreirocarcinus chacei (Pretzmann, 1968)

(Fig. 6A)

Trichodactylus (Trichodactylus) chacei Pretzmann, 1968b, p. 3.
Zilchiopsis chacei ecuadoroides Pretzmann, 1978, p. 169; 1983b, p. 310; 1983c, p. 327.
Zilchiopsis chacei: Pretzmann, 1983c, p. 327, pls. 11, 12.
Moreirocarcinus chacei: Magalhães & Türkay, 1996, p. 82 (in list), figs. 20, 29; Ng *et al*., 2008, p. 187 (in list).

Material examined. Santa Teresita, Orellana Province, Ecuador, 4 Aug. 2013, 1 carapace (25.7 × 20.2 mm; 20.9 × ca. 18 mm).

Remarks. This species is larger than *M. emarginatus* (H. Milne-Edwards); the carapace (Fig. 6A) is wider, more or less quadrilateral in its outline, and gently convex longitudinally, with the ill-defined regions. The frontal margin is deeply and widely concave. The lateral margin of the carapace is weakly convex for its anterolateral part and narrowly rimmed for whole length; there are two small, but distinct notches at anterior one fourth of the lateral margin; the outer margin of the first lobe thus formed is nearly straight and confluent with the obscure external orbital angle; the outer margin of the second lobe is about two thirds as long as the first; the anterior end of the third lobe is at anterior one fourth of the lateral margin, the outer margin being confluent with the medial and posterior parts of the lateral margin of the carapace.

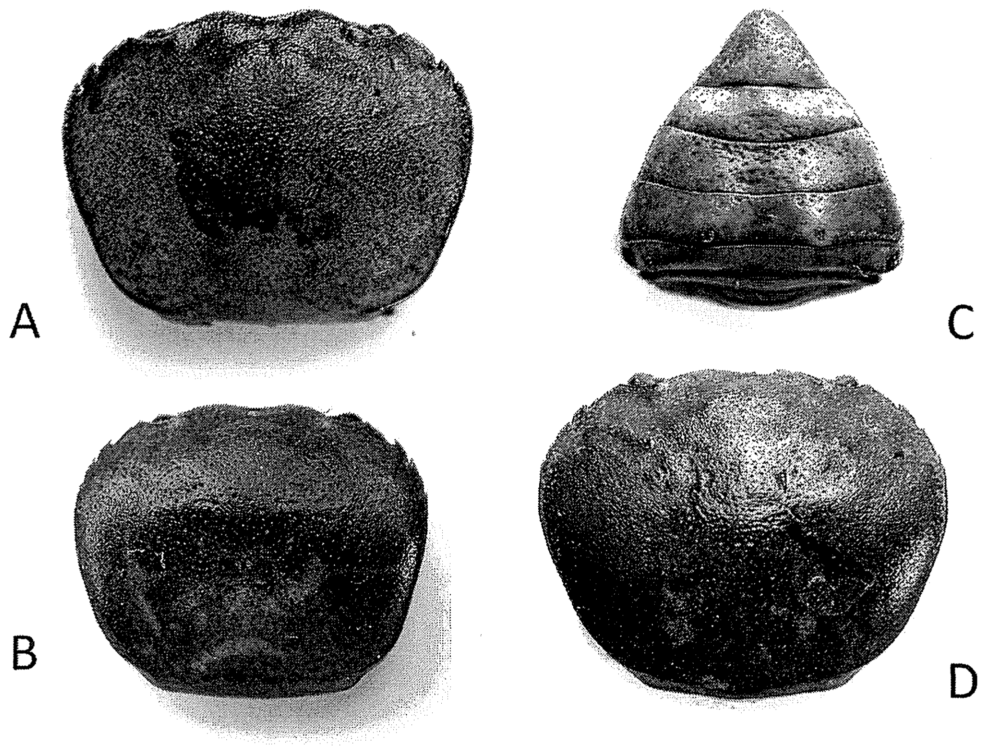

Fig. 6. A: *Moreirocarcinus chacei* (Pretzmann), . B-D: *M. emarginatus* (H. Milne-Edwards),

The male first pleopod is stout and tapering, with the long, curled second pleopod protruded from the distal aperture of the first pleopod.

