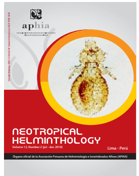
ISSN Versión impresa 2218-6425 ISSN Versión Electrónica 1995-1043

Neotropical Helminthology, 2018, 12(2), jul-dic:243-259.

aphia
ASOCIACIÓN PERUANA DE HELMINTOLOGÍA E INVERTEBRADOS AFINES

Neotropical Helminthology



ORIGINAL ARTICLE / ARTÍCULO ORIGINAL

COMPONENT COMMUNITY OF THE PARASITIC METAZOANS OF THE AFRO-AMERICAN HOUSE GECKO *HEMIDACTYLUS MABOUIA* (MOREAU DE JONNÈS, 1818) (SQUAMATA: GEKKONIDAE) FROM THE JUNGLE OF PERU

COMPONENTE COMUNITARIO DE LOS METAZOOS PARÁSITOS DEL GECKO-CASERO TROPICAL HEMIDACTYLUS MABOUIA (MOREAU DE JONNÈS, 1818) (SQUAMATA: GEKKONIDAE) DE LA SELVA DEL PERÚ

David Minaya-Angoma[1]; Carlos Mendoza-Vidaurre[2]; Jhon Chero-De la Cruz[3]; Gloria Saez-Flores[3]; Reinaldo José da Silva[4] & José Iannacone[1,5]

[1]Laboratorio de Ecología y Biodiversidad Animal, Facultad de Ciencias Naturales y Matemática, Universidad Nacional Federico Villarreal - UNFV. El Agustino, Lima, Perú.
[2]Universidad Alas Peruanas – UAP. Tarapoto, San Martín, Perú.
[3]Laboratorio de Parasitología General y Especializada, Facultad de Ciencias Naturales y Matemática, Universidad Nacional Federico Villarreal - UNFV. El Agustino, Lima, Perú.
[4]São Paulo State University (Unesp), Institute of Biosciences, Department of Parasitology, Laboratory of Parasitology of Wild Animals. Botucatu, São Paulo, Brasil.
[5]Laboratorio de Parasitología. Facultad de Ciencias Biológicas. Universidad Ricardo Palma. Santiago de Surco, Lima, Perú. Corresponde Author: E-mail: joseiannacone@gmail.com

ABSTRACT

The purpose of this study was to evaluate the component community of the parasitic metazoans of the Afro-American house gecko *Hemidactylus mabouia* (Moreau de Jonnès, 1818) from the jungle of Peru. Ninety-one specimens of *H. mabouia* from seven localities of San Martín and Huánuco were collected from April to June 2015. The parasites were collected and processed according to standard protocols. Eighty-five percent of the geckos were infected with at least one parasite species and a total of 1,120 parasite specimens were collected with a prevalence of 90%. The parasitic fauna of *H. mabouia* was composed of 11 species, as follow: six species of nematodes - *Oswaldocruzia aff. brasiliensis* Lent et Freitas, 1935*, Spauligodon* sp. Skrjabin, Schikhobalova & Lagodovskaja, 1960, *Parapharyngodon* sp. Chatterji, 1933, *Physaloptera* sp. Rudolphi, 1819, Acuariidae gen. sp. Railliet, Henry & Sisoff, 1912, and one species not identified of nematode; one cestode species - *Oochoristica vanzolinii* Rego & Rodrigues, 1965; two trematode species - *Paradistomum* sp.1 Kossack, 1910, *Paradistomum* sp.2 Kossack, 1910; one pentastomid species - *Raillietiella hebitihamata* Self & Kuntz, 1960; and one mite species - *Geckobia hemidactyli* Lawrence, 1936. The three parasites with the higher prevalence (P) and mean abundance (MA) were *G. hemidactyli* (P = 45.05%, MA = 4.16), *Spauligodon* sp. (P = 37.36%, MA = 2.64), and *Raillietiella hebitihamata* (P = 32.97%, MA = 2.3). Single and multiple parasitic infections with at least one, two, three, four, and five species of parasites were observed in 25, 35, 15, 6, and 1 hosts, respectively.

A positive association was observed between the prevalence of infection of *R. hebitihamata* and *Parapharyngodon* sp. with the total length (TL) of the gecko. There was also a relationship between TL of *H. mabouia* and MA and mean intensity of *Spauligodon* sp. The cestode *O. vanzolinii* and the pentastomid *R. hebitihamata* are first geographical record for Peru. Non-metric multidimensional scaling (NMDS) and the relationship between community composition and explanatory variables (host length, sex, and locality) were examined by permutational analysis of variance (PERMANOVA) applied to species abundances which showed high homogeneity among metazoan parasite communities of *H. mabouia*.

Keywords: gecko – helminths – Neotropic – parasitology – Peru

RESUMEN

La finalidad de este estudio fue evaluar el componente comunitario de los metazoos parásitos del gecko-casero tropical *Hemidactylus mabouia* (Moreau de Jonnès, 1818) de la selva del Perú. Se colectaron en siete localidades de San Martín y de Huánuco, noventa y un especímenes de *H. mabouia* durante abril a junio del 2015. Los parásitos fueron colectados y procesados siguiendo protocolos estándares. El 89% de los geckos estuvieron infectados con al menos una especie de parásito, se colectaron un total de 1,120 especímenes parásitos. La fauna parasitaria de *H. mabouia* estuvo compuesta de 11 especies, como sigue: Seis especies de nematodos *Oswaldocruzia aff. brasiliensis* Lent et Freitas, 1935, *Spauligodon* sp. Skrjabin, Schikhobalova & Lagodovskaja, 1960, *Parapharyngodon* sp. Chatterji, 1933, *Physaloptera* sp. Rudolphi, 1819, Acuariidae gen. sp. Railliet, Henry & Sisoff, 1912 y una especie no identificada de nemátoda; una especie de cestodo *Oochoristica vanzolinii* Rego & Rodrigues, 1965, dos especies de trematodos *Paradistomum* sp.1 Kossack, 1910, *Paradistomum* sp.2 Kossack, 1910; una especies de pentastómido *Raillietiella hebitihamata* Self & Kuntz, 1960; y una especie de ácaro *Geckobia hemidactyli* Lawrence, 1936. Los tres parásitos con la más alta prevalencia (P) y abundancia media (AM) fueron *G. hemidactyli* (P = 45.05 %, AM = 4.16), *Spauligodon* sp. (P = 37.36 %, AM = 2.64) y *R. hebitihamata* (P= 32.97 %, AM = 2.3). Las infecciones parasitarias individuales y múltiples con al menos una, dos, tres, cuatro y cinco especies de parásitos fueron observadas en 25, 35, 15, 6 y 1 hospederos, respectivamente. Se observó asociación positiva entre la prevalencia de infección de *R. hebitihamata* y *Parapharyngodon* sp. con la longitud total (LT) del gecko. También se observó relación entre la LT de *H. mabouia* y la AM e intensidad media de *Spauligodon* sp. El cestodo *O. vanzolinii* y el pentastómido *R. hebitihamata* son reportadas por primera vez a la composición de la fauna de parásitos de Perú. El escalamiento multidimensional no métrico (NMDS) y la relación entre la composición de la comunidad y variables explicativas (longitud, sexo del hospedero y localidad) fueron examinadas por el análisis de varianza de permutación (PERMANOVA) aplicadas a la abundancia de especies y mostraron una alta homogeneidad entre los parásitos metazoos de las comunidades de *H. mabouia*.

Palabras clave: gecko – helmintos – Neotrópico – parasitología – Perú

INTRODUCTION

The research focused on the study of parasite communities in exotic reptiles is scarce both in America and even more in Peru (Goldberg *et al*., 1995; Hanley *et al*., 1995; Goldberg & Bursey, 2000; Criscione & Font, 2001; Bursey *et al*., 2005). However, parasitological studies focused on new host records, localities, and descriptions of several new species of helminths that infect reptiles in South America have been increasing in recent years (Goldberg *et al*., 2004; Ávila & Silva, 2010). Many of these studies date back to 1920 when Lauro

Travassos and collaborators presented important contributions to this field (Travassos, 1920; Travassos, 1931; Ávila & Silva, 2010).

