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, Schikhabalova & Lagodovskaja, 1960, Parapharyngodon sp. Chatterji, 1933, Physaloptera sp. Rudolphi, 1819, Acuariidae gen. sp. Railliet, Henry & Sissoff, 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, Schikholabova & Lagodovskaja, 1960, *Parapharyngodon* sp. Chatterji, 1933, *Physaloptera* sp. Rudolphi, 1819, Acariformes 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 especie 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 hospedero, 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 parasitic 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
A total of 91 gecko specimens were collected from April to June 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.

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**
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 X² (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 (X²) 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*<sub>Levene</sub> = 0.031, *p* = 0.86, *t* = 4.02, *n* = 91).

The component community was composed of 11 parasite species: the nematodes *Oswaldocruzia aff. brasiilienis* Lent & Freitas, 1935 (Diaphanocephalidae), *Spauligodon* sp. Skrjabin, Schikhobalova & Lagodovsk, 1960 (Pharyngodonidae), *Parapharyngodon* sp. Chatterji, 1933 (Pharyngodonidae), *Physaloptera* sp. Rudolphi, 1819 (Physalopteraeidae), a larval nematode of the family Acuaridae 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 *Railletiella hebitihamata* S elf & K untz, 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.
PERMANOVA analysis confirmed the low heterogeneity among metazoan parasites communities of *H. mabouia* (Table 5).

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

**Figure 1.** Box plot diagram for the total length (in cm) of the total of Geckos, males, and females of *Hemiactylus 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 *Hemiactylus mabouia* parasites of San Martin and Huánuco, Peru. GH=*Geckobia hemidactyli*, RF=*Raillietiella hebithamata*, 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 hebithamata, 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 - 14.0 cm, 5, >14 cm) 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 = ●.
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. hebithamata* 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* Méggin, 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 (%) | AM  | IM  |
|-----------------------------------|--------------|----------------|----|-----|-------|-----|-----|
| **ACARI**                         |              |                |    |     |       |     |     |
| *Geckobia hemidactyli* Lawrence, 1936 | Skin         | Adults, nymphs, larvae | 41 | 379 | 45.05 | 4.16 | 9.24 |
| **PENTASTOMIDA**                  |              |                |    |     |       |     |     |
| *Raillietiella hebithamata* 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 |

Metazoans of the Afro-American house gecko
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       |
| with two species | 35    | 38.46   | 26     | 9       |
| with three species | 15    | 16.48   | 13     | 2       |
| Polyspecific or multiple | | | | |
| with four species | 6     | 6.59    | 6      | 0       |
| with five species | 1     | 1.09    | 1      | 0       |
| Not parasited    | zero species | 9 | 9.89 | 6 |

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. Martinez-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.
Anjos et al. (2008) determined the mean infection intensity (MI) for *R. hebitihamata* in *H. mabouia*. Barton (2007) also shows values of the MI of *R. hebitihamata* in *H. frenatus* from different locations. 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).

| Parasite                  | P vs TL Spearman r/p | MA vs TL Pearson r/p | MI vs TL Pearson r/p | P vs sex X²/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 vanzolii*   | 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            | 0.10/0.87            | 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 Martin | 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 locations.
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. rhabduschnom 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 Régio & Ibáñez, 1965, O. iguanae Bursey & Goldberg, 1996, O. insulamargarithae López -Neyra & Díaz-Ungria, 1957, O. travassosi Régio & Ibáñez, 1965, and O. vanzolinii Régio & Oliveira-Rodrigues, 1965, all parasitizing the intestine of reptiles, but only O. ameivae, O. freitasi, O. iguanae, and O. travassosi have been recorded for Peru (Ávila & Silva, 2010). Goldberg & Bursey (2010) conducted helminth studies on 4 species of Phyllophactylus gray, 1828 in Peru and found O. travassosi parasitizing only P. johnwighti 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 oxutzcabiensis Chitwood, 1938 in Phyllophactylus inaequalis Cope, 1876 (P = 14%, MI = 2), P. johnwighti (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. johnwighti (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.
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