This species is distinguished from the close congener, *M. emarginatus* (H. Milene-Edwards) by the less convex, wider carapace, and the rimmed lateral margins having three lobes formed by two small, but distinct notches.

Distribution. The type locality is Sevilla de Oro, between Mendez and Paute, Ecuador.

Moreirocarcinus emarginatus (H. Milne-Edwards, 1853)

(Fig. 6B-D)

Dilocarcinus emarginatus H. Milne-Edwards, 1853, p. 216; 1854, p. 181, pl. 14 fig. 4.

Trichodactylus (Dilocarcinus) emarginatus: Rathbun, 1906, p. 64, pl. 18 fig. 2.

Trichodactylus (Valdivia) ecuadoriensis Pretzmann, 1968a, p. 3.

Zilchiopsis emarginatus: Bott, 1969, p. 35, pl. 21 fig. 56; Pretzmann, 1893c, p. 327; Rodríguez, 1992, p. 102, figs. 3G, 4T, 5M, 7H, 8B, 9I, 10C, 13G, H, 35, 36.

Zilchiopsis ecuadoriensis: Smalley & Rodríguez, 1972, p. 49, figs. 9, 10; Pretzmann, 1983b, p. 328, pl. 13 figs. 29, 30, pl. 24 figs. 31, 32.

Material examined. Nuevo Rocaferte, Orellana Province, Ecuador, 12 Aug. 2013, 1♂, carapace and abdomen with pleopods (30.5 × 24.5 mm), 1 ♀, carapace and abdomen (18.7 × 15.8 mm).

Remarks. On establishment of a new genus *Moreirocarcinus* by Magalhães & Türkay (2008), this species was included in the genus together with the type species, *Trichodactylus (Trichodactylus) chacei* Pretzmann, 1968 [= *Zilchiopsis chacei ecuadoroides* Pretzmann, 1978], and an additional species *Dilocarcinus laevifrons* Moreira, 1901.

The young specimen (Fig. 6B) agrees well with the figures of a young specimen from Ecuador given by Rodríguez (1992). The carapace is narrow and rounded quadrangular somewhat different from the hexagonal outline of the larger specimen (Fig. 6D); the dorsal surface is strongly convex fore and aft, and ill-defined; the anterolateral margin is armed with four teeth behind the external orbital angle, and the first two teeth do not project from the curved outline of the carapace, with the sharp tips directed obliquely inward; the external orbital angle is obtuse, and the following lobe is as long as the first and second teeth combined; the third and fourth teeth are much smaller than the preceding two teeth; in the specimen examined the last tooth of the left side is almost worn out. The male abdomen (Fig. 6C) is wide, with a pair of tubercle on the fourth segment; the segmentation of all the segments are distinct, but the third to sixth segments are coalescent.

The male first pleopod was figured by Pretzmann (1983b) and Rodríguez (1992), being curved obliquely outward at distal one fourth, differing from the straight and tapering pleopod of the close congener, *M. chacei* (Pretzmann), in which the carapace is wider, with the strongly and regularly convex anterolateral and posterolateral margins (Fig. 6A).

Distribution. Colombia, Venezuela, Peru and Ecuador.

Genus ***Rotundovaldivia*** Pretzmann, 1968

Rotundovaldivia latidens (A. Milne-Edwards, 1869)

(Fig. 7A-C)

Sylviocarcinus latidens A. Milne-Edwards, 1869, p. 175.

Orthostoma latidens: Ortmann, 1897, pp. 326 (in key), 328.

Trichodactylus (Valdivia) latidens: Rathbun, 1906, p. 49, fig. 112, pl. 17 fig. 4.

Trichodactylus (Valdivia) bourgeti Rathbun, 1906, p. 56, fig. 118, pl. 16 fig. 4.

Trichodactylus (Valdivia) bourgueti falcipenis Pretzmann, 1968a, p. 5.

Valdivia (Rotundovaldivia) latidens: Pretzmann, 1968b, p. 73.

Valdivia (Valdivia) serrata latidens: Bott, 1969, p. 41.