In Peru, the first studies related to the parasitology of reptiles start with the work of Baylis (1926) who described for the first time the nematode *Thubunaea parkeri* Baylis 1926 parasitizing the lizards *Microlophus occipitalis* (Peters, 1871) and *Dicrodon heterolepis* (Baylis, 1926).

Hemidactylus mabouia (Moreau de Jonnès, 1818) (Squamata: Gekkonidae) is a species of exotic gecko of African origin that is well established and widely distributed in South America (Ávila-Pires, 1995). *Hemidactylus mabouia* is very common in Brazil, where it is usually associated with man-made structures and is frequently found around human dwellings, both in rural areas and urban areas (Vanzolini, 1978; Ávila-Pires, 1995). In relation to its conservation status, it is not cataloged by the IUCN (International Union for the Conservation of Nature) and nor by CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora). GISS (2018) cited as an invasive exotic species that displaces and feeds on native geckos.

Many of the studies related to the parasitic fauna of this reptile have been carried out in Brazil where fifteen taxa of parasitic helminths have been reported (two species of trematodes, one of cestode, eleven of nematodes and one of acanthocephalan), pentastomids, and a mite species (Martínez-Rivera *et al*., 2003; Anjos *et al*., 2005; Anjos *et al*., 2008; Ávila & Silva, 2010; Ávila & Silva, 2011; Sousa *et al.,* 2014).

The objective of this study was to evaluate the component community of the parasitic metazoans of the Afro-American house gecko *H. mabouia* of the jungle of Peru, as well as to determine the association between the main parasitic indexes with some biometric parameters of this host.

MATERIAL AND METHODS

Area of study, capture, and identification of lizards

A total of 91 gecko specimens were collected from April to Juny 2015, in the following locations: San Martín Department, Bellavista Province (Bellavista District: 7°02'25" S 76°34'23" W, n = 5), province of Lamas (districts of Barranquita: 6°14'35" S 76°02'08" W, n = 11, and Lamas: 6°25'06" S 76°31'14" W, n = 7), province of San Martín (districts of Morales: 6°28'45" S 76°24'09" W, n = 8; of Tarapoto: 6°29'49" S 76°23'53" W, n = 51, and of the Banda de Shilcayo: 6°29'46" S 76°21'47" W, n = 1), and finally in the Department of Huánuco, Province Leoncio Prado (9°17'02" S 75°59'05" W, n = 8), Peru. The technique of direct detection or search by visual encounter was used. The individuals were captured and euthanized in the lethal chamber with chloroform. The identification was made by the Department of Herpetology of the Natural History Museum of San Marcos. Data of total length (TL) in cm and sex (S) were taken for all studied individuals. The collection was authorized by Directorial Resolution N°024-2014-SERFOR-DGGSPFFS.

Collection, fixation, and identification of parasites

For the collection of the endoparasites, coelomic cavity, lungs, stomach, small intestine, large intestine, gonads, heart, gallbladder, liver, and spleen were surveyed. The nematodes were fixed in 70% hot ethyl alcohol; the pentastomids, cestodes and trematodes were fixed under slight pressure of coverslip for 24 h. After, they were preserved in 70% ethyl alcohol and placed in labeled vials for transfer to the Laboratory (Lamothe, 1997). For the collection of ectoparasites, the skin of the geckos was checked. All the mites were stored in 70% ethyl alcohol for later identification.

For their taxonomic study, cestodes and trematodes were stained in Semichon acetic carmine and mounted in balsam of Canada; the nematodes were cleared in a mixture of alcohol-phenol to observe in detail structures of taxonomic importance; the pentastomids were mounted on slides and treated with a Hoyer medium (Lamothe, 1997). The photographs and measurements were made with the help of a Leica DM500 microscope with Leica Application Suite software version 3.1.0.

The nomenclature and classification of parasite species were carried out following the taxonomic keys of Gibson *et al.* (2008) for trematodes, Khalil *et al.* (1994) for cestodes, Anderson (2000) for nematodes, and Krantz (1978) for the mites. The specimens of the parasite species were deposited in the Helminthological Collection of the Institute of Biosciences (CHIBB) of São Paulo State University (UNESP), municipality of Botucatu under registration numbers CHIBB 7813-7818.

Statistical analysis

The data of total length (TL, in cm) and sex (S) were plotted in a Box plot. Ecological parasitological indexes: prevalence (P, %), mean abundance (MA), and mean intensity (MI) of infection were calculated following the indications of Bush *et al*. (1997) and Bautista-Hernández *et al.* (2015). The P, MA, and MI were determined for each of the parasites registered in the geckos. The index of specific importance (ISI) calculated as the importance of each parasitic species in the ecological assembly was used. ISI = P + (MA x 100) in order to obtain an integrated infection index of both ecological descriptors (Bursey *et al*., 2001; Iannacone & Alvariño, 2013).

The frequency of dominance was determined as the number of times a parasitic species is dominant in all the hosts examined and the frequency of relative dominance as the number of individuals of a taxon on the total number of individuals of all the taxa in the parasitic infracomunity (Rohde *et al*., 1995). Individual (monospecific) and multiple parasitic infections (two to three parasite species) were determined.

For the case of parasitic species with prevalence greater than 10% (Esch *et al.*, 1990), three aggregation indices were applied: Dispersion (Id), Poulin Discrepancy Index (PDI), and K of the negative binomial equation with its respective value of X^2 (Bego & Von Zuben, 2010). The Quantitative Parasitology 3.0 package was used (Rózsa *et al*., 2000). These indices were calculated in order to show if parasitic helminths had a distribution: (1) contagious, aggregated or conglomerate; (2) uniform-regular or (3) randomized.The Pearson correlation coefficient was used to evaluate the association between the TL versus the P of infection, previously transforming the values of P to the square root of arcosene. The Spearman correlation coefficient was used to determine the ratio of the TL of the host to the MA and MI of each parasitic species. In all cases, the normality of the data was verified using the Kolmogorov-Smirnov test with the Lillierfors modification and the variance homocentricity based on the Levene test (Zar, 2014).

2 x 2 contingency tables were used to calculate the degree of association between the sex of the host and the prevalence of each parasite using Chi-squared (X^2) and the Likelihood Ratio test. The Student t-test was used to compare the MA and MI of each parasite and the sex of the host. The analysis of the parasites in relation to the size and sex of the host was made only for the species with prevalence greater than 10% (Esch *et al*., 1990).

Dendrograms were performed with the qualitative Jaccard similarity index and the Morisita-Horn quantitative index for paired association data between the *H. mabouia* parasites of the San Martin and Huánuco regions, Peru. The level of significance was evaluated at a level of alpha = 0.05. For the determination of descriptive and inferential statistics, the statistical package IBM SPSS Statistics 20 was used.

The non-metric multi-dimensional scaling (NMDS), an ordination technique, was used to study pattern in the parasite community structure based on the abundance of parasite species. A similarity matrix was constructed based on the Bray–Curtis measure. The abundance of infection of each parasite species in each host and its relation to length, sex, and locality of the host were analyzed through one-way analysis of variance with a non-parametric permutational ANOVA (PERMANOVA) test (Anderson, 2001; Míguez-Lozano *et al*., 2012).

Ethical aspects

The procedures for collecting the diversity of parasitic fauna in the gecko followed the guidelines of the "Institutional Animal Care and Use Committee" (IACUC) (APA, 2012), minimizing the number of organisms used, repetitions and using the three Rs "Rs-replacement, reduction, and refinement", and resolution 2558-2018-CU-UNFV that includes the code of ethics for research at the National University Federico Villarreal (UNFV). For the management of the parasitic fauna, the guidelines of the protection and animal welfare law of Peru were followed (Law No. 30407: Article 19). The collection of the parasitic fauna is indicated by the SERFOR (National Forestry and Wildlife Service) of Peru that establishes the guidelines for the scientific investigation of flora and/or wild fauna (Resolution of Executive Direction Nº060-2016 SERFOR-DE). For the field collection of the geckos, the impact on the abundance of species was minimized so that it is minimal (Costello *et al*., 2016).

Conflicts of interest
The authors declare that they do not present any conflict of interest.

