

# Dry season ecology of *Medopheo edracanthus* (Sauria: teiidae) in Cerros de Amotape National Park (Tumbes, Peru)

Ecología de *Medopheo edracanthus* (Sauria: teiidae) en el Parque Nacional Cerros de Amotape (Tumbes, Perú) durante la temporada seca

Juan C. Jordán A.<sup>1,2\*</sup> and Karen Eckhardt R.<sup>3</sup>

- 1 Centro de Investigación en Biología Tropical y Conservación (Cinbiotyc). Piura, Perú.
- 2 Departamento de Herpetología, Museo de Historia Natural, Universidad Nacional Mayor de San Marcos. Lima, Perú.
- 3 Universidad Nacional Agraria la Molina. Lima, Perú.



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\* Corresponding author email:  
juan.jordan@gmail.com

## ABSTRACT

Despite the high diversity of Sauria in Peru, little is known about their ecology, particularly in the dry forests of northwestern Peru. Between September and December 2006, three areas of the ecological niche occupied by *Medopheos edracanthus* were evaluated in the Cerros de Amotape National Park (Tumbes, Peru). *Medopheos edracanthus* is a diurnal species, with an activity pattern between 08:00 and 16:00 hours, presenting a peak of activity between 11:00 and 13:00 hours, with no differences observed between juveniles and adults. This species tends to mostly occupy the ground surface and leaf litter, selecting patches exposed to sunlight. No differences were recorded between adults and juveniles regarding the use of microhabitats, although juveniles were observed more frequently on exposed ground, which may be related to their physiology or to territorial segregation between adults and juveniles. This species presented a high body temperature ( $36.5 \pm 0.63$  °C), with no differences observed between males and females. The observed body temperature was similar to that of other species of Neotropical teiids. This lizard consumes mainly Isoptera and larvae, including sedentary and grouped prey, similar to those consumed by other species of Neotropical teiids. *Medopheos edracanthus* forages actively, a historical factor resulting in ecological similarities within the Teiidae family. Research on basic ecological aspects of lizards in dry forests is of paramount importance, due to their vulnerability to anthropogenic changes.

**Keywords:** Dry forests, ecological niche, diet, activity pattern, body temperature, microhabitat use, lizards

## RESUMEN

A pesar de la alta diversidad de saurios en el Perú, poco se conoce sobre su ecología, particularmente en los bosques secos del noroeste del Perú. Entre setiembre y diciembre de 2006 se evaluaron tres dimensiones del nicho ecológico del teiido *Medopheos edracanthus* en el Parque Nacional Cerros de Amotape (Tumbes, Perú). *Medopheos edracanthus* es una especie diurna, con un patrón de actividad entre las 8:00 y 16:00 horas, que presenta un pico de actividad entre las 11:00 y 13:00 horas, sin diferencias observables entre juveniles y adultos. Esta especie tiende a ocupar con mayor frecuencia el suelo y la hojarasca, seleccionando parches expuestos al sol. No se registraron diferencias entre adultos y juveniles respecto al uso de microhábitats, aunque los juveniles fueron observados con mayor frecuencia sobre suelo expuesto, lo cual puede estar relacionado con su fisiología o con una segregación territorial entre adultos y juveniles. Esta especie presentó una temperatura corporal elevada ( $36,5$  °C  $\pm$   $0,63$  °C), sin diferencias entre machos y hembras; la temperatura corporal observada fue similar a otras especies de teiidos. Esta lagartija consume principalmente isópteros y larvas, presas sedentarias y agrupadas, similares a las consumidas por otras especies de teiidos. *Medopheos edracanthus* presenta un modo de forrajeo activo, factor histórico que estaría generando similitudes ecológicas en la familia Teiidae. Las investigaciones sobre los aspectos ecológicos básicos de las lagartijas en bosques secos son de suma importancia, debido a su vulnerabilidad a los cambios antropogénicos.

