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Helminths infecting the parthenogenetic whiptail lizard *Cnemidophorus nativo* in a restinga habitat of Bahia State, Brazil

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Abstract

A sample of 101 specimens of the unisexual whiptail lizard *Cnemidophorus nativo* (Squamata; Teiidae) from a coastal site in Bahia State, Brazil were examined for the presence of endoparasites. Of these, 35 (34.7%) harboured helminths. Six helminth species were recovered from *C. nativo*, including five nematodes (*Physaloptera retusa*, *Physalopteroides venancioi*, *Subulura lacertilia*, *Skrjabinelazia intermedia* and *Parapharyngodon* sp., and one cestode (*Oochoristica ameivae*), all representing new host records. Most lizards were infected by a single species of helminth and none by more than three. Infection rates were neither significantly influenced by host body size nor by environmental factors. The results are compared with data from studies on other whiptail species in both South and North America.

Introduction

Host–parasite relationships represent an important factor in the study of population dynamics and community structure (Gregory & Keymer, 1989; Esch *et al.*, 1990; Clayton & Moore, 1997). Different abiotic and biotic factors, such as seasonal climatic variations, feeding and foraging habits of the host, host body size, and parasite life cycles can influence the prevalence and intensity of infection of parasites (Telford, 1970; Esch *et al.*, 1990; Rocha, 1995).

In Brazil, ecological studies with helminth parasites of lizards are still relatively scarce. Most available studies deal with the helminth fauna of lizards inhabiting the 'restingas' (coastal sand-dune habitats) of eastern Brazil (Ribas *et al.*, 1995, 1998a,b; Rocha, 1995; Van Sluys *et al.*, 1997; Vrcibradic *et al.*, 2000a, 2002a,b) and are restricted to bisexual species, with no data on intestinal helminths of unisexual lizards.

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Whiptail lizards (Teiidae: *Cnemidophorus*) are remarkable among the Lacertilia in containing numerous unisexual species (Wright, 1993). This genus is widely distributed in South America, with 11 described species occurring in Brazil and a number of others awaiting formal description (Dias *et al.*, 2002; Colli *et al.*, 2003a,b). However, information on helminths occurring in species of this genus in Brazil is restricted to *C. lemniscatus* (L. 1758) (sic) from a 'caatinga' (semi-arid savanna-like habitat) locality in the northeast (Pereira, 1935) [the species reported in that study must actually be *C. ocellifer* (Spix, 1825), which is widespread in the caatingas (Vanzolini *et al.*, 1980), since members of the *lemniscatus* complex are restricted to the Amazonian region (Ávila-Pires, 1995)], and to *C. littoralis* Rocha, Araújo, Vrcibradic and Costa, 2000 from restingas of Rio de Janeiro State [Ribas *et al.*, 1995 (referred as *C. ocellifer*); Vrcibradic *et al.*, 2000a].

Cnemidophorus nativo Rocha, Bergallo & Peccinini-Seale, 1997 is a unisexual whiptail lizard apparently endemic to restinga habitats of eastern Brazil, with a known distribution between 13° and 20° S, along the coastal plains of the states of Espírito Santo and Bahia (Rocha

et al., 1997, 1999; Vrcibradic *et al.*, 2002c). In the presesnt study, we survey the helminth community associated with a population of *C. nativo* at a restinga habitat in Bahia State, Brazil.

Materials and methods

The study was carried out in the restinga habitat of Guaratiba (17°25′S, 39°12′W), located in the Alcobaça district, Prado Municipality, in southern Bahia State, northeastern Brazil. The area has a tropical wet and warm climate with marked seasonality in rainfall. Mean annual rainfall is 1383 mm and mean annual temperature usually varies from 22°C to 26°C (Dutra, 2000). The restinga of Guaratiba presently encompasses an area of approximately 20 ha of native vegetation remnants and most of the surrounding areas have been subjected to considerable anthropic disturbance in recent years.