RESULTS

Ninety-one specimens of *H. mabouia* were examined, of which 20.9% (n = 19) were females and 79.1% (n = 72) were males. The individuals showed an average total length (TL) of 11.54 ± 2.09 cm; the males showed a TL of 11.96 ± 1.96 cm and the females a TL of 9.95 ± 1.84 cm (Fig. 1). The t-test for independent samples accepts the null hypothesis assuming the equality of variances and in which the averages of the TL of the male and female geckos do not have significant differences (F_{Levene} = 0.031, p = 0.86, t = 4, 02, n = 91).

The component community was composed of 11 parasite species: the nematodes *Oswaldocruzia aff. brasiliensis* Lent & Freitas, 1935 (Diaphanocephalidae), *Spauligodon* sp. Skrjabin, Schikhobalova & Lagodovsk, 1960 (Pharyngodonidae), *Parapharyngodon* sp. Chatterji, 1933 (Pharyngodonidae), *Physaloptera* sp. Rudolphi, 1819 (Physalopteridae), a larval nematode of the family Acuariidae Railliet, Henry & Sisoff, 1912, and a nematode cyst in Liver; the trematodes *Paradistomum* sp.1 Kossack, 1910 (Dicrocoeliidae),and *Paradistomum* sp.2 Kossack, 1910 (Dicrocoeliidae); the cestode *Oochoristica vanzolinii* Rego & Rodrigues, 1965 (Linstowiidae); the pentastomid *Raillietiella hebitihamata* Self & Kuntz, 1960 (Cephalobaenidae); and the mite *Geckobia hemidactyli* Lawrence, 1936 (Pterygosomatidae), which was the only ectoparasite species. The site of infection/infestation, stage, prevalence, mean abundance and mean intensity of infection of the parasites collected in *H. mabouia* were presented in Table 1.

A total of 1,120 parasites was recovered. Species richness was represented mostly by nematodes (n = 6) which were collected from the intestine of the geckos. *Geckobia hemidactyli* is the ectoparasite with the highest abundance (379 individuals), which was found infecting 41 hosts (P = 45.05%) followed by the nematode *Spauligodon* sp (N = 240 individuals, n = 34 hosts, P = 37.36%).

The percentage of parasitized geckos with at least one parasite species was 90.11% (n = 82). In the case of specific infections, 27.47% (n = 25) was infected with a single species of parasite, 38.46% (n = 35) with two species, 16.48% (n = 15), with three species, 6.59% (n = 6), with four species, and 1.11% (n = 1) with five species (Table 2).

The highest specific importance, frequency of dominance and relative dominance were also for *G. hemidactyli* and *Spauligodon* sp. (Table 3). Aggregation indices: Dispersion (Id), Poulin Discrepancy Index (PDI) and K of the negative binomial equation indicate a conglomerate or contagious type distribution for parasites with prevalence greater than 10% (Table 3).

Table 4 shows a positive correlation between the prevalence of *R. hebitihamata* and the length of its hosts. The same degree of association is observed between the P% of *Parapharyngodon* sp. and the TL of *H mabouia*. The MA and MI of *O. vanzolinii* and *Spauligodon* sp. were also positively related to the gecko TL. In relation to the sex of the host, this was only associated with the P and AM of the nematode *Parapharyngodon* sp., not finding females parasitized with this parasite.

The level of similarity between the parasitic species is observed in Figure 2, which indicates that there is a low similarity (below 50%) among the parasites associated with *H. mabouia*. The highest similarity at a qualitative level (presence and absence) is between *G. hemidactyli* and *R. hebitihamata* and at quantitative levels between *G. hemidactyli* and *Spauligodon* sp. *Paradistomum geckonum* and *Paradistomum* sp. are the second group that forms most similarly, which show similar similarities at a quantitative and qualitative level.

Figure 5, 6 and 7 display the NMDS ordination plot of the 91 metazoan parasites communities from *H. mabouia*. The NMDS ordination suggests a high degree of homogeneity across communities. The PERMANOVA analysis confirmed the low heterogeneity among metazoan parasites communities of *H. mabouia* (Table 5).

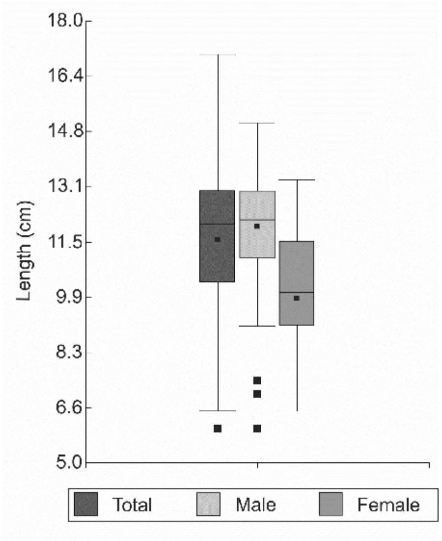


Figure 1. Box plot diagram for the total length (in cm) of the total of Geckos, males, and females of *Hemidactylus mabouia* collected in the region of San Martin and Huanuco, Peru.

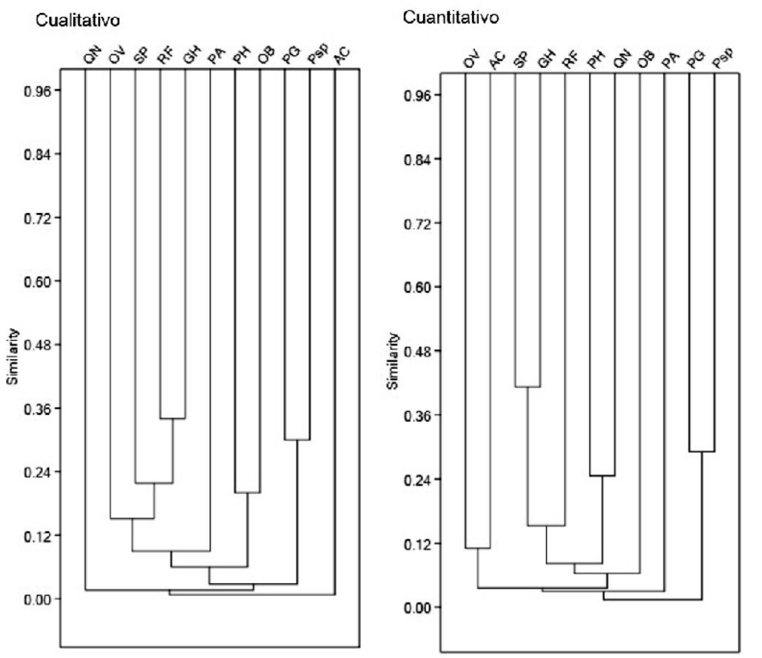


Figure 2. Dendrogram with the Jaccard similarity index (left) and the Morisita-Horn quantitative index (right) for paired data of association between *Hemidactylus mabouia* parasites of San Martin and Huánuco, Peru. GH=*Geckobia hemidactyli*, RF=*Raillietiella hebitihamata*, PG=*Paradistomum* sp1., Psp=*Paradistomum* sp2., OV=*Oochoristica vanzolinii*, OB=*Oswaldocruzia aff. brasiliensis*, SP=*Spauligodon* sp., PA=*Parapharyngodon* sp., PH=*Physaloptera* sp., AC=Acuariidae, and QN=nematode cyst.

