



During ongoing nocturnal snake surveys in the Chetumal area of southern Quintana Roo, Mexico, the authors have recorded 31 species of snakes. The species treated in the following article (*Leptodeira frenata*, *Ninia sebae*, and *Micrurus diastema*) have been some of the most commonly encountered snakes in this study. The road-killed specimens are collected and later dissected to generate data on the diet and reproduction of the species. Pictured here is an adult female of *Leptodeira frenata* from between Calderitas and Ruinas de Oxtankah, Quintana Roo, Mexico (not collected), a nocturnal, arboreal snake with a diet consisting mostly of anurans and lizards.

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The Chetumal Snake Census: generating biological data from road-killed snakes. Part 3. *Leptodeira frenata*, *Ninia sebae*, and *Micrurus diastema*

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ABSTRACT: We present data and observations on the snake species *Leptodeira frenata*, *Ninia sebae*, and *Micrurus diastema* collected during bimonthly surveys along a 39 km road transect near the city of Chetumal, Quintana Roo, Mexico, since February of 2010. For these species, we present data on their external morphology, seasonality, spatial distribution, reproduction, and diet.

Key Words: Dipsadidae, diet, Elapidae, Mexico, monitoring, population dynamics, Quintana Roo, reproduction, road-kills, snake survey

RESUMEN: Presentamos datos y observaciones sobre las especies de serpientes *Leptodeira frenata*, *Ninia sebae* y *Micrurus diastema* registradas durante muestreos realizados cada 15 días a lo largo de un transecto de carretera de 39 km cercano a la ciudad de Chetumal (Quintana Roo, Mexico) desde febrero de 2010. De cada una de estas especies presentamos datos sobre morfología externa, estacionalidad, distribución espacial, reproducción y dieta.

Palabras Claves: Dipsadidae, dieta, Elapidae, Mexico, mortalidad por atropello, muestreo y monitoreo de serpientes, dinámica poblacional, Quintana Roo, reproducción

Citation: Köhler, G., J. R Cedeño-Vázquez, M. Spaeth, and P. M. Beutelspacher-García. 2016. The Chetumal Snake Census: generating biological data from road-killed snakes. Part 3. *Leptodeira frenata*, *Ninia sebae*, and *Micrurus diastema*. Mesoamerican Herpetology 3: 930–947.

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Received: 23 November 2016; **Accepted:** 5 December 2016; **Published:** 31 December 2016.

INTRODUCTION

In a previous article (Köhler et al., 2016), we introduced our long-term snake survey study based on snakes found along a 39 km road transect in southern Quintana Roo, Mexico. Here we report the data for three species of snakes (*Leptodeira frenata*, *Ninia sebae*, and *Micrurus diastema*), generated from road-killed specimens and supplemented by observations of living individuals found on the road during our nocturnal surveys. Since 13 February 2010, we recorded 49 specimens of *Leptodeira frenata*, 49 of *Ninia sebae*, and 25 of *Micrurus diastema* (see Appendix 1 for list of specimens collected). For measurements, we use the abbreviations SVL (snout–vent length) and TL (tail length).

SPECIES ACCOUNTS

Leptodeira frenata (Cope 1886)

Figs. 1–2

Material: We collected 49 specimens of *Leptodeira frenata* (Fig. 1), of which we identified 24 as males, 22 as females, and 3 as indeterminate.

External morphology: See Table 1 for variation in selected morphometric and scalation characters.