A total of 101 lizards was collected monthly from March 1997 to February 1998 (except in May and July 1997, on which no collections were done), and each lizard collected was immediately anaesthetized with ether. In the laboratory, the snout–vent length (SVL) of the lizards was measured using a Vernier caliper (to the nearest 0.1 mm) and their body mass (to the nearest 0.1 g) determined using a Pesola spring balance, prior to fixation in 10% formalin. Lizards were later dissected and their digestive tract was removed, slit open and checked for the presence of helminths under a stereomicroscope. Nematodes were cleared in phenol and mounted on temporary slides for identification under a microscope. Cestodes were stained in haematoxylin, dehydrated in a graded series of ethanol, cleared in xylene, and mounted in balsam for identification. Helminths that could not be identified to genus (due to their damaged state) were included only in the calculations of monthly overall mean intensity and prevalence, and are cited in the table as indeterminate. Voucher helminth specimens were deposited at the Coleção Helmintológica do Instituto Oswaldo Cruz (CHIOC 34888-91) and at the US National Parasite Collection (USNPC 91936-8).

The effect of host body size (SVL) on the overall infection intensity (log-transformed) was tested by simple regression analysis (Zar, 1999). The effect of environmental conditions on infection rates was also tested using simple regression analysis, with monthly mean intensity of infection (log-transformed) and monthly prevalence (arcsine-transformed) each being each regressed against monthly rainfall (in mm). Seasonal differences in helminth prevalence and intensity of infection (log transformed) were tested using, respectively, the Z-test for proportions and one-way analysis of variance (ANOVA) (Zar, 1999). Seasonal differences in prevalence and infection intensity were tested only for the two most frequent helminth species, since the other species were represented by relatively small sample sizes. During the period of study, most of the rainfall (630.6 mm) occurred from December to April, with the period from May to November being comparatively drier (total rainfall 347.1 mm); thus, those periods were considered as wet and dry seasons, respectively, for purposes of inter-seasonal comparisons.

Basic statistics given in the text represent arithmetic means plus one standard deviation. Ecological terms referred in the text follow Bush *et al.* (1997).

Results

A total of 111 helminths of six species were associated with *C. nativo*, including five nematodes: *Physaloptera retusa* Rudolphi, 1819 ($n = 42$) and *Physalopteroides venancioi* (Lent, Freitas & Proença, 1946) ($n = 43$) (Physalopteroidea: Physalopteridae), *Subulura lacertilia* Vicente *et al.*, 2000 (Subuluroidea: Subuluridae) ($n = 6$), *Skrjabinelazia intermedia* (Freitas, 1941) (Seuratoidea: Seuratidae) ($n = 1$) and *Parapharyngodon* sp. (Oxyuroidea: Pharyngodonidae) ($n = 1$), and one cestode: *Oochoristica ameivae* (Beddard, 1914) (Cyclophyllidea: Linstowiidae) ($n = 8$) (table 1).

Of the 101 lizards examined, 35 were infected with at least one helminth (overall prevalence of 34.7%). The majority of infected lizards (68.6%) harboured only one helminth species, whereas 31.4% harboured two or more species. The highest number of helminth species harboured by an individual host was three, and the highest total number of individual helminths found in a single host was 13. *Physaloptera retusa* had the highest prevalence (22.8%; table 1), and was also the only species found throughout the study. *Oochoristica ameivae* and *Physalopteroides venancioi* had the highest mean intensities of infection (4.0 and 3.6, respectively; table 1). The two physalopterids frequently occurred together in the same site of infection. No lizard showed any external evidence of infection.

Table 1. Prevalence, mean infection intensity and site of infection for each helminth species in the digestive tract of 101 *Cnemidophorus nativo* from the restinga of Guaratiba, Bahia, Brazil.

Parasite	Prevalence (%)	Mean intensity ± SD	Infection site*
Nematoda			
Parapharyngodon sp.	1.0	1.0	c
Physaloptera retusa	22.8	1.8 ± 1.3	a, b, c
Physalopteroides venancioi	11.9	3.6 ± 3.5	a, b
Skjrabinelazia intermedia	1.0	1.0	b
Subulura lacertilia	4.0	1.5 ± 0.6	b
Cestoda			
Oochoristica ameivae	2.0	4.0 ± 4.2	a, b

* a, stomach; b, small intestine; c, large intestine.