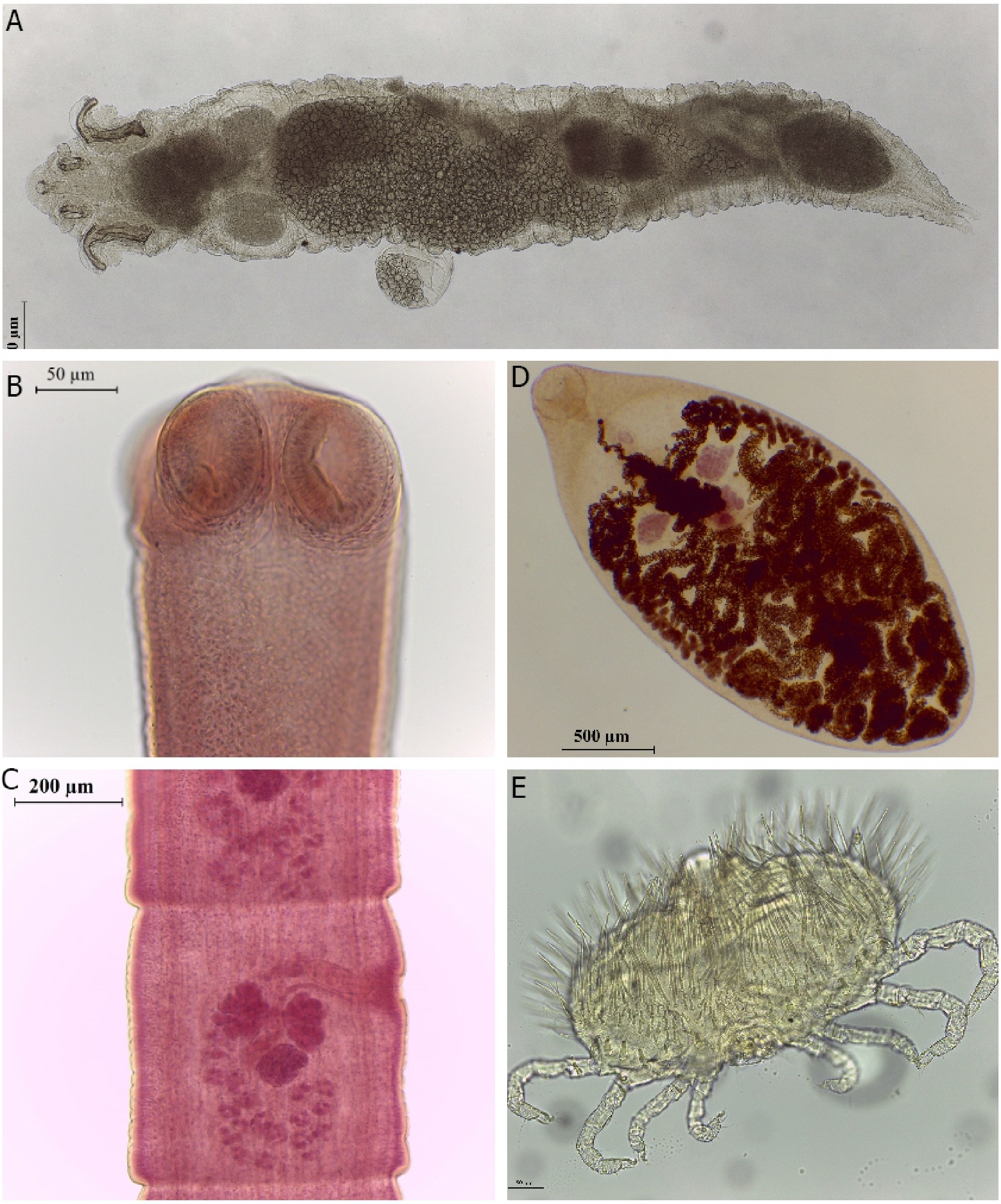


Figure 3. A. *Raillietiella hebitihamata*, B-C. *Oochoristica vanzolinii*, B. Scolex, C. Madure proglottid, D. *Paradistomum* sp.1. and E. *Geckobia hemidactyli*.

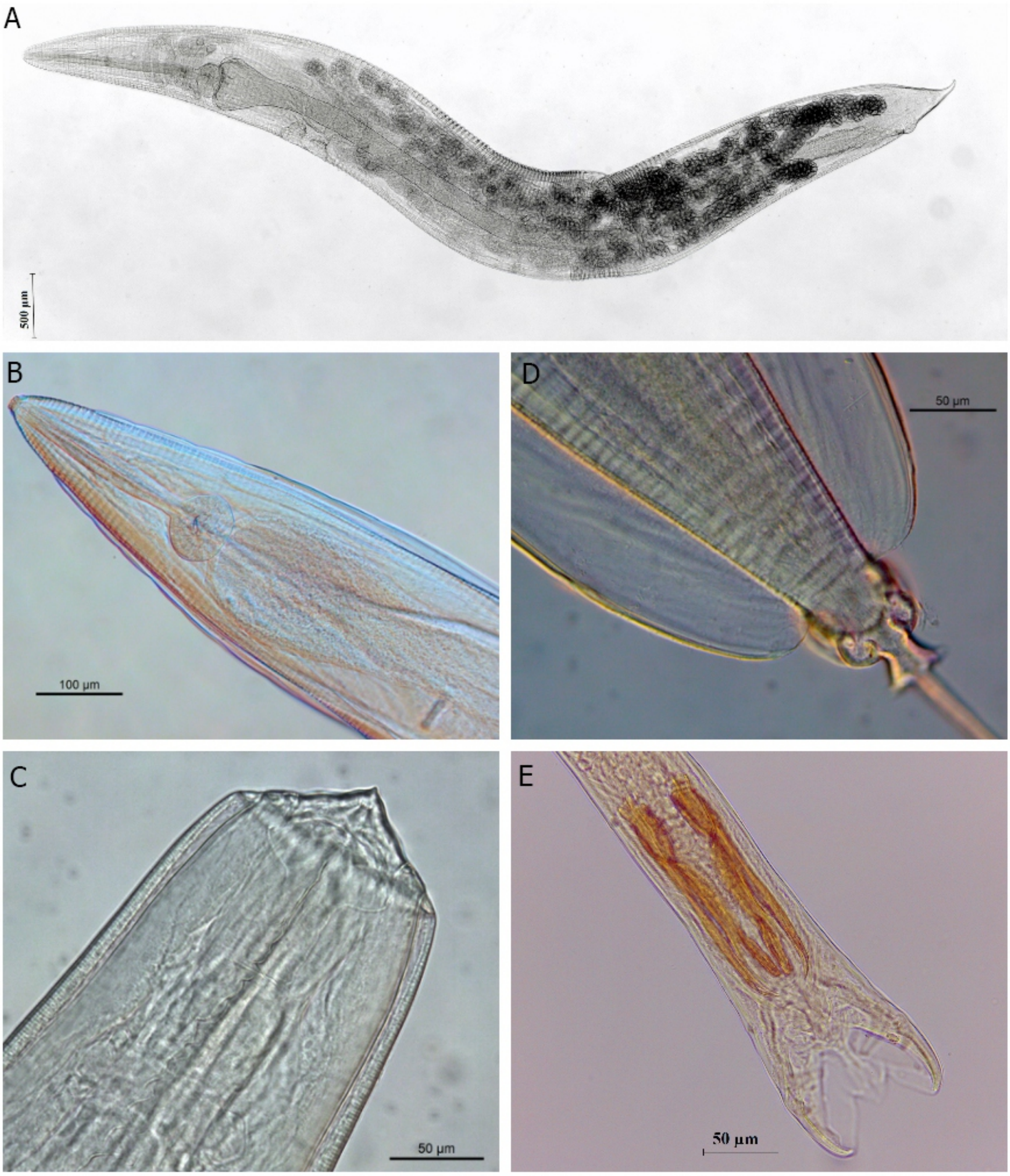


Figura 4. A. *Parapharyngodon* sp., B-C. *Spauligodon* sp, D. *Physaloptera* sp, E. *Oswaldocruzia aff. brasiliensis.*

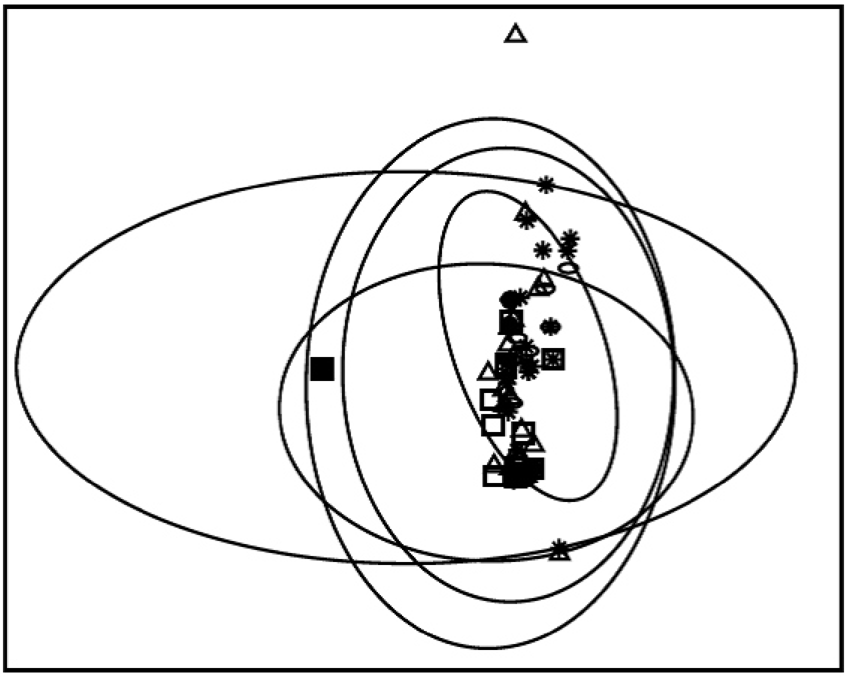


Figure 5. Non-metric multidimensional scaling (NMDS) plots results of all lengths (1, 6.0 cm -8.0 cm. 2, 8.1 cm – 10.0 cm. 3, 10.1 cm -12.0 cm 4, 12.1-14.0cm 5, >14cm) in terms of their parasitic abundance. Bray Curtis similarity. 2D Stress = 0.58. 1 =•. 2 =□. 3 =□. 4 =Δ. 5=⬭ .