**Palabras clave:** bosques secos, nicho ecológico, dieta, patrones de actividad, temperatura corporal, uso de microhábitat, lagartijas



## Introduction

Located in northwestern coastal Peru, Cerros de Amotape National Park (CANP) conserves a representative sample of Equatorial Pacific seasonally dry forest (Linares-Palomino et al., 2010) and Pacific tropical forest (SERNANP, 2012; Leal-Pinedo and Linares-Palomino, 2005). This national park, together with two other conservation units, El Angolo Hunting Area and Tumbes Mangroves National Sanctuary, forms part of the Northwestern Biosphere Reserve, considered a «biodiversity hotspot» («Tumbes-Chocó-Magdalena»; Mittermeier et al., 2005; Ponce, 2001). Seasonally dry forest (SDF) is a unique and fragile ecosystem found in southern Ecuador and northern Peru, exhibiting high rates of endemism in birds (BirdLife International, 2003) and plant species (Sagástegui et al., 1999). Cerros de Amotape National Park is one of the sixteen protected areas which conserve dry forests within the Equatorial Pacific Region comprising Peru and Ecuador (Linares-Palomino et al., 2010; Espinoza et al., 2012), home to unique endemic species (Wust, 1998; INRENA, 2001); however, this ecosystem is underrepresented in the Peruvian conservation system.

Lizards are considered «ideal» subjects for ecological study due to their abundance, trophic position and ecological diversification (Huey et al., 1983; Vitt and Pianka, 1994); however, despite their relative high diversity in Peru (MINAM, 2019) ecological studies of this reptile group, specifically in the ecosystems of Cerros de Amotape, are scarce (Guzmán, 2016; Jordán, 2006, 2010, 2012; Jordán and Amaya, 2011). Teiid lizard species inhabit the West Indies, Central America and South America, occupying tropical forests, sandy beaches and savannah (Hillman, 1969; Vitt and Colli, 1994; Hower and Blair, 2003). *Medopheos edracanthus* occupies coastal desert and SDF (or northwestern dry forest) (Carrillo and Icochea, 1995; Venegas, 2008, Aguilar et al., 2007), and inhabits transitional dry forest in Cerros de Amotape National Park. In this paper, basic ecological data (diet, microhabitat use and activity patterns) for *Medopheos edracanthus* were evaluated within this natural protected area during the dry season.

## Material and methods

### Study area

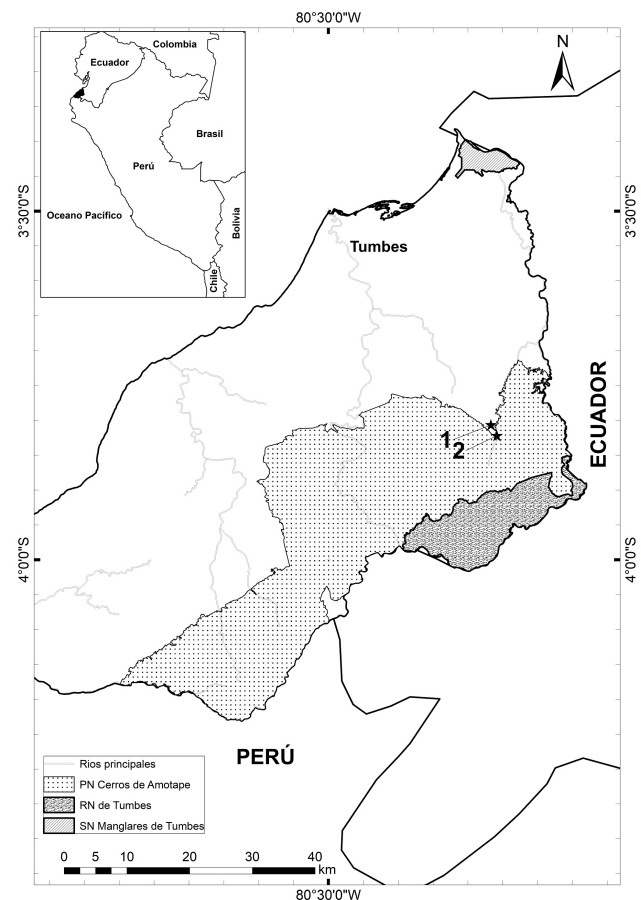
The study site was located near the El Caucho Biological Station (S 03°48'23.3", W 080°16'00.4", 651 meters above sea level; Figure 1). This area displays an isothermal climate with an average annual temperature above 26°C, and a marked dry and rainy seasonality (Ponte, 1998). The area is characterized by dense partially caducous forest with considerable areas of secondary forest at lower levels (Wust, 1998; Pacheco et al., 2009) and a transitional vegetation type ranging from dry and Pacific tropical forest, including species such as *Bauhinia aculeata subsp. grandiflora*, *Triplaris cumingiana*,