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Lizard SVL ($\bar{x} = 47.7 \pm 9.5$ mm, range 30.9–67.4 mm) did not affect overall infection intensity rates ($F_{1,33} = 0.33$, $P = 0.57$). Likewise, rainfall did not have a significant effect on monthly prevalence and mean intensity of infection by *Physaloptera retusa* ($F_{1,8} = 0.10$, $P = 0.76$; $F_{1,8} = 0.04$, $P = 0.84$, respectively) and *Physalopteroides venancioi* ($F_{1,8} = 0.38$, $P = 0.55$; $F_{1,8} = 0.27$, $P = 0.63$, respectively). Moreover, there were no significant correlations between monthly overall prevalence and rainfall ($F_{1,8} = 0.0$, $P = 0.73$), and between overall mean infection intensity and rainfall ($F_{1,8} = 0.13$, $P = 0.99$). The prevalence (Z-test; $Z = 0.12$, $P = 0.45$) and mean intensity (ANNOVA; $F_{9,13} = 0.48$, $P = 0.86$) of *Physaloptera retusa* did not differ between wet and dry seasons. There was also no significant seasonal variation in overall helminth prevalence (Z-test; $Z = -0.60$, $P = 0.27$) and overall infection intensity (ANNOVA; $F_{9,25} = 0.73$, $P = 0.68$)

Discussion

All helminth species found associated with *C. nativo* in this study represent new host records. Moreover, the occurrence of *Physalopteroides venancioi*, *Subulura lacertilia* and *Skrjabinelazia intermedia* represents the first record for lizards of the genus *Cnemidophorus*. *Physalopteroides venancioi* has been previously found infecting the lizards *Ameiva ameiva* (Vrcibradic *et al.*, 2000b), *Tropidurus torquatus* (Vrcibradic *et al.*, 2000a), *Mabuya macrorhyncha* and *M. agilis* (Vrcibradic *et al.*, 2000a, 2002b) and the toad *Bufo paracnemis* (Lent *et al.*, 1946). *Subulura lacertilia*, a recently discovered and described species, was previously known only from the iguanian *Eurolophosaurus nanuzae* (formerly in the genus *Tropidurus*; see Frost *et al.*, 2001) from a montane region in central Minas Gerais State, Brazil (Vicente, *et al.*, 2000); the present record thus represents the second host reported for *S. lacertilia*, as well as an extension of its distribution to coastal Brazil. *Skjrabinelazia intermedia* was previously known only from lizards of the genus *Tropidurus* (Vicente *et al.*, 1993; Vrcibradic *et al.*, 2000a).

The physalopterid *Physaloptera retusa* has been reported for other species of *Cnemidophorus* both in the Neotropical and Neartic realms (Caballero & Vogelsang, 1947; Specian & Whittaker, 1980; Goldberg & Bursey, 1989; Ribas *et al.*, 1995; Vrcibradic *et al.*, 2000a). This nematode species thus appears to be a particularly common and widespread parasite in lizards of that genus.

Four of the six helminth species found in *C. nativo* had prevalences of less than 5%, with only two species (both the physalopterid nematodes) having prevalences high enough (i.e. $\geq 10\%$) to be considered as component species (see Bush *et al.*, 1990). Besides, no helminth species attained core status (i.e. prevalence $>50\%$). Also, most infected lizards harboured a single helminth species and none harboured more than three, which suggests a low richness and diversity of *C. nativo* infracommunities. This is in agreement with other studies where helminth communities of terrestrial reptiles tend to be generally depauperate compared to those of other vertebrates (e.g. Aho, 1990; Bush *et al.*, 1990).