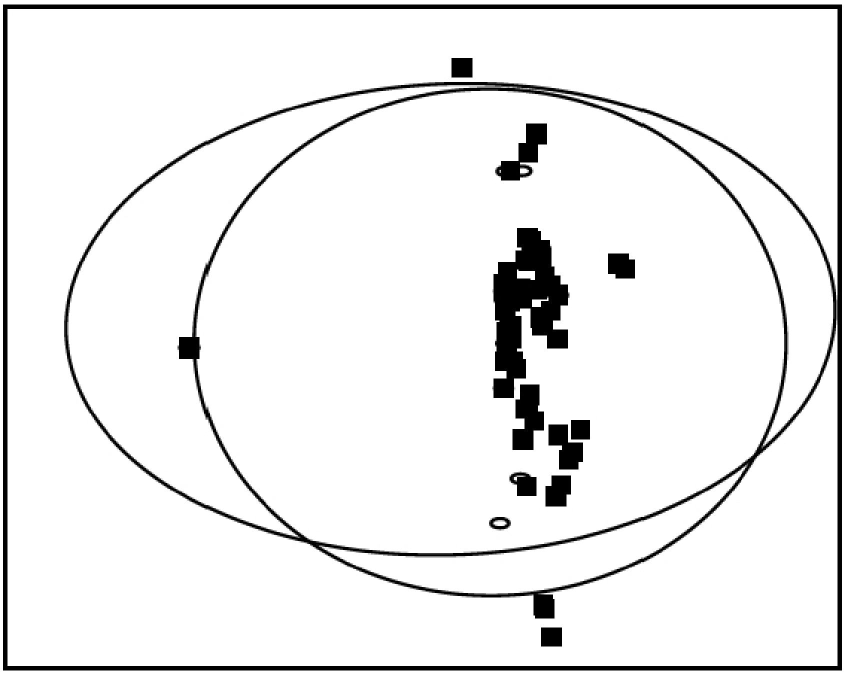


Figure 6. Non-metric multidimensional scaling (NMDS) plots results of sex (1, males. 2, females) in terms of their parasitic abundance. Bray Curtis similarity. 2D Stress = 0. 58. 1= ■. 2= ⬭.

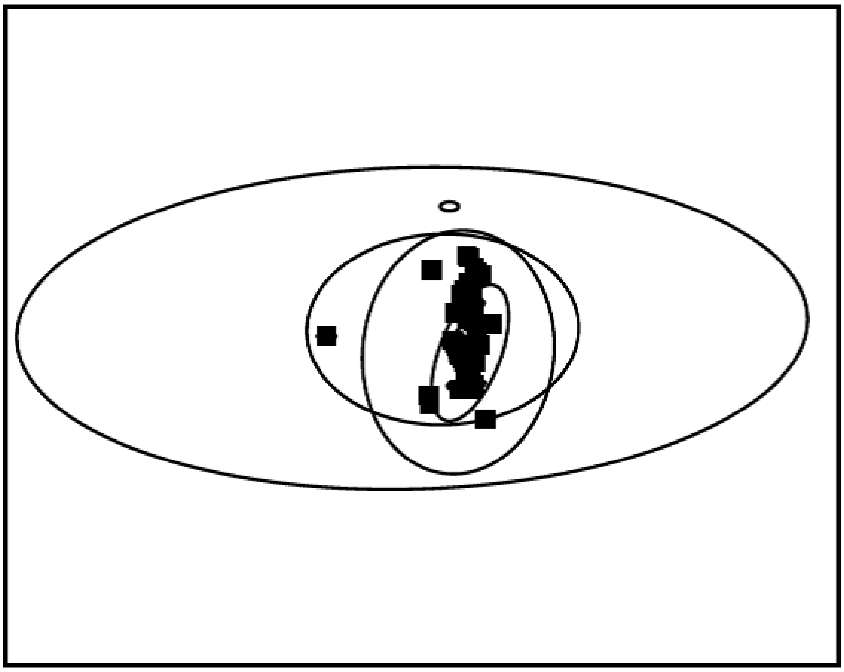


Figure 7. Non-metric multidimensional scaling (NMDS) plots results of localities (1, Leoncio Prado (Huánuco). 2, San Martín (San Martín). 3, Lamas (San Martín). 4, Bellavista (San Martín)) in terms of their parasitic abundance. Bray Curtis similarity. 2D Stress = 0. 58. 1= ■. 2= . 3 =♦. 4 =Δ.

DISCUSSION

In this study, 11 species of parasites were recorded parasitizing the *H. mabouia* gecko collected in San Martin and Huánuco, Peru. To date, studies have been carried out in Brazil where 18 *taxa* of parasites have been reported: 15 helminths, 2 pentastomids and 1 mite (Anjos *et al*., 2008, Ávila & Silva, 2010, Paredes-León *et al*., 2013). In comparison to that reported by Anjos *et al.* (2008), where only 5 species of helminths (1 acanthocephalans and 4 nematodes) were recorded in 291 individuals of *H. mabouia* collected in southeastern Brazil, in this study the species richness of helminths is higher (n = 9) for a smaller population size (n = 91) to the one studied by Anjos *et al.* (2008). In this same work, the degree of association of the parasitic prevalence with the TL of the host was evaluated and no association between both was detected. In contrast, in the present study, it was observed that the TL of the host significantly influences the parasitism of the species of *R. hebitihamata* and *Parapharyngodon* sp.

Another study addressing the parasitic fauna of *H. mabouia* is the one carried out by Sousa *et al.* (2014) in which it records 6 parasitic species (between helminths and pentastomids) for 76 individuals collected in Northeast Brazil. This is still lower than what was recorded in our study. It is important to point out that in the studies conducted by Anjos *et al*. (2008) and Sousa *et al.* (2014) trematode species were not recovered.

Pterygosomatidae mites have a worldwide distribution and are comprised of 10 genera and 177 species, some of which have high specificity towards the host. Within Pterygosomatidae, the genus *Geckobia* Mégnin, 1878 is the one that has the widest geographic distribution and the greatest richness with 72 parasitic species of Geckonidae lizards (Quiroz-Gutiérrez *et al*., 2015). In this study we found *G. hemidactyli* parasitizing *H. mabouia* with moderate prevalence (P = 45%) and there was no influence on the parasitic load with the TL and

Table 1. Ecological descriptors, location, and stage of *Hemidactylus mabouia* parasites of San Martin and Huánuco, Peru. P (%) = Prevalence, AM = average abundance, IM = average intensity of infection, n = number of infected hosts, N = total number of parasites.