*Ceiba trichistandra*, *Cavanillesia platanifolia*, *Phytolacca weberbaueri*, *Trichilia hirta*, *Ficus maxima*, *Ficus eximia*, *Acacia huarango*, *Morus celtidifolia* and *Psidium rostratum* (Leal-Pinedo and Linares-Palomino, 2005). The area was surveyed by two herpetologists over 630 person-hours, between September and December 2006 (dry season) in randomly selected transects.

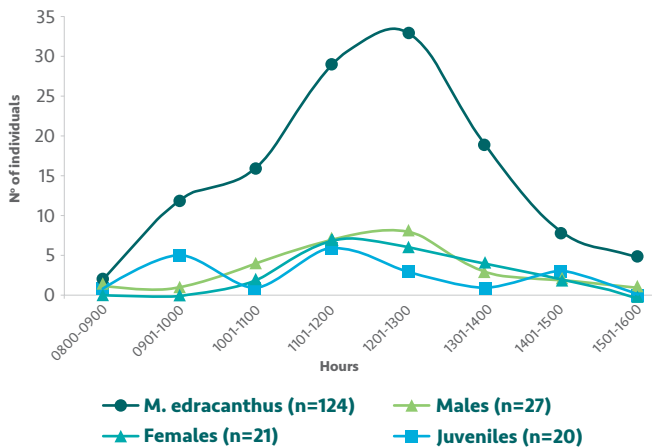
## Data analysis

### Activity pattern and thermal ecology

For each observed individual (n=124), the times of sightings were recorded, and a histogram elaborated from this data (Figure 2). Body temperature (°C) was recorded for each captured individual (n=25) as well as air and substrate temperature (Vitt and Carvalho, 1995). Temperatures were recorded using a Miller and Weber® cloacal thermometer to the nearest 0.2°C. Potential differences in activity patterns across sex and age categories were evaluated using the Kolmogorov-Smirnov test. The relationship between body and environmental temperatures was analyzed through simple and multiple regressions. The degree of exposure to sunlight (exposed, filtered, in shade) for each observed individual was



**Figure 1.** Study site in Cerros de Amotape National Park. 1: El Caucho Biological Station-SERNANP (National Service for State Protected Natural Areas). 2: La Angostura Control Post-SERNANP.



**Figure 2.** Activity patterns for *Medopheo edracanthus* in Cerros de Amotape National Park. The total number of individuals observed ( $n = 124$ ) includes unidentified sex/age categories.

recorded and analyzed using an ANOVA procedure, as relevant factors for control of body temperature (Vitt and Carvalho, 1995). Thermal data associated with exposure to sunlight were not assessed, because not all individuals were captured.

**Microhabitat use**

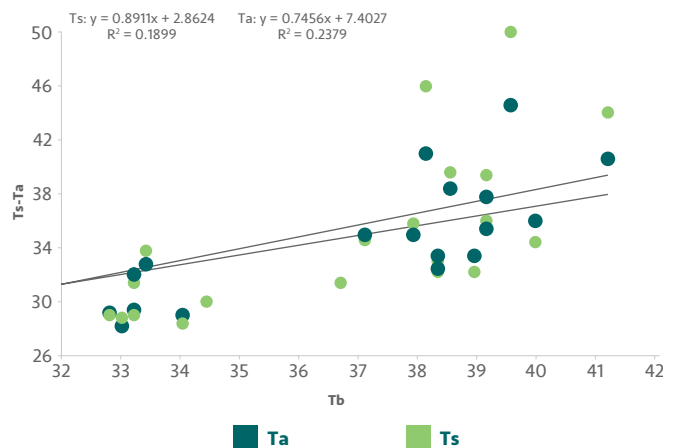
Eight microhabitat categories were identified within the study site: (1) leaf litter (substrate totally covered by leaf litter); (2) soil (substrate without leaf litter); (3) gravel (<5 cm); (4) sand; (5) tree branches; (6) tree trunks; (7) vegetation (creeping, grasses, shrubs); and (8) rock (> 5 cm). Potential differences in microhabitat use between sex and age categories were evaluated using ANOVA and Tukey’s range tests.