Table 1. Selected measurements, proportions, and scale characters of <i>Leptodeira frenata</i> , <i>Ninia sebae</i> , and <i>Micrurus diastema</i> . Range is followed by mean value and standard deviation in parentheses. See text for abbreviations.				
Character		<i>Leptodeira frenata</i> ♂ 16 ♀ 17	<i>Ninia sebae</i> ♂ 14 ♀ 14	<i>Micrurus diastema</i> ♂ 13 ♀ 7
SVL (mm)	Males	181–452 (345.00 ± 88.10)	174–265 (228.00 ± 24.00)	357–669 (505.00 ± 108.00)
	Females	237–512 (367.00 ± 84.00)	189–304 (254.00 ± 35.40)	389–690 (553.00 ± 120.00)
TL / SVL	Males	0.260–0.368 (0.301 ± 0.029)	0.237–0.351 (0.287 ± 0.023)	0.159–0.249 (0.187 ± 0.024)
	Females	0.247–0.336 (0.290 ± 0.029)	0.215–0.249 (0.230 ± 0.012)	0.124–0.129 (0.126 ± 0.002)
Ventrals	Males	164–186 (177.10 ± 5.75)	130–142 (137.80 ± 3.28)	197–213 (205.3 ± 5.4)
	Females	170–187 (179.30 ± 4.56)	133–158 (143.30 ± 6.68)	216–229 (221.5 ± 5.8)
Subcaudals	Males	65–79 (74.00 ± 4.71)	49–60 (53.60 ± 2.87)	52–65 (54.9 ± 4.1)
	Females	64–78 (72.10 ± 4.83)	40–49 (44.90 ± 2.30)	40–46 (42.8 ± 2.5)
Number of dorsal scales rows at midbody		17–21 (20.10 ± 1.38)	19 (19.0 ± 0.0)	15 (15.0 ± 0.0)
Number of dorsal scales rows anterior to vent		15–19 (16.20 ± 1.40)	19 (19.0 ± 0.0)	15 (15.0 ± 0.0)
Cloacal scute		divided	single	divided
Number of loreal scales		1 (1.0 ± 0.0)	1 (1.0 ± 0.0)	0 (0.0 ± 0.0)
Number of preocular scales		1 (1.0 ± 0.0)	0 (0.0 ± 0.0)	1 (1.0 ± 0.0)
Number of postocular scales		2 (2.0 ± 0.0)	2 (2.0 ± 0.0)	2 (2.0 ± 0.0)
Number of anterior temporals		1 (1.0 ± 0.0)	1 (1.0 ± 0.0)	1 (1.0 ± 0.0)
Number of posterior temporals		2 (2.0 ± 0.0)	2 (2.0 ± 0.0)	2 (2.0 ± 0.0)
Number of supralabials		8 (8.0 ± 0.0)	7 (7.0 ± 0.0)	7 (7.0 ± 0.0)
Number of infralabials		9–10 (9.90 ± 0.26)	6–7 (6.2 ± 2.3)	7 (7.0 ± 0.0)

Diet: Three of the preserved specimens of *Leptodeira frenata* contained identifiable intestinal contents. SMF 100553 contained the remains (hind feet and part of tail, SMF 101254) of a *Sceloporus*, presumably *S. chrysostictus*. In the stomach of SMF 100552 we found the hind legs of a subadult *Incilius valliceps* (SMF 101256), and in the stomach of SMF 100556 we detected a partly digested subadult of *Smilisca baudinii* (SMF 101255).



Fig. 1. *Leptodeira frenata* in life. (A) An adult (ECO-CH-H 3738); and (B) a juvenile (not collected).