Rotundovaldivia latidens: Pretzmann, 1983c, p. 326, pls. 8, 9; Magalhães & Türkay, 1996, p. 88 (in discussion), figs. 35, 43, 44; 2008, p. 225, figs. 7-18.

Rotundovaldivia falcipenis: Pretzmann, 1983c, p. 326, pl. 10.

Valdivia latidens: Rodríguez, 1992, p. 93.

Material examined. Santa Teresita, Orellana Province, Ecuador, 12 Aug. 2013, 2 ♂♂, carapaces and abdomen with pleopods (47.5 × 39.3 mm; 57.5 × 39.5 mm), 1 ♀, carapace and abdomen with pleopods (46.3 × 40.0 mm), 1 carapace (25.8 × 21.8 mm).

Remarks. Four specimens examined are seemingly somewhat different in contour; the carapace of the larger specimen (Fig. 7A) is subcircular like the photographs given by Pretzmann (1983c, pl. 9) and Magalihães and Türkay (2008, fig. 9), while that of the smaller specimen (Fig. 7B) is seemingly narrower, with straight posterolateral margin of the carapace similar to the photograph of the holotype of *Trichodactylus bourgeti* Rathbun given by Magalhães and Türkay (2008, fig. 8). In both specimens examined, it is remarkable that the posterolateral tooth behind the last anterolateral tooth is distinct, but very small and rather vestigial. The dorsal surface of the carapace is generally flattened, with the thin frontal and anterolateral margins, and uneven, with the shallow depressions, flattened regions and interregional furrows.

This species is a monotypic representative of the genus *Rotundovaldivia*. The type species is *Trichodactylus (Valdivia) bourgeti* Rathbun, 1905, which is considered as a synonym of *R. latidens* (A. Milne-Edwards, 1869)

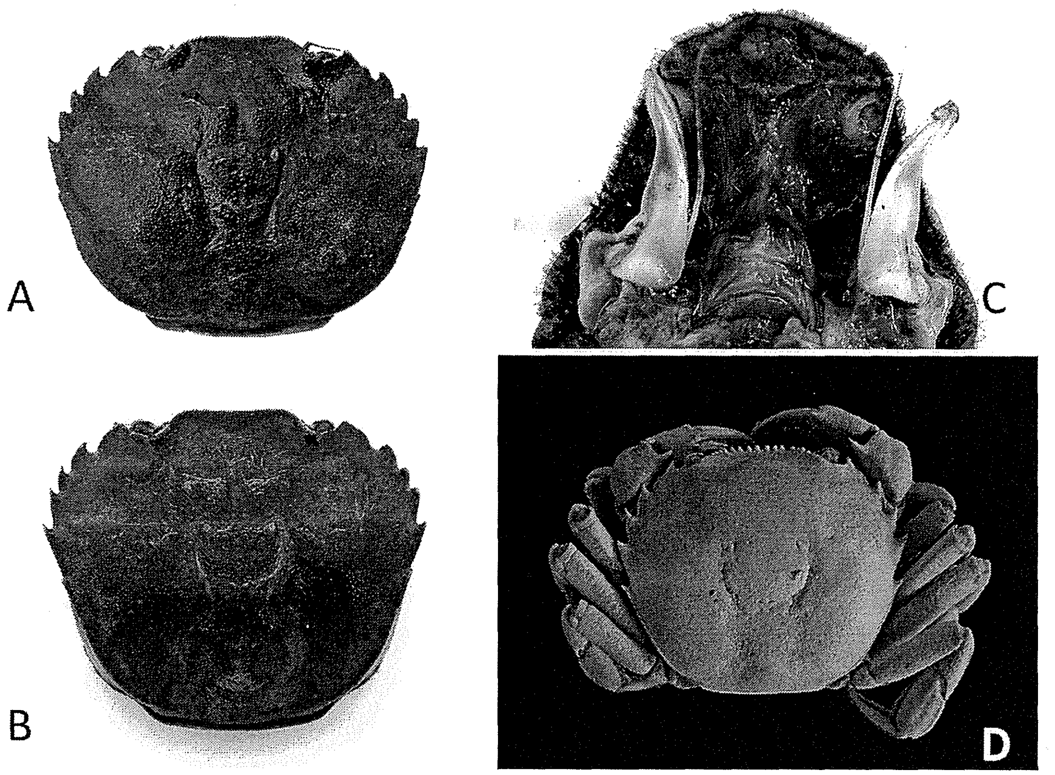

Fig. 7. A-C: *Rotundovaldivia latidens* (A. Milne Edwards), D: *Sylviocarcinus devillei* H. Milne-Edwards.

originally referred to the genus *Sylviocarcinus*.