**Diet**

Adult captured lizards were sacrificed immediately using Halatal® and preserved in 70° alcohol. Their stomachs ( $n = 43$ ) were analyzed under a stereo microscope, identifying prey items to the order level (Borror et al., 1992) or morphospecies (e.g. larvae). All diet data were combined as a result of the high proportion of degraded prey items contained in the stomachs. The specimens collected were deposited in the Department of Herpetology collection of the San Marcos National University Museum of Natural History (MUSM).

**Morphometry**

The following morphological measurements were recorded in adult and juvenile individuals: snout-vent length (SVL), head width (HW), head length (HL) and head height (HH) using a Mitutoyo® digital caliper (to the nearest 0.1 mm), and weight (W) using Pesola® spring



**Figure 3.** Relationships between body ( $T_b$ ), air ( $T_a$ ) and substrate ( $T_s$ ) temperatures.

scales (to the nearest 0.1 g). Data used for comparisons were transformed to  $\log_{10}$  to create a normally distributed variable (Vitt and Zani, 1996; Vitt et al., 2001).

**Niche breadth**

Niche breadth (spatial, temporal and trophic) was calculated using the inverse of Simpson’s diversity index formula (Simpson, 1949; Pianka, 1973; Vitt and Zani, 1996). Niche breadth value ranged from 1 to  $n$ , where low values indicate restricted use of resources, while high values indicate intensive use (Vitt and Zani, 1996).

**Statistical analysis**

PAST® Version 4.02 for Windows ( $\alpha > 0.05$ ) was used for statistical analysis. Data means appear as  $\pm 1$  SD in the text. Normality was verified through an Anderson-Darling test before parametric or non-parametric statistics were applied.

**Results**

**Activity patterns and thermal ecology**

*Medopheos edracanthus* ( $n = 124$ ) displayed a diurnal activity pattern (08:00 - 16:00 hours) with activity peaks around 11:00 and 13:00 hours (Figure 2). There was no significant difference between activity patterns for adults and juveniles ( $D_{max} = 0.5$ ,  $p = 0.18$ ) or between females and males ( $D_{max} = 0.37$ ,  $p = 0.51$ ). The temporal niche breadth ( $B_t$ ) was 5.52.

Average body temperature was not found to be significantly divergent from average  $T_a$  and  $T_s$  ( $F_{2,62} = 0.81$ ;  $p = 0.44$ ). Body temperature of *Medopheos edracanthus* is shown in Table 1.



**Table 1.** Body ( $T_b$ ), air ( $T_a$ ) and substrate ( $T_s$ ) temperatures recorded for *M. edracanthus* in Cerros de Amotape National Park

<i>M. edracanthus</i> (n=22)	$T_b$ (C°)	$T_a$ (C°)	$T_s$ (C°)
Mean ± SD	36.5 ± 0.63	34.6 ± 1.00	35.33 ± 1.34
Range (min-max)	30° - 41°	28.2° - 44.6°	28.4° - 50°

Body temperature of *Medopheus edracanthus* was moderately related to  $T_a$  ( $R^2 = 0.237$ ;  $p = 0.02$ ,  $n = 24$ ) and to  $T_s$  ( $R^2 = 0.19$ ;  $p = 0.048$ ;  $n = 24$ ) (Figure 3). Multiple regression did not display a significant interaction among the  $T_a$ - $T_s$  versus  $T_b$  of *M. edracanthus* ( $R^2 = 0.20$ ;  $F_{2,18} = 3.13$ ;  $p = 0.068$ ;  $n = 65$ ).