Parasite	Location	stage	n	N	P (%)	MA	MI
ACARI							
Geckobia hemidactyli Lawrence, 1936	Skin	Adults, nymphs, larvae	41	379	45.05	4.16	9.24
PENTASTOMIDA							
Raillietiella hebitihamata Self & Kuntz, 1960	Lung	Adult	30	185	32.97	2.03	6.17
TREMATODA							
Paradistomum sp.1 Kossack, 1910	Bile duct	Adult	10	153	10.99	1.68	15.30
Paradistomum sp.2 Kossack, 1910	Bile duct	Adult	3	23	3.30	0.25	7.67
CESTODA							
Oochoristica vanzolinii Rego & Rodrigues, 1965	Intestine	Adult	20	45	21.98	0.49	2.25
NEMATODA							
Spauligodon sp. Skrjabin, Schikhobalova & Lagodovskaja, 1960	Intestine	Adult	34	240	37.36	2.64	7.06
Parapharyngodon sp. Chatterji, 1933	Intestine	Adult	16	68	17.58	0.75	4.25
Physaloptera sp. Rudolphi, 1819	Intestine	Larvae	10	21	10.99	0.23	2.10
Acuariidae sp. Railliet, Henry & Sisoff, 1912	Intestine	Larvae	2	2	2.20	0.02	1.00
Oswaldocruzia aff brasiliensis Lent et Freitas, 1935	Intestine	Adult	2	3	2.20	0.03	1.50
Non identified nematode species	Liver	Cyst	1	1	1.10	0.01	1.00

Table 2. Individual or multiple parasitic infections in males and females of *Hemidactylus mabouia* of San Martin and Huanuco, Peru.

Type of infection		Total	% total	Machos	Hembras
Monospecific	with one species	25	27.47	20	5
Polyspecific or múltiple	with two species	35	38.46	26	9
	with three species	15	16.48	13	2
	with four species	6	6.59	6	0
	with five species	1	1.09	1	0
Not parasited	zero species	9	9.89	6	3

Table 3. Values of the index of specific importance, frequency of dominance and frequency of relative dominance, and of the aggregation indexes (id = dispersion index, PDI = Poulin Discrepancy index and the K of the negative binomial equation with its respective value of X^2) applied to the most prevalent parasites. ISI = index of specific importance, FD = frequency of Dominance and FRD = frequency of Relative Dominance of the parasitic component of *Hemidactylus mabouia* of San Martin and Huánuco, Peru.

Parasite	ISI	FD	FRD	id	PDI	K	X^2
ACARI							
Geckobia hemidactyli	461.5	17	0.33	12.70	0.72	ND**	ND**
PENTASTOMIDA							
Raillietiella hebitihamata	236.3	5	0.16	16.10	0.85	0.14	5.97
TREMATODA							
Paradistomum sp.1	179.1	4	0.13	28.39	0.93	0.02	4.19
Paradistomum sp.2	28.3	0	0.02	ND*	ND*	ND*	ND*
CESTODA							
Oochoristica vanzolinii	71.4	1	0.04	4.28	0.85	0.19	4.69
NEMATODA							
Spauligodon sp	301.1	11	0.21	11.19	0.80	0.17	11.25
Parapharyngodon sp	92.3	4	0.06	8.02	0.90	0.08	2.98
Physaloptera sp	34.1	0	0.02	3.19	0.92	0.09	0.84
Acuariidae gen. sp	4.4	0	0.002	ND*	ND*	ND*	ND*
Oswaldocruzia aff *brasiliensis*	5.5	0	0.003	ND*	ND*	ND*	ND*
Nematodo gen. sp.	2.2	0	0.001	ND*	ND*	ND*	ND*

ND * = Not determined by having prevalences of less than 10%
ND ** = Not determined due to significantly different variances.

the sex of the geckos. Martínez-Rivera *et al.* (2003) also recorded *G. hemidactyli* in *H. mabouia* collected near buildings in Culebra and Mona Island in Puerto Rico. They found high prevalences (P = 100%) in adults and a range of mites from 3 to <300 parasites per individual. Revisions of samples of *H. mabouia* collected in Peru (Tarapoto, Moyobamba, and Iquitos) showed no infestation with mites. The authors argue that this is due to the age of the samples, their different uses for other studies, and the constant change of the preservation status where they were.

Pentastomid crustaceans are common parasites of the respiratory tract of reptiles. The infection with *Raillietiella* Sambon, 1910 species in geckos in America (Rego, 1983) is known. The prevalence of *R. hebitihamata* parasitizing *H. mabouia* found in this study (P = 32.9%) was lower than that reported in the same host Gecko of Puerto Rico (89%) (Simonsen & Sarda, 1985) and *H. angulatus* Hallowell, 1854 of the Hispaniola Caribbean Island (62%) (Powell *et al*., 1993). However, our results were higher than those reported in *H. turcicus* (Linnaeus, 1758) from the United States

Table 4. Correlation coefficients (r) used to evaluate the relationship between the total length (TL) of *Hemidactylus mabouia* versus the prevalence (P), mean abundance (MA) and mean intensity (MI) of the parasites. Test of t of student (t) and Chi squared (X^2) used to evaluate the relationship between the sex of *H. mabouia* and prevalence and parasitic abundance.

Parasite	P vs TL Spearman r/p	MA vs TL Pearson r/p	MI vs TL Pearson r/p	P vs sex X^2/p	MA vs sex t/p	MI vs sex t/p
Geckobia hemidactyli	0.60/0.29	0.20/0.75	-0.23/0.72	0.05/0.82	0.42/0.68**	3.56/0.73**
Raillietiella hebitihamata	0.90/0.04	0.92/0.88	-0.13/0.84	0.87/0.65	1.16/0.26*	1.63/0.18*
Paradistomum sp.1	0.10/0.87	-0.25/0.69	-0.02/0.97	0.01/0.94	0.97/0.33**	0.84/0.55*
Oochoristica vanzolinii	0.70/0.19	0.85/0.07	0.81/0.10	2.08/0.15	1.14/0.26**	0.45/0.66**
Spauligodon sp.	-0.15/0.81	0.98/0.00	0.99/0.00	0.35/0.55	0.53/0.60**	0.21/0.83**
Parapharyngodon sp.	0.90/0.04	0.76/0.14	0.86/0.05	8.35/0.00	2.95/0.00*	ND***
Physaloptera sp.	0.10/0.87	0.15/0.81	010/0.87	0.52/0.47	0.91/0.37*	1.09/0.31**

p = level of significance, ND = not determined by the absence of data in the group of females.
* Unequal variances (Levene test). ** Equal Variances (Levene Test).
Values in bold indicate that they are statistically significant.

Table 5. Summary of main results of the non-parametrical permutational ANOVA (PERMANOVA) relating abundances of parasite species of *Hemidactylus mabouia* and length, sex and locality.

Source	F	P(perm)
Length	0.82	0.63
Groups (bounferroni test)		
6-8 cm x 8.1-10cm		0.47
6-8 cm x 10.1-12cm		0.31
6-8 cm x 12.1-14cm		0.37
6-8 cm x >14 cm		0.22
8.1-10cm x 10.1-12cm		0.38
8.1-10cm x 12.1-14cm		0.63
8.1-10cm x >14cm		0.59
10.1-12cm x 12.1-14cm		0.33
10.1-12cm x >14cm		0.93
12.1-14cm x >14 cm		0.84
Sex	1.67	0.15
Groups (bounferroni test)		
Males x females		0.14
Locality	0.93	0.44
Groups (bounferroni test)		
Leoncio Prado x San Martín		0.29
Leoncio Prado x Lamas		0.74
Leoncio Prado x Bellavista		0.13

(19.8%) (Riley *et al*., 1988) and *H. frenatus* Duméril & Bibron, 1836 from Indonesia (25-33%) (Matsuo & Oku, 2002). In Brazil, studies have shown an unequal prevalence in native lizard species *Brasiliscincus agilis* (Raddi, 1823) (3.6-9.0%) (Vrcibradic *et al*., 2002); *Cnemidophorus abaetensis* Reis Dias, Rocha & Vrcibradic, 2002 (6.0%) (Dias *et al*., 2005) and *C. ocellifer* Dirksen & De la Riva, 1999 (2.5%) (Dias *et al*., 2005), and *Tropidurus hispidus* (Spix, 1825) (11.1%) (Almeida *et al*., 2008).

Anjos *et al*. (2008) determined the mean infection intensity (MI) for *R. hebitihamata* (MI = 1.8) in *H. mabouia.* Barton (2007) also shows values of the MI of R. *hebitihamata* in *H. frenatus* from different localities and their values range from 3 to 8.3. In our study, a MI of 6.17 is observed. *Raillietiella hebitihamata* is not a specific parasite of its host; this is shown in a report shown by Barton (2007) which summarizes a list of 6 species of Geckonidae lizards, one species of Agamidae, and one species of Scincidae as hosts of this parasite.