The present study represents the second survey of endoparasites for *C. nativo*. In an earlier study by Van Sluys *et al.* (1997), no nematodes were found in a sample of 15 specimens from a restinga habitat in Linhares, Espírito Santo State. This may perhaps be explained by differences in the pool of parasite species between the two localities, with species such as *Physaloptera retusa* and *Physalopteroides venancioi* being perhaps absent or rare in the Linhares restinga. Rocha (2000) believes that the Doce river, on whose margin the Linhares restinga lies, may represent the southern limit of distribution for *C. nativo*, with the Linhares population of *C. nativo* being thus located at the periphery of the species distribution. Moreover, the Linhares restinga represents a 'habitat island', being surrounded by wet rainforest and isolated from other restinga patches (Van Sluys *et al.*, 1997). These observations concur with those of Aho (1990), who states that low values of local helminth richness may reflect the degree of isolation or peripherical location of a given host population.

The low infection rates of *C. nativo* contrast with the high values exhibited by the closely related bisexual congener *C. littoralis* in southeastern Brazil. The overall prevalence of helminths in the Guaratiba population of *C. nativo* (c. 35%) was appreciably lower than those recorded for two *C. littoralis* populations at the restingas of Barra de Maricá (86%; Ribas *et al.*, 1995) and Jurubatiba (77%; Vrcibradic *et al.*, 2000a) in Rio de Janeiro State, even though these two studies dealt only with nematode infections. Since the two species are closely related and have similar ecological traits (Rocha *et al.*, 2000), the low infection intensities of *C. nativo* may reflect differences in the density of intermediate hosts for physalopterids between localities (*Physalopetera retusa* completely dominated the nematode faunas of the aforementioned *C. littoralis* populations).

The fact that *C. nativo* is an all-female species could also be associated with its relatively low infection rates. Ribas *et al.* (1995) reported female *C. littoralis* to have a significantly lower prevalence of infection by *P. retusa* than males, which suggest the latter may be more susceptible, although Vrcibradic *et al.* (2000a) found no intersexual differences in another population of the same species. Nevertheless, the prevalence of infection found by Ribas *et al.* (1995) for female *C. littoralis* was still much higher (*c.* 70%) than that observed for the unisexual *C. nativo* in the present study. Studies with eight unisexual species of North American whiptails reported overall prevalences ranging from 8% to 50% (mean = 30%) and from zero to three (mean = 1.3) component species per host species (McAllister *et al.*, 1991a; Goldberg & Bursey, 1990; McAllister, 1990a,b,c, 1992), whereas studies with six bisexual species of North American whiptails reported overall prevalences ranging from 12% to 49% (mean = 33%) and from zero to three (mean = 1.7) component species per host species (Telford, 1970; Dyer, 1971; Lyon, 1986; Goldberg & Bursey, 1989, 1990, 2003; McAllister, 1990d; McAllister *et al.*, 1991b). Thus, there is little difference in the infection parameters of unisexual and bisexual species of whiptails and our studied population of *C. nativo* appears to be typical of whiptails as a whole with reference to its overall infection prevalence (35%) and number of component helminth species (two). However, in most of the studies of North American taxa the lizard samples consisted of lizards

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from two or more localities. This obscures possible interpopulational variations in the aforementioned parameters within host species, making comparisons of their data with those of the present study (which deals with a single host population) less meaningful.

The size of lizards did not affect overall helminth infection intensities, which may be due to the low infection rates observed, indicating that infracommunities are probably not saturated with worms. Thus, an increase in host body size would not necessarily imply an increase in overall helminth density.

Seasonality in prevalence and intensity of infection of lizards with nematodes may be influenced by changes in the physical environment, which may affect transmission and survival rates both directly and indirectly (e.g. Alho, 1970; Telford, 1970; Rocha, 1995; Ribas *et al.*, 1998a; Goldberg *et al.*, 2002). However, as in other studies with Brazilian lizards (Van Sluys *et al.*, 1994; Ribas *et al.*, 1995, 1998b; Vrcibradic *et al.*, 1999), monthly prevalences and mean helminth intensities in *C. nativo* were not significantly related to rainfall, despite a marked seasonality. This suggests that humidity in the area does not influence helminth infection rates in a significant way, but it could also be a consequence of the low local abundance of helminths capable of infecting *C. nativo*. In addition, although the availability of soil arthropods in restingas may vary between seasons (Rocha, 1996), the lack of seasonal differences in infection parameters observed here could be explained by the wide-foraging habit of *C. nativo*. This strategy, which is often combined with a preference for colonial insects (Huey & Pianka, 1981), may compensate for decreases in food abundance during the less productive season, leaving the lizards less susceptible to seasonal fluctuations in the availability of arthropodan prey (e.g. Teixeira-Filho *et al.*, 2003). The presence of intermediate hosts for physalopterids in the diet of *C. nativo* throughout the year at the study area could be another factor influencing the lack of seasonal variation in infection rates.