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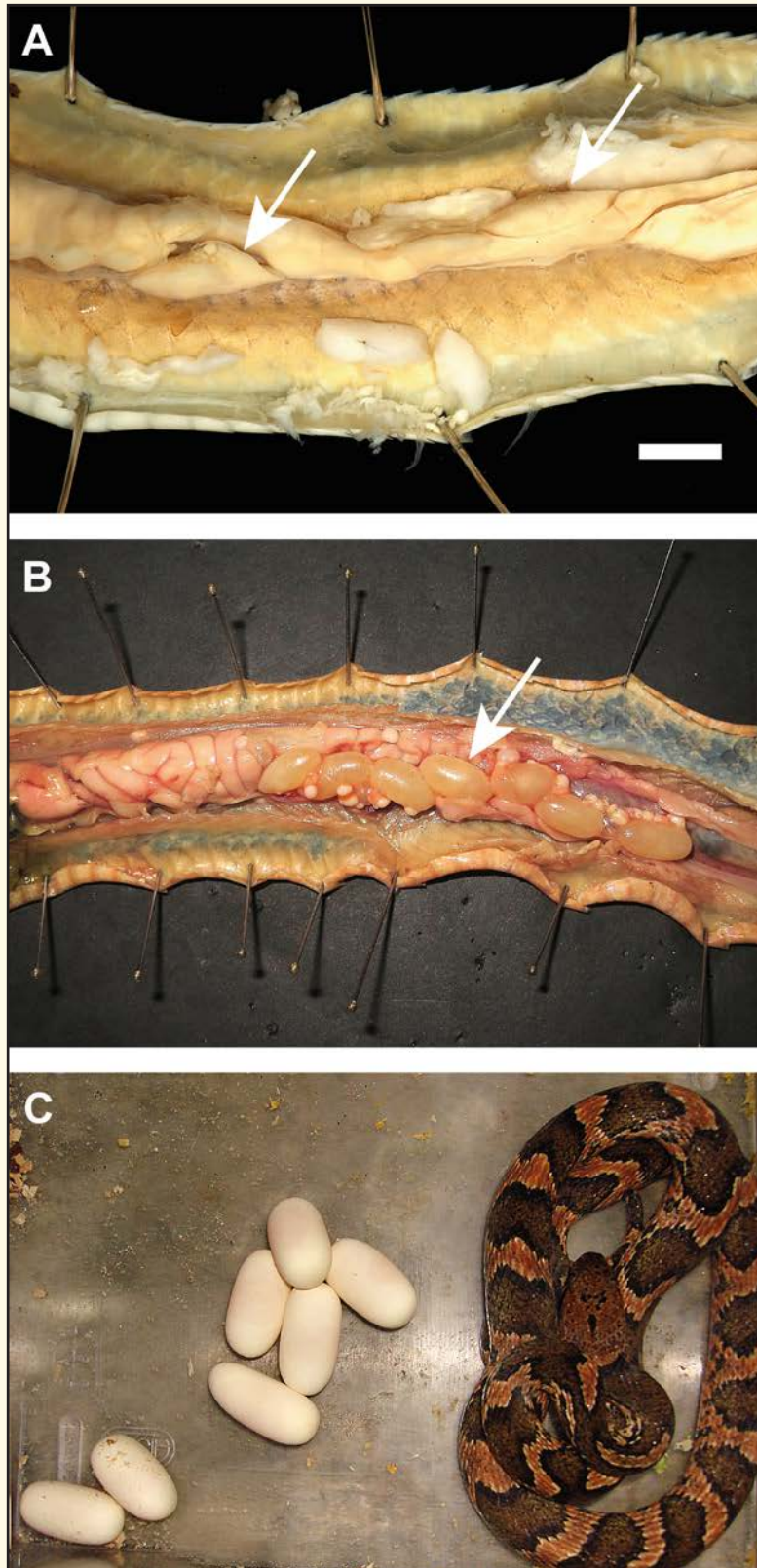


Fig. 2. Specimens of *Leptodeira frenata* dissected to study their gonads (A, B) as well as (C) a female (not collected) that produced a clutch on 7 June 2013. (A) A male (SMF 100555); and (B) a female (ECO-CH-H 3738). The testes and follicles, respectively, are indicated by arrows. Scale bar = 5 mm.

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Reproduction: The dissection of 3 male and 2 female specimens of *Leptodeira frenata* yielded data on reproduction (also see Fig. 2A,B). The relative testis size (ratio of testis length \times width/SVL) in the 3 males was 0.050–0.110 (0.081 ± 0.026). We found the largest relative testis size (0.110) in a specimen collected in March, and the one with the smallest value (0.050) in a specimen preserved in September. The relative ovary size (ratio of ovary length \times width/SVL) in the two females was 0.056 (SMF 100554, collected in November) and 0.054 (SMF 100558, collected in April). SMF 100554 contained four vitellogenic follicles per side, with the largest follicles measuring 2.6–3.1 mm \times 1.1–1.4 mm. None of our specimens contained oviducal eggs. On 30 August 2016, we collected a female *Leptodeira frenata* (SVL 604 mm; ECO-CH-H 3738) that we encountered outside of our road transect, but in same the general area (Chetumal, 18.49964°N, -88.33601°W, elev. 17 m). It contained seven large vitellogenic follicles (Fig. 2B), with a size of 10.2–12.7 (11.0 ± 0.79) mm \times 4.9–6.3 (5.5 ± 0.37) mm. These dissection results are supplemented by data on clutch size obtained from three gravid females that PGB found alive in the study area and later laid eggs in captivity. The clutches contained 2 eggs (14 February 2008), 4 eggs (5 January 2011), and 7 eggs (7 June 2013), respectively (see also Fig. 2C).