Species of the genus *Paradistomum* have been reported parasitizing the bile ducts and the intestine of reptiles in Europe, South East Asia, Madagascar, Australia, and Brazil. In America, only three species of *Paradistomum* are known: *P. boae* (McCallum, 1921) Travassos, 1924, *P. parvissimum* Travassos, 1918, and *P. rabusculum* Kossack, 1910, all three are found in South America and only *P. parvissimum* is recorded parasitizing *H. mabouia* (Ávila & Silva, 2010). Our specimens of *Paradistomum* sp1 and *Paradistomum* sp2. differ from *P. parvissimum* by the position of the vitelline glands, being those of the latter posterior to the testicles and in our previous one, as well as the proportion of the suckers, being the oral wider than the ventral one in *P. parvissimum* and vice versa in the specimens collected in our study.

Seven species of *Oochoristica* have been recorded in South America: *O. ameivae* (Beddard, 1914), O. *bresslaui* Fuhrmann, 1927, *O. freitasi* Rêgo & Ibáñez, 1965, *O. iguanae* Bursey & Goldberg, 1996, *O. insulamargaritae* López -Neyra & Diaz-Ungría, 1957, *O. travassosi* Rêgo & Ibáñez, 1965, and *O. vanzolinii* Rêgo & Oliveira-Rodrigues, 1965, all parasitizing the intestine of reptiles, but only *O. ameivae*, *O. freitasi*, *O. iguanae*, and *O. travassosi* have been registered for Peru (Ávila & Silva, 2010). Goldberg & Bursey (2010) conducted helminth studies on 4 species of *Phyllodactylus* Gray, 1828 in Peru and found *O. travassosi* parasitizing only *P. johnwrighti* Dixon & Huey, 1970 with P = 11% and MI = 1. Bursey *et al.* (2005) found *O. ameivae* parasitizing the lizard *Ameiva ameiva* Linnaeus, 1758 with P = 12% and MI = 1.2 in Peru. Here we report *O. vanzolinii* parasitizing *H. mabouia* with a higher prevalence and infection intensity (P = 21.98%, MI = 2.25), and at the same time it is reported to Peru as a new geographical place for this species of cestode.

The species of *Spauligodon* sp. and *Parapharyngodon* sp. were not identified at the species level, because only females were found in the case of *Parapharyngodon* and few males for *Spauligodon*. The lack of male specimens made the identification work difficult because these nematode species are differentiated by the copulatory structures of the males. These nematode species are common parasites of Peruvian geckos and their prevalences have been recorded by several authors, including *Spauligodon oxkutzcabiensis* Chitwood, 1938 in *Phyllodactylus inaequalis* Cope, 1876 (P = 14%, MI = 2), *P. johnwrighti* (P = 8%, MI = 3.7), *P. microphyllus* Cope, 1876 (P = 45%, MI = 18.6), and *Thecadactylus rapicauda* (Houttuyn, 1782) (P = 20%, MI = 13.5) (Bursey *et al*., 2005; Goldberg & Bursey, 2010). We registered *Spauligodon* sp. in *H. mabouia* with P = 37.3, MI = 7.06. For the case of *Parapharyngodon*, this nematode has also been recorded in the Goldberg & Bursey (2010) studies, as *Parapharyngodon scleratus* (Travassos, 1923) Freitas, 1957 parasitizing *P. johnwrighti* (P=55%, MI = 1.8). Other *Parapharyngodon* species are also reported for Peru as is the case of *P. scleratus* in *Varzea bistriata* (Spix, 1825) (P = 9%, MI = 1), *A. ameiva* (P = 4%, MI = 1), and *Kentropyx pelviceps* (Cope, 1868) (P = 7%, MI = 1) (Bursey *et al*., 2005). In this study, *Parapharyngodon* specimens were recorded parasitizing only *H. mabouia* males with P = 17.58% and MI = 4.25, values higher than those recorded above.

High homogeneity among metazoan parasite communities of *H. mabouia* was observed. The parasites communities generally did not exhibit clear differences in abundance in relation to length, sex, and locality of *H. mabouia*.

It is concluded that the parasitic fauna associated with *H. mabouia* from the Huanuco and San Martin region, Peru was composed of 11 parasitic species of which *R. hebitihamata* and *Parapharyngodon* sp. were positively correlated with the TL of the host, while the MA of *O. vanzolinii* and *Spauligodon* sp. were significantly associated with the TL of the *H. mabouia* gecko. Only the species *Parapharyngodon* sp. showed to have a greater preference of infection in prevalence and abundance in host males. *Oochoristica vanzolinii* and *R. hebitihamata* are new recorded parasites for Peru.

BIBLIOGRAPHICAL REFERENCES

Almeida, WO, Freire, EMX & Lopez, S. 2008. *A new species of pentastomida infecting* Tropidurus hispidus *(Squamata: Tropiduridae) from Caatinga in Northeastern Brazil.* Brazilian Journal of Biology, vol. 68, pp. 199-203.

Anderson, RC (ed). 2000. *Nematode parasites of vertebrates: their development and transmission.* Cabi.

Anderson, MJ. 2001. A new method for nonparametric multivariate analysis of variance. Austral Ecology, vol. 26, vol. 32-46.

Anjos, LA, Almeida, WO, Vasconcellos, A, Freire, EX & Rocha, CD. 2008. *Pentastomids infecting an invader lizard,* Hemidactylus mabouia *(Gekkonidae) in northeastern Brazil.* Brazilian Journal of Biology, vol. 68, pp. 611-615.

Anjos, LA, Rocha, CD, Vrcibradic, D. & Vicente, JJ. 2005. *Helminths of the exotic lizard* Hemidactylus mabouia *from a rock outcrop area in southeastern Brazil.* Journal of Helminthology, vol. 79, pp. 307–313.

APA (American Psychological Association). 2012. *Guidelines for ethical conduct in the care and use of nonhuman animals in research.* American Psychological Association Committee on Animal Research and Ethics in 2010-11. American Psychological Association. Washington USA. 9 pp.

Ávila, RW & Silva, RJ. 2010. *Checklist of helminths from lizards and amphisbaenians (Reptilia, Squamata) of South America.* The Journal of Venomous Animals and Toxins including Tropical Diseases, vol. 16, pp. 543-572.

Ávila, RW & Silva, RJ. 2011. *Helminths of Lizards (Reptilia: Squamata) from Mato Grosso State, Brazil.* Comparative Parasitology, vol. 78, pp. 129–139.

Avila-Pires, TC. 1995. *Lizards of Brazilian Amazonia (Reptilia: Squamata).* Zoologische Verhandelingen, vol. 299, p. 706.

Barton, DP. 2007. *Pentastomid parasites of the Introduced Asian House Gecko,* Hemidactylus frenatus *(Gekkonidae), in Australia*. Comparative Parasitology, vol. 74, pp. 254–259.

Bautista-Hernández, CE, Monks, S, Pulido-Flores, G & Rodríguez-Ibarra, AE. 2015. *Revisión bibliográfica de algunos términos ecológicos usados en parasitología, y su aplicación en estudios de caso.* pp. 1-11. *En*: Estudios en Biodiversidad, Volumen I. Pulido-Flores, G, Monks, S & López-Herrera, M. (eds). (Lincoln, NE: Zea Books, 2015).

Baylis, HA. 1926. *On a New Species of the nematode Genus* Thubunaea. Annals & magazine of natural history, vol. 9, pp. 361–364.

Bego, NM & Von Zuben, CJ (eds). 2010. *Métodos quantitativos em parasitologia.* Jaboticabal. FUNEP.

Bursey, CR, Goldberg, SR & Parmelee RJ. 2001. *Gastrointestinal helminths of 51 species of anurans from Reserva Cuzco Amazónico, Peru.* Comparative Parasitology, vol. 68, pp. 21-35.

Bursey, CR, Goldberg, SR. & Parmelee RJ. 2005. *Gastrointestinal helminths from 13 species of Lizards from Reserva Cuzco Amazónico, Peru.* Comparative Parasitology, vol. 72, pp. 50–68.