Aho (1990) commented that helminth communities of reptiles and amphibians are frequently dominated by parasites with monoxenic or direct life-cycles, in which host infection occurs via direct ingestion of eggs/larvae. Of the helminths infecting *C. nativo*, only the pharyngodonid and seuratid species have direct life cycles, although the seuratid *Skrjabinelazia* is thought to be monoxenic only early in its adult life, becoming heteroxenic later on (Chabaud *et al.*, 1988). Incidentally, these two nematodes showed the lowest prevalences (1%), probably representing accidental occurrences. Thus, in spite of the wide-foraging habits of *C. nativo*, which would presumably expose the lizards to eggs of monoxenic parasites (mainly through its tongue-flicking and soil-rooting behaviour), its helminth fauna is dominated by heteroxenic forms, which require ingestion of intermediate hosts. This suggests that diet composition may be the most important factor influencing the helminth community richness and diversity found in this lizard.

Considering the relatively low prevalence and intensity of helminth infections, *C. nativo* is unlikely to be the specific host for any helminth species in the study area. This fact, as well as the scarcity of helminths in a *C. nativo* population from Linhares (Van Sluys *et al.*, 1997), suggest that this lizard species may be relatively resistant to parasitic worm infections. However, to better understand the host–parasite relationships in *C. nativo* further studies are necessary, not only on other conspecific populations but also on populations of other Brazilian species of *Cnemidophorus*.

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References

Aho, J.M. (1990) Helminth communities of amphibians and reptiles: comparative approaches to understanding patterns and processes. pp. 157–195 *in* Esch, G.W., Bush, A.O. & Aho, J.M. (*Eds*) *Parasite communities: patterns and processes*. New York, Chapman & Hall.

Alho, C.J.R. (1970) Frequency of infestation by *Strongyluris freitasi* Alho, 1969 in *Tropidurus torquatus* (Wied). *Revista Brasileira de Biologia* **30**, 539–542.

Ávila-Pires, T.C. (1995) Lizards of Brazilian Amazonia (Reptilia: Squamata). *Zoologische Verhandelingen* **299**, 1–706.

Bush, A.O., Aho, J.M. & Kennedy, C.R. (1990) Ecological versus phylogenetic determinants of helminth parasite community richness. *Evolutionary Ecology* **4**, 1–20.

Bush, A.O., Lafferty, K.D., Lotz, J.M. & Shostak, A.W. (1997) Parasitology meets ecology in its own terms: Margolis *et al*. revisited. *Journal of Parasitology* **83**, 575–583.

Caballero, E. & Vogelsang, E.G. (1947) Fauna helmintologica venezolana. I. *Ochetosoma miladerocai* n. sp. de *Bothrops atrox* L. y hallazgo de *Physaloptera retusa* Rud., 1819, en *Cnemidophorus lemniscatus lemniscatus*. *Revista de Medicina Veterinaria y Parasitologia* **6**, 53–62.

Chabaud, A.G., Bain, O. & Poinar, G.O. Jr (1988) *Skrjabinelazia galliardi* (Nematoda, Seuratoidea); complements morphologiques et cycle biologique. *Annales de Parasitologie Humaine et Comparée* **63**, 278–284.

Clayton, D.H. & Moore, J. (1997) *Host-parasite evolution: general principles and avian models*. 400 pp. Oxford, Oxford University Press.

Colli, G.R., Caldwell, J.P., Costa, G.C., Gainsbury, A.M., Garda, A.A., Mesquita, D.O., Filho, C.M.M., Soares, A.H.B., Silva, V.N., Valdujo, P.H., Vieira, G.H.C., Vitt, L.J., Werneck, F.P., Wiederhecker, H.C. & Zatz, M.G. (2003a) A new species of *Cnemidophorus* (Squamata, Teiidae) from the Cerrado biome in central Brazil.