Distribution. Amazon basin in Ecuador, Peru and Brazil.

Genus ***Sylviocarcinus*** H. Milne-Edwards, 1853

Sylviocarcinus devillei H. Milne-Edwards, 1853

(Fig. 7D)

Sylviocarcinus devillei H. Milne-Edwards, 1853, p. 215; Bott, 1969, p. 28, pl. 3 figs. 5a-c; Rodríguez, 1992, p. 71, figs. 4H, 5C, 7F, 9B, 13A, 25; Magalhães & Türkay, 1996, p. 101, figs. 9-26.

Sylviocarcinus peruvianus A. Milne-Edwards, 1869, p. 174.

Dilocarcinus spinifrons Kingsley, 1880, p. 35.

Dilocarcinus margaritifrons Ortmann, 1893, p. 492, pl. 17 fig. 11.

Sylviocarcinus gigas Smalley & Rodríguez, 1972, p. 48, figs. 6, 7, 21, 22.

Holthuisia peruviana margaritifrons: Pretzmann & Mayta, 1891, p. 141, figs. 9, 10.

Holthuisia peruviana peruviana: Pretzmann, 1893c, p. 323, pl. 4 figs. 9, 10, pl. 5 figs. 11-13.

Material examined. Photographs of 1 ♀ in dorsal and ventral views, without exact locality and size.

Remarks. Magalhães and Türkay (1996b) gave a full account of the variation as for the frontal and anterolateral armature of the carapace. Typically the outline of the carapace is subcircular, with evenly convex dorsal surface, but the marginal armature is surprisingly variable. The female examined (Fig. 7D) seems to be the closest to the holotype of *T. (Valdivia) peruvianus* A. Milne-Edwards represented by Magalhães and Türkay (1996b), having five markedly sharp anterolateral teeth and a line of subacute spinules fringing the frontal margin. Rodríguez (1992) synonymized all the nominal species, and Magalhães and Türkay (1996b) confirmed the extreme variability on the examination of numerous specimens from the whole Amazon system.

Distribution. Widely distributed in Brazil, Peru, Ecuador and Colombia.

Genus ***Trichodactylus*** Latreille, 1828

Trichodactylus faxoni Rathbun, 1906

(Fig. 8)

Trichodactylus (Valdivia) faxoni Rathbun, 1906, p. 49, fig. 113, pl. 18 fig. 10; Bott, 1969, p. 23.

Trichodactylus (Trichodactylus) maytai Pretzmann, 1978, p. 165, fig. 8; 1983c, p. 320.

Trichodactylus maytai: Pretzmann, 1983b, p. 307, pl. 1 fig. 1, pl. 2 fig. 7, pl. 3 fig. 11, pl. 4 fig. 15, pl. 5 fig. 19; Rodríguez, 1992, p. 47.

Trichodactylus faxoni: Magalhães & Türkay, 1996a, p. 75 (in list); Ng *et al.*, 2008, p. 188 (in list).

Material examined. Santa Teresita, Orellana Province, Ecuador, 12 Aug. 2013, 1 ♂ (12.5 × 11.3 mm), 1 ♀ (11.5 × 10.0 mm). 27 carapaces (13.5 × 12.2 mm − 7.3 × 6.8 mm) ; Nuevo Rocafuerte, Orellana Province, Ecuador, 7 ♀♀, many carapaces and abdomens (13.4 × 12.0 mm − 10.0 × 9.1 mm).