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

Costello, M, Beard, KH, Corlett, RT, Cumming, G, Devictor, V, Loyola, R, Maas, B, Miller-Rushing, AJ, Pakeman, R & Primack, RB. 2016. *Field work ethics in biological research.* Biological Conservation, vol. 203, pp. 268-271.

Criscione, CD & Font, WF. 2001. *The guest playing host: colonization of the introduced Mediterranean gecko,* Hemidactylus turcicus, *by helminth parasites in southeastern Louisiana.* The Journal of Parasitology, vol. 87, pp. 1273–1278.

Dias, EJ, Vrcibradic, D & Rocha CD. 2005. *Endoparasites infecting two species of whiptail lizards (*Cnemidophorus abaetensis *and* C. ocellifer*; Teiidae) in a restinga habitat of northeastern Brazil.* The Herpetological Journal, vol. 15, pp. 133-137.

Esch, GW, Shostak, AW, Marcogliese, DJ &

Goater, TM. 1990. *Patterns and process in helminth parasite communities: an overview.* pp. 1-19. *In*: Esch, G, Bush, AC & Aho, J. (eds). *Parasite Communities: Patterns and processes.* Chapman and Hall. New York.

Gibson, DI, Arlene, J. & Bray, RA (eds). 2008. *Keys to the Trematoda Volume 3.* Cabi. The Natural History Museum, London, UK.

GISS (Global Invasive Species Database) 2018: *Species profile:* Hemidactylus mabouia. Downloaded from http://www.iucngisd.org/gisd/species.php?sc=1639 on 21-12-2018.

Goldberg, SR & Bursey, CR. 2000. *New helminth record for one teiid and four gekkonid lizard species from the Lesser Antilles.* Caribbean Journal of Science, vol. 36, pp. 342–344.

Goldberg, SR, Bursey, CR. & Tawil, R. 1995. *Gastrointestinal helminths of three introduced anoles:* Anolis bimaculatus leachi*,* Anolis grahami*, and* Anolis roquet *(Polychrotidae) from Bermuda.* Journal of the Helminthological Society of Washington, vol. 62, pp. 62–64.

Goldberg, SR, Bursey, CR & Morando M. 2004. *Metazoan endoparasites of 12 species of lizards from Argentina.* Comparative Parasitology, vol. 71, pp. 208-214.

Goldberg, SR & Bursey, CR. 2010. *Helminths from four species of* Phyllodactylus *(Squamata: Gekkonidae) from Peru.* Comparative Parasitology, vol. 77, pp. 91–93.

Hanley, KA, Vollmer, DM & Case, TJ. 1995. *The distribution and prevalence of helminths, coccidia and blood parasites in two competing species of gecko: implications for apparent competition.* Oecologia, vol. 102, pp. 220–229.

Iannacone, J & Alvariño, L. 2013. *Parasitological indices of Pacific pomfret* Brama japonica *Hilgendorf, 1878 (Osteichthyes, Bramidae) acquired at fishing terminal of Chorrillos Lima, Peru*. Neotropical Helminthology, vol. 7, pp. 117-132.

Khalil, LF, Jones, A, & Bray, RA, (eds) 1994. *Keys to the cestode parasites of vertebrates*. CAB international.

Krantz, GW. (eds) 1978. *A Manual of Acarology*. Oregon State University Book Stores, Corvallis, Oregon.

Lamothe, RA. (ed). 1997. *Manual de técnicas para preparar y estudiar los parásitos de animales silvestres.* AGT Editor. México.

Martínez-Rivera, CA, González-Negrón, M, Bertrand & Acosta, J. 2003. Hemidactylus mabouia *(Sauria: Gekkonidae), host of* Geckobia hemidactyli *(Actinedida: Pterygosomatidae), throughout the Caribbean and South America.* Caribbean Journal of Science, vol. 3, pp. 321-326.

Matsuo, K & Oku, Y. 2002. *Endoparasites of three species of house geckos in Lampung, Indonesia*. Journal of helminthology, vol. 76, pp. 53-57.

Míguez-Lozano, R, Pardo-Carranza, TV, Blasco-Costa, I & Balbuena, JA. 2012. *Spatial structure of helminth communities in the Golden Grey Mullet,* Liza aurata *(Actinopterygii: Mugilidae), from the Western Mediterranean.* The Journal of Parasitology, vol. 98, pp. 904-912.

Paredes-León, R, Cuervo-Pineda, N & Pérez, MT. 2013. *Pterygosomatid mites from Cuba, with the description of a new species of* Bertrandiella *(Acari: Prostigmata: Pterygosomatidae).* Revista Mexicana de Biodiversidad, vol. 84, pp. 1142-1152.

Powell, R, Hall, PJ, Smith, DD & Riley, J. 1993. *The occurrence of* Raillietiella *sp. (Pentastomida: Cephalobaenida) in* Hemidactylus haitianus *(Lacertilia: Gekkonidae) from Hispaniola.* Dactylus, vol. 2, pp. 51-53.

Quiroz-Gutiérrez, CG, Paredes-León, R, Roldán-Rodríguez, J & Pérez, TM. 2015. *Dos especies nuevas de ácaros de los géneros* Geckobia y Bertrandiella *(Acari: Prostigmata: Pterygosomatidae) ectoparásitos del gecko endémico* Phyllodactylus microphyllus *(Squamata: Phyllodactylidae) del cerro Campana, La Libertad, Perú.* Revista mexicana de biodiversidad, vol. 86, pp. 310-318.

Rego, AA. 1983. *Pentastomídeos de répteis do Brasil: Revisão dos Cephalobaenidae.* Memórias do Instituto Oswaldo Cruz, vol. 78, pp. 399-411.

Riley, J, Mcallister, C & Freed, PS. 1988. Raillietiella teagueselfi *n sp (Pentastomida: Cephalobaenida) from the mediterranean gecko,* Hemidactylus turcicus *(Sauria: Gekkonidae), in Texas.* The Journal of parasitology, vol. 74, pp. 481-486.

Rodhe, K, Hayward, C & Heap, M. 1995. *Aspects of the ecology of metazoan ectoparasites of marine fishes*. International Journal for Parasitology, vol. 25, pp. 945-970.

Rózsa, L, Reiczigel, J & Majoros, G. 2000. *Quantifying parasites in samples of hosts.* The Journal of Parasitology, vol. 86, pp. 228-232.

Simonsen, PE & Sarda, RK. 1985. *Helminth and arthropod parasites of* Hemidactylus mabouia *from Tanzania*. Journal of Herpetology, vol. 19, pp. 428-430.

Sousa, JG, Brito, SV, Ávila, RW, Teles, DA, Araujo-Filho, JA, Teixeira, AM, Anjos, LA & Almeida, WO. 2014. *Helminths and Pentastomida of two synanthropic gecko lizards,* Hemidactylus mabouia *and* Phyllopezus pollicaris*, in an urban area in Northeastern Brazil.* Brazilian Journal of Biology, vol. 74, pp. 943-948.

Travassos, LP. 1920. *Contribuições para o conhecimento da fauna helmintológica brasileira. IX. Sobre as espécies do gênero* Spinicauda. Memórias do Instituto Oswaldo Cruz, vol. 12, pp. 41-50.

Travassos, LP. 1931. *Pesquizas helminthologicas realizadas em Hamburgo. IX. Ensaio monographico da familia Cosmocercidae Travassos, 1925 (Nematoda).* Memórias do Instituto Oswaldo Cruz, vol. 25, pp. 237-98.

Vanzolini, PE. 1978. *On South American* Hemidactylus *(Sauria, Gekkonidae).* Papeis Avulsos de Zoologia, Sao Paulo, vol. 31, pp. 307–343.

Vrcibradic, D, Rocha, CF, Bursey, CD. & Vicente, JJ. 2002. *Helminth communities of two sympatric skinks* (Mabuya agilis *and* Mabuya macrorhyncha) *from two 'restinga' habitats in southeastern Brazil*. Journal of Helminthology, vol. 76, pp. 355-361.

Zar, JH (ed). 2014. *Biostatistical Analysis* 5th ed. London: Pearson New International Edition.

Received December 1, 2018.
Accepted December 31, 2018.