Most *Medopheus edracanthus* individuals were recorded under filtered sun (48.3 %), direct sun exposure (47.1 %), or in shade (4.6 %) (Figure 4). However, slight differences were detected among sex and age categories, as shown in Figure 4. No differences between body temperatures and sun exposure categories were detected for this species ( $F_{1,20} = 3.73$ ;  $p = 0.06$ ).

**Microhabitat use**

Most *M. edracanthus* individuals ( $n = 112$ ) occupy soil (37.5 %), followed by leaf litter (33 %), and rock (15.2 %) (Figure 5). No differences between sex or age categories ( $F_{2,18} = 0.27$ ;  $p = 0.76$ ) were observed with regard to microhabitat use. However, juveniles were found to use soil more frequently (40 %) than adults, where data was categorized by age, while adults were recorded with a higher frequency in leaf litter (35.6 %) (Figure 5). The spatial niche breadth ( $B_s$ ) of *M. edracanthus* was 3.39.

**Diet and morphological analysis**

A total of 43 *M. edracanthus* individuals were subjected to dietary analysis. The species was found to consume a broad variety of prey items, with Aranae, Coleoptera, Isoptera, Orthoptera and insect larvae (Table 2) comprising 93.8 % of its diet, and Isoptera comprising 58.8% and larvae 21 % of total items recorded; however, larvae (66.7%), orthopterans (35.7 %) and spiders (31 %) were the most frequent items found in analysis of stomach content (Table 2). The trophic niche breadth ( $B_d$ ) for *M. edracanthus* was 2.33 (Table 3).

*M. edracanthus* displayed an average snout-vent length of 73.2 mm ( $n = 49$ ) and an average weight of 10.4 g (Table 4) with no differences between sexes for these two variables (SVL:  $F_{(1,31)} = 1.36$ ;  $p = 0.24$ ; weight:  $F_{(1,31)} = 8.98$ ;  $p = 0.0053$ ). However, they differ in head height ( $F_{(1,26)} = 11.15$ ;  $p = 0.002$ ), head weight ( $F_{(1,26)} = 9.92$ ;  $p = 0.004$ ) and head length ( $F_{(1,26)} = 11.09$ ;  $p = 0.002$ ), where males were larger.



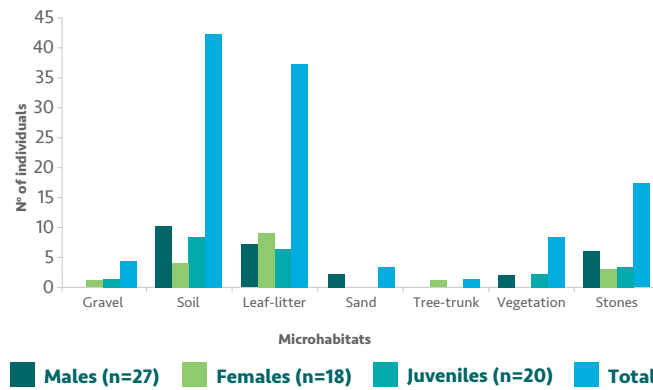
**Figure 4.** Degree of exposure to sunlight (exposed, filtered and shade) of adult (females and males) and juvenile *Medopheus edracanthus* in Cerros de Amotape National Park.

**Table 2.** *Medopheus edracanthus* diet in Cerros de Amotape National Park.

<b>Medopheus edracanthus</b>					
Prey items	N	%	F	F %	IP
<b>Dictyoptera</b>					
Isoptera	210.0	58.8	8	19.0	68.3
Larvae	75.0	21.0	28	66.7	54.3
Orthoptera	18.0	5.04	15	35.7	22.9
Aranae	21.0	5.88	13	31.0	21.4
Coleoptera	11.0	3.1	9	21.4	13.8
<b>Hymenoptera</b>					
Formicidae	7.0	2.0	7	16.7	10.3
Apidae	1.0	0.3	1	2.4	1.5
Hemiptera	6.0	1.7	6	14.3	8.8
Blattodea	4.0	1.1	4	9.5	5.9
Phasmoptera	2.0	0.6	2	4.8	2.9
Neuroptera	1.0	0.3	1	2.4	1.5
<b>Other arthropods</b>					
Scorpiones	1.0	0.3	1	2.4	1.5