Remarks. This species is small, attaining the size at most 15 mm in carapace breadth. The general contour of the carapace (Fig. 8A) is roughly square, with the weakly convex lateral margins. The dorsal surface is ill-defined, convex anteriorly for its anterior one third, smooth, without hairs in most specimens, but covered with a very short tomentum in some specimens. The front is shallowly concave in the middle, and the frontorbital margin is as wide as the posterior margin of the carapace. The lateral margin of the carapace is only weakly convex as a whole, without interruption. The chelipeds of male (Fig. 8C) are distinctly unequal, with the heavy larger cheliped. The ambulatory legs are comparatively long and scantly hairy. The male abdomen (Fig. 8C) is wide, tapering rapidly, and the first

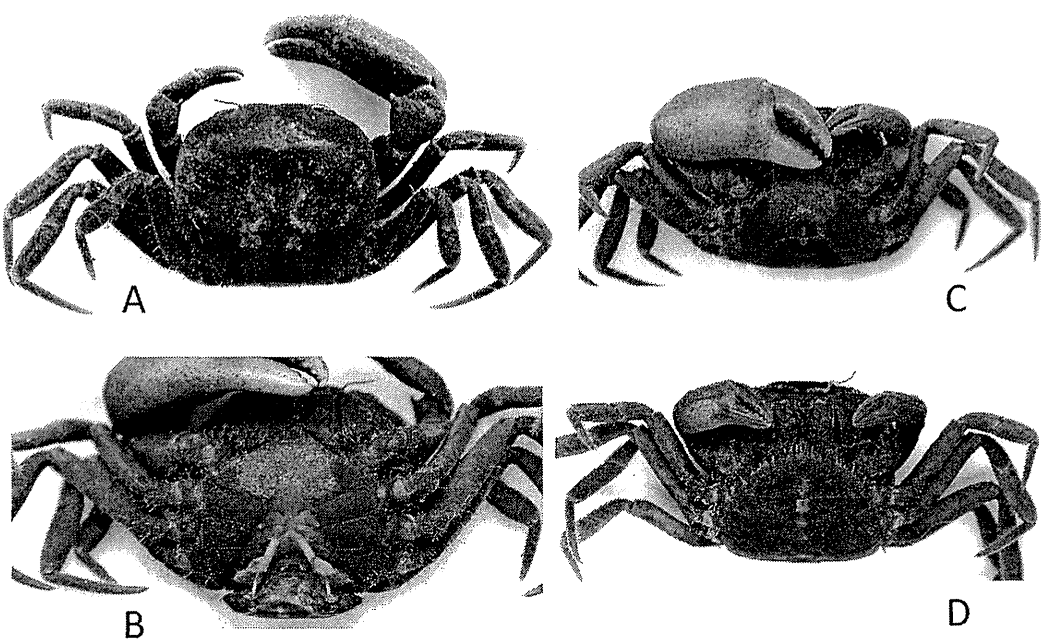

Fig. 8. *Trichodactylus faxoni* Rathbun. ♂ (12.5 × 11.3 mm)(A-C) and ♀ (11.5 × 10.0 mm) (D). Dorsal view (A), and ventral views (B-D) showing chelae, abdomens and male pleopods.

pleopod (Fig. 3E, F, 8B) is constricted in the middle, and the club-shaped distal half is armed with many conical or elongated tubercles directed to the base along the margins.

This species is very close to *T. fluviatilis* Latreille, 1828 from Brazil, which is variable, as some subspecies were distinguished by Bott (1969). This species was elaborately examined by Rodríguez (1992), and the subspecies were synonymized with the nominate species. In the Brazilian species the anterolateral margin of the carapace is sometimes unarmed, but typically armed with three teeth or lobes defined by small notches. In the present specimens examined from Ecuador, the anterolateral margin is completely devoid of teeth or lobes, without notches or depressions. The male first pleopod is basically similar to the figures given by Rodríguez (1992), but the spines may be fewer and restricted to the distal part. In the male examined, the fingers of the larger cheliped are about half the length of the palm, differing from the figure given by Rodríguez (1992), in which the fingers are almost half the length of the palm.

Distribution. The type localities of *Trichodactylus (Valdivia) faxoni* Rathbun and *Trichodactyus (Trichodactylus) maytai* Pretzmann are Tabatinga, Brazil, and Tingomaria, Peru, respectively.

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