Occasional Papers of the Oklahoma Museum of Natural History **14**, 1–14.

Colli, G.R., Costa, G.C., Garda, A.A., Kopp, K.A., Mesquita, D.O., Peres, A.K., Valdujo, P.H., Vieira, G.H.C. & Wiederhecker, H.C. (2003b) A critically endangered new species of *Cnemidophorus* (Squamata, Teiidae) from a Cerrado enclave in southwestern Amazonia, Brazil. *Herpetologica* **59**, 76–88.

Dias, E.J.R., Rocha, C.F.D. & Vrcibradic, D. (2002) New *Cnemidophorus* (Squamata: Teiidae) from Bahia State, Northern Brazil. *Copeia* **2002**, 1070–1077.

Dutra, G.F. (2000) *Tamanho corporal e dieta de Tropidurus torquatus (Sauria: Tropiduridae) em três ilhas do Arquipélago dos Abrólhos e em três restingas no extremo sul da Bahia*. Unpublished MSc dissertation, Universidade Estadual de Campinas, 80pp.

Dyer, W.G. (1971) Some helminths of the six-lined lizard, *Cnemidophorus sexlineatus* in South Dakota. *Proceedings of the Helminthological Society of Washington* **38**, 256.

Esch, G.W., Bush, A.O. & Aho, J.M. (1990) *Parasite communities: patterns and processes*. 304 pp. New York, Chapman & Hall.

Frost, D.R., Rodrigues, M.T., Grant, T. & Titus, T.A. (2001) Phylogenetics of the lizard genus *Tropidurus* (Squamata: Tropiduridae: Tropidurinae): direct optimization, descriptive efficiency, and sensitivity analysis of congruence between molecular data and morphology. *Molecular Phylogenetics and Evolution* **21**, 352–371.

Golberg, S.R. & Bursey, C.R. (1989) Helminths of the giant spotted whiptail, *Cnemidophorus burti stictogrammus* (Sauria: Teiidae). *Proceedings of the Helminthological Society of Washington* **56**, 86–87.

Golberg, S.R. & Bursey, C.R. (1990) Helminths of the Arizona little striped whiptail, *Cnemidophorus inornatus arizonae*, and the desert grassland whiptail, *Cnemidophorus uniparens* (Sauria: Teiidae), from southeastern Arizona. *Journal of the Helminthological Society of Washington* **57**, 83–86.

Golberg, S.R. & Bursey, C.R. (2003) Natural history notes. *Cnemidophorus hyperythrus* (orange-throated whiptail). *Endoparasites. Herpetological Review* **34**, 142.

Golberg, S.R., Bursey, C.R. & Kraus, F. (2002) Seasonal variation in the helminth community of the brown anole, *Anolis sagrei* (Sauria: Polychrotidae), from Oahu, Hawaii. *American Midland Naturalist* **148**, 409–415.

Gregory, R.D. & Keymer, A.E. (1989) The ecology of host-parasite interactions. *Science Progress* **73**, 67–80.

Huey, R.B. & Pianka, E.R. (1981) Ecological consequences of foraging mode. *Ecology* **62**, 991–999.

Lent, H., Freitas, J.F.T. & Proença, M.C. (1946) Alguns helmintos de batraquios colecionados no Paraguai. *Memórias do Instituto Oswaldo Cruz* **44**, 195–214.

Lyon, R.E. (1986) Helminth parasites of six lizard species from southern Idaho. *Proceedings of the Helminthological Society of Washington* **53**, 291–293.

McAllister, C.T. (1990a) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 1. The Colorado checkered whiptail (*Cnemidophorus tesselatus*). *Journal of Wildlife Diseases* **26**, 139–142.

McAllister, C.T. (1990b) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 2. The New Mexico whiptail (*Cnemidophorus neomexicanus*). *Journal of Wildlife Diseases* **26**, 403–406.