**Table 3.** *Medopheus edracanthus* niche breadth in Cerros de Amotape National Park: Temporal ( $B_t$ ), spatial ( $B_s$ ) and trophic ( $B_d$ )

	$B_t$	$B_s$	$B_d$
<i>M. edracanthus</i>	5.52	3.39	2.33



**Figure 5.** *Medopheo edracanthus* microhabitat use (total, male and female adults, and juveniles) in Cerros de Amotape National Park. The total number of individuals observed (n = 112) includes unidentified sex/age categories.

**Table 4.** Morphological characteristics of *Medopheo edracanthus* in Cerros de Amotape National Park

	<i>Medopheo edracanthus</i> (n=49)			Males (n=16)			Females (n=17)			Juveniles (n=12)		
	X± DS	min.	max.	X± DS	min.	max.	X± DS	min.	max.	X± DS	min.	max.
Snout-ventlength(SVL)(mm)	73.2 ± 1.92	57.4	94.5	76.8 ± 3.19	58	94.5	71.4 ± 2.32	57.4	83.9	49.4 ± 2.00	37.2	59.2
Head height (HH) (mm)	8.9 ± 0.47	6.2	16.2	10.3 ± 0.71	7	16.2	7.5 ± 0.27	6.2	9.6	5.6 ± 0.31	4.5	7
Head width (HW) (mm)	10.9 ± 0.45	8.1	16	12.2 ± 0.67	9.1	16	9.64 ± 0.32	8.1	11.7	7.6 ± 0.34	5.8	8.9
Head length (HL) (mm)	19.72 ± 0.82	14.2	29.7	22 ± 1.21	15.8	29.7	17.2 ± 0.56	14.2	20.3	12.9 ± 0.65	9.6	15.6
Weight (W) (g)	10.4 ± 0.78	4.8	20.1	13.1 ± 1.36	5.6	20.1	8.4 ± 0.59	4.8	12.8	3.4 ± 0.36	1.4	5.4

## Discussion

*Medopheo edracanthus* exhibited a diurnal activity pattern coincident with major solar radiation (Vitt and Colli, 1994, Vitt et al., 2003) which allows it to retain a high body temperature, as has been recorded for other teiids (Vitt and Colli, 1994, Vitt, et al., 1996, Vitt and Zani, 1996, Sproston et al., 1999) and which may be related to the active foraging mode exhibited by this lizard family (Huey and Pianka, 1981, Garland et al., 1991, Cooper, 1994). This is reflected in the temporal niche breadth of this species, which is similar to those of other teiid species in the study area (Jordán, 2010). Indeed, there were no differences in activity patterns among males, females and juveniles, which may be related to their thermal physiology and environmental constraints.

*Medopheo edracanthus* occupies microhabitats with high environmental temperatures ( $T_a$  and  $T_s$ ), similar to other teiid species inhabiting tropical forests, and exhibiting a similar average  $T_b$  to *Holcosus semptemlineatus* ( $36.6 \pm 0.4$  °C, Jordán, 2010) at the study site, *Ameiva ameiva* ( $37.9 \pm 0.09$  °C; Vitt and Colli, 1994), *A. taeniura*, *A. leberii* and *A. chrysomela* ( $37.2 \pm 0.4$  °C,  $38.1 \pm 0.5$  °C,  $36.6 \pm 0.4$  °C, respectively, Sproston et al., 1999) and *A. festiva* ( $35.6 \pm 0.5$  °C; Vitt and Zani, 1996). Degree of microhabitat exposure does not affect