McAllister, C.T. (1990c) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 3. The Chihuahuan spotted whiptail (*Cnemidophorus exsanguis*). *Journal of Wildlife Diseases* **26**, 544–546.

McAllister, C.T. (1990d) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 4. The Texas spotted whiptail (*Cnemidophorus gularis*). *Texas Journal of Science* **42**, 381–388.

McAllister, C.T. (1992) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 8. The Gila spotted whiptail (*Cnemidophorus flagellicaudus*), Sonoran spotted whiptail (*Cnemidophorus sonorae*), and Plateau striped whiptail (*Cnemidophorus velox*). *Texas Journal of Science* **44**, 233–239.

McAllister, C.T., Cordes, J.E. & Walker, J.M. (1991a) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 6. The gray checkered whiptail (*Cnemidophorus dixoni*). *Texas Journal of Science* **43**, 309–314.

McAllister, C.T., Trauth, S.E. & Conn, D.B. (1991b) Helminth parasites of unisexual and bisexual whiptail lizards (Teiidae) in North America. 7. The 6-lined racerunner (*Cnemidophorus sexlineatus*). *Texas Journal of Science* **43**, 391–397.

Pereira, C. (1935) Os Oxyurata parasitos de Lacertilia do nordeste brasileiro. *Archivos do Instituto Biológico, São Paulo* **6**, 5–27.

Ribas, S.C., Rocha, C.F.D., Teixeira-Filho, P.F. & Vicente, J.J. (1995) Helminths (Nematoda) of the lizard *Cnemidophorus ocellifer* (Sauria: Teiidae): assessing the effect of rainfall, body size and sex in the nematode infection rates. *Ciência e Cultura* **47**, 88–91.

Ribas, S.C., Rocha, C.F.D., Teixeira-Filho, P.F. & Vicente, J.J. (1998a) Nematode infection in two sympatric lizards (*Tropidurus torquatus* and *Ameiva ameiva*) with different foraging tactics. *Amphibia-Reptilia* **19**, 323–330.

Ribas, S.C., Teixeira-Filho, P.F., Rocha, C.F.D. & Vicente, J.J. (1998b) Parasitismo por nematóideos em duas espécies simpátricas de *Mabuya* (Lacertilia: Scincidae) na restinga da Barra de Maricá, RJ. *Anais do VIII Seminário Regional de Ecologia, São Carlos*, 883–894.

Rocha, C.F.D. (1995) Nematode parasites of the Brazilian sand lizard, *Liolaemus lutzae*. *Amphibia-Reptilia* **16**, 412–415.

Rocha, C.F.D. (1996) Seasonal shift in lizard diet: the seasonality in food resources affecting the diet of *Liolaemus lutzae* (Tropiduridae). *Ciência e Cultura* **48**, 264–269.

Rocha, C.F.D. (2000) Biogeografia de répteis de restinga: distribuição, ocorrências e endemismos. pp. 99–116 *in* Esteves, F.A. & Lacerda, L.D. (*Eds*) *Ecologia de restingas e lagoas costeiras*. Macaé, NUPEM/UFRJ.

Rocha, C.F.D., Bergallo, H.G. & Peccinini-Seale, D. (1997) Evidence of an unisexual population of the Brazilian whiptail lizard genus *Cnemidophorus* (Teiidae), with description of a new species. *Herpetologica* **53**, 374–382.

Rocha, C.F.D., Menezes, V.A. & Dutra, G.F. (1999)

Geographical distribution *Cnemidophorus nativo*. *Herpetological Review* **30**, 109.

Rocha, C.F.D., Vrcibradic, D. & Araújo, A.F.B. (2000) Ecofisiologia de répteis de restingas brasileiras. pp. 117–149 *in* Esteves, F.A. & Lacerda, L.D. (*Eds*) *Ecologia de restingas e lagoas costeiras*. Macaé, NUPEM/UFRJ.

Specian, R.D. & Whittaker, F.H. (1980) A survey of the helminth fauna of *Cnemidophorus murinus* from the island of Curaçao. *Proceedings of the Helminthological Society of Washington* **47**, 275–276.

Teixeira-Filho, P.F., Rocha, C.F.D. & Ribas, S.C. (2003) Relative feeding specialization may depress ontogenetic, seasonal and sexual variations in diet: the endemic lizard *Cnemidophorus littoralis* (Teiidae). *Brazilian Journal of Biology* **63**, 321–328.

Telford, S.R. Jr, (1970) A comparative study of endoparasitism among some southern California lizard populations. *American Midland Naturalist* **83**, 516–554.

Van Sluys, M., Rocha, C.F.D. & Ribas, S.C. (1994) Nematodes infecting the lizard *Tropidurus itambere* in southeastern Brazil. *Amphibia-Reptilia* **15**, 405–408.

Van Sluys, M., Rocha, C.F.D., Bergallo, H.G., Vrcibradic, D. & Ribas, S.C. (1997) Nematode infection in three sympatric lizards in an isolated fragment of restinga habitat in southeastern Brazil. *Amphibia-Reptilia* **18**, 442–446.

Vanzolini, P.E., Ramos-Costa, A.M.M. & Vitt, L.J. (1980) *Repteis das caatingas*. 161 pp. Rio de Janeiro, Academia Brasileira de Ciências.

Vicente, J.J., Rodrigues, H.O., Gomes, D.C. & Pinto, R.M. (1993) Nematóides do Brasil. Parte III: Nematóides de Répteis. *Revista Brasileira de Zoologia* **10**, 19–168.

Vicente, J.J., Van Sluys, M., Fontes, A.F. & Kiefer, M.C. (2000) *Subulura lacertilia* sp.n. (Nematoda, Subuluridae) parasitizing the Brazilian lizard *Tropidurus nanuzae* Rodrigues (Lacertilia, Tropiduridae). *Revista Brasileira de Zoologia* **17**, 1065–1068.

Vrcibradic, D., Rocha, C.F.D., Ribas, S.C. & Vicente, J.J. (1999) Nematodes infecting the skink *Mabuya frenata* in Valinhos, São Paulo State, southeastern Brazil. *Amphibia-Reptilia* **20**, 333–339.

Vrcibradic, D., Cunha-Barros, M., Vicente, J.J., Galdino, C.A.B., Hatano, F.H., Van Sluys, M. & Rocha, C.F.D. (2000a) Nematode infection patterns in four sympatric lizards from a restinga habitat (Jurubatiba) in Rio de Janeiro state, southeastern Brazil. *Amphibia-Reptilia* **21**, 307–316.

Vrcibradic, D., Vicente, J.J. & Bursey, C.R. (2000b) *Thubunaea dactyluris* sensu Fabio and Rolas, a synonym of *Physalopteroides venancioi* (Spirurida, Physalopteridae). *Journal of Parasitology* **86**, 1163–1165.

Vrcibradic, D., Rocha, C.F.D., Bursey, C.R. & Vicente, J.J. (2002a) Helminths infecting *Mabuya agilis* (Lacertilia, Scincidae) in a 'restinga' habitat (Grumari) of Rio de Janeiro, Brazil. *Amphibia-Reptilia* **23**, 109–114.

Vrcibradic, D., Rocha, C.F.D., Bursey, C.R. & Vicente, J.J. (2002b) Helminth communities of two sympatric skinks (*Mabuya agilis* and *Mabuya macrorhyncha*) from two 'restinga' habitats in southeastern Brazil. *Journal of Helminthology* **76**, 355–361.

Vrcibradic, D., Rocha, C.F.D. & Teixeira, R.L. (2002c) Geographic distribution *Cnemidophorus nativo*. *Herpetological Review* **33**, 223.

Wright, J.W. (1993) Evolution of the lizards of the genus *Cnemidophorus*. pp. 27–81 *in* Wright, J.W., Vitt, L.J. (*Eds*) *Biology of whiptail lizards (genus Cnemidophorus)*. Norman, Oklahoma Museum of Natural History.

Zar, J.H. (1999) *Biostatistical analysis*. 4th edn. 663 pp. Upper Saddle River, Prentice Hall, Inc.

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