body temperature for this species. However, the high body temperature of *M. edracanthus* may be related to its degree of sun exposure; this species must select sunny patches in order to achieve optimal body temperature by thermoregulation, and cooling by alternating between sunny patches and filtered-sun patches while foraging. Similar results were reported by Vitt et al. (2000) for *Ameiva ameiva*, *Kentropyx pelviceps* and *K. altamazonica* and for *Kentropyx calcarata* and *Mabuya nigropunctata* (Vitt et al., 1997) in Brazilian tropical forests. Teiid body temperatures may reflect microhabitat structural differences and be related to degree of sun exposure, rather than to activity pattern (Vitt et al., 2000); however, no differences in *M. edracanthus* body temperature were recorded between filtered and exposed sites. Extremely fine thermoregulatory adjustments may be playing a role in the thermoregulatory behavior of this (and other) species in this area (Jordán and Pérez, 2012).

Because of their active foraging mode, teiids consume sedentary or grouped prey (termites or insect larvae), covering considerable distances in search of their prey in leaf litter and on tree trunks, etc. (Huey and Pianka, 1981; Pianka, 1986; Bergallo and Rocha, 1993), as observed in *M. edracanthus*. Their diets are similar to those of other teiids in tropical environments, such as *Ameiva ameiva* (Vitt and Colli, 1994), *Ameiva festiva* (Vitt and Zani, 1996a),





*Kentropyx altamazonica* (Vitt et al., 2001), *K. pelviceps* (Vitt, et al., 1994), *Cnemidophorus ocellifer* (Mesquita and Colli, 2003) and *Cnemidophorus littoralis* (Menezes et al., 2006), with the consumption of a major proportion of termites and insect larvae, sedentary and lumped prey, which explains the trophic niche breadth calculated for this species. Also, mobile prey such as arachnids and grasshoppers are consumed by this species, although in a lesser proportion. The diet described may be related to a high encounter probability, maximizing their energy intake per search area, due to the high mobility displayed by this lizard. Foraging mode may be influencing microhabitat use (soil and leaf litter) and thermoregulatory behavior, as has been noted above.

Trophic niche breadth values indicate that this species consumes a higher proportion of two prey items, even when *M. edracanthus* consumes a wide variety of prey, similar to that of other teiids (Vitt and Colli, 1994; Vitt et al., 2000; Mesquita and Colli, 2003; Menezes et al., 2006). In the dry forest, *M. edracanthus* exhibited a higher trophic niche breadth (Jordán, 2011), principally consuming insect larvae, comprising 45.6 % of its diet (21 % in this study), suggesting that: 1) this species selects similar prey types in allopatry and sympatry; 2) some prey types are abundant in both habitats, maximizing energy intake per search time unit (Jordán, 2010; Colli et al., 2006). Teiid foraging modes, including that of *M. edracanthus*, impose restrictions and advantages reflected in activity patterns, thermal ecology, diet, etc. This historical factor, firmly established in teiids (Cooper, 1994; Vitt et al., 2000, 2003) may be generating similarities among teiids, reflecting the common evolutionary history of the Teiidae family. Due to the small sample size, prey item size could not be associated with morphological differences (head measurements). It is possible that there is no relationship between these two variables, as recorded in other teiid species, namely *Cnemidophorus ocellifer* and *Cnemidophorus littoralis* (Texeira-Filho et al., 2003). This may be related to the high rate of consumption of isopterans (termites) recorded for these species, which is a small prey, as well as in *M. edracanthus*, and which may prevent sexual dimorphism related to sexual differences in diet.

More seasonally dry forest (SDF) conservation work is needed in northern Peru, particularly within Cerros de Amotape National Park, due to its vulnerability to the anthropic disturbance (illegal logging, agriculture, cattle ranching) occurring within its buffer zone. Given its high biodiversity values (Sagástegui et al., 1999; BirdLife International, 2003; Linares et al., 2010; Hurtado and Pacheco, 2015), we encourage more research focused on CANP's wildlife, in order to gain greater insight into its ecology and ecosystem functions. However, in order ensure to the success of conservation efforts, a more sustainability approach to human activity in the areas bordering the CANP will be required.

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## Authorship contribution

JCJ: Fieldwork, data analysis, writing and editing. KE: Data analysis, writing and editing

## Conflict of interest

The authors declare no conflict of interest.

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