Seasonality: See Figure 3 for the temporal distribution of the 49 individuals of *Leptodeira frenata* encountered on our road transect over a six-year period. We collected very few individuals during the winter months (October through January), and found the majority during the warmer months (March through September).

Distribution in the transect: We recorded this species throughout the 39 km road transect (Fig. 4). We found 4.1% of the specimens near cropland, 2.0% near residential areas, 10.2% in areas surrounded by vegetation-free open habitat, 2.0% near wetlands, 18.5% in areas surrounded by vegetation-covered open habitat, 11.2% adjacent to tree plantations, 1.0% in areas surrounded by open, sandy habitat, and 51.0% adjacent to natural forest. The few individuals we encountered alive (4) either were crawling across the road or were found in the low vegetation bordering the road.

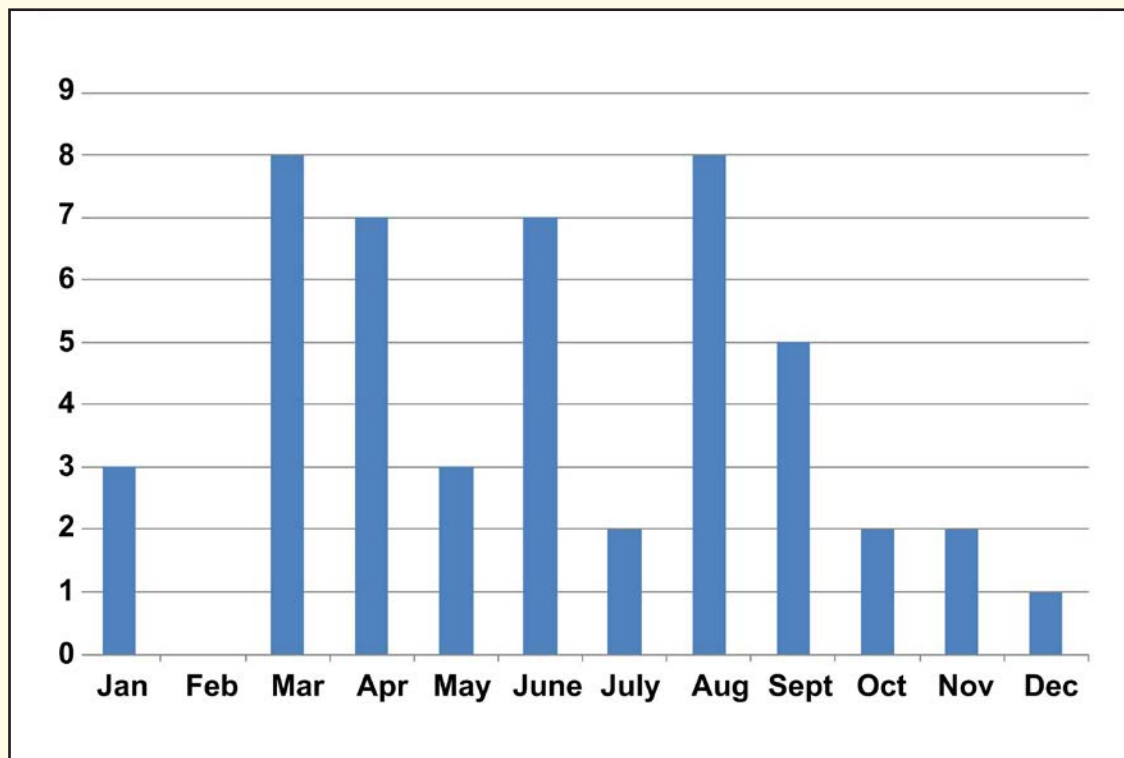


Fig. 3. Diagram showing the frequency distribution of collected specimens of *Leptodeira frenata* during the course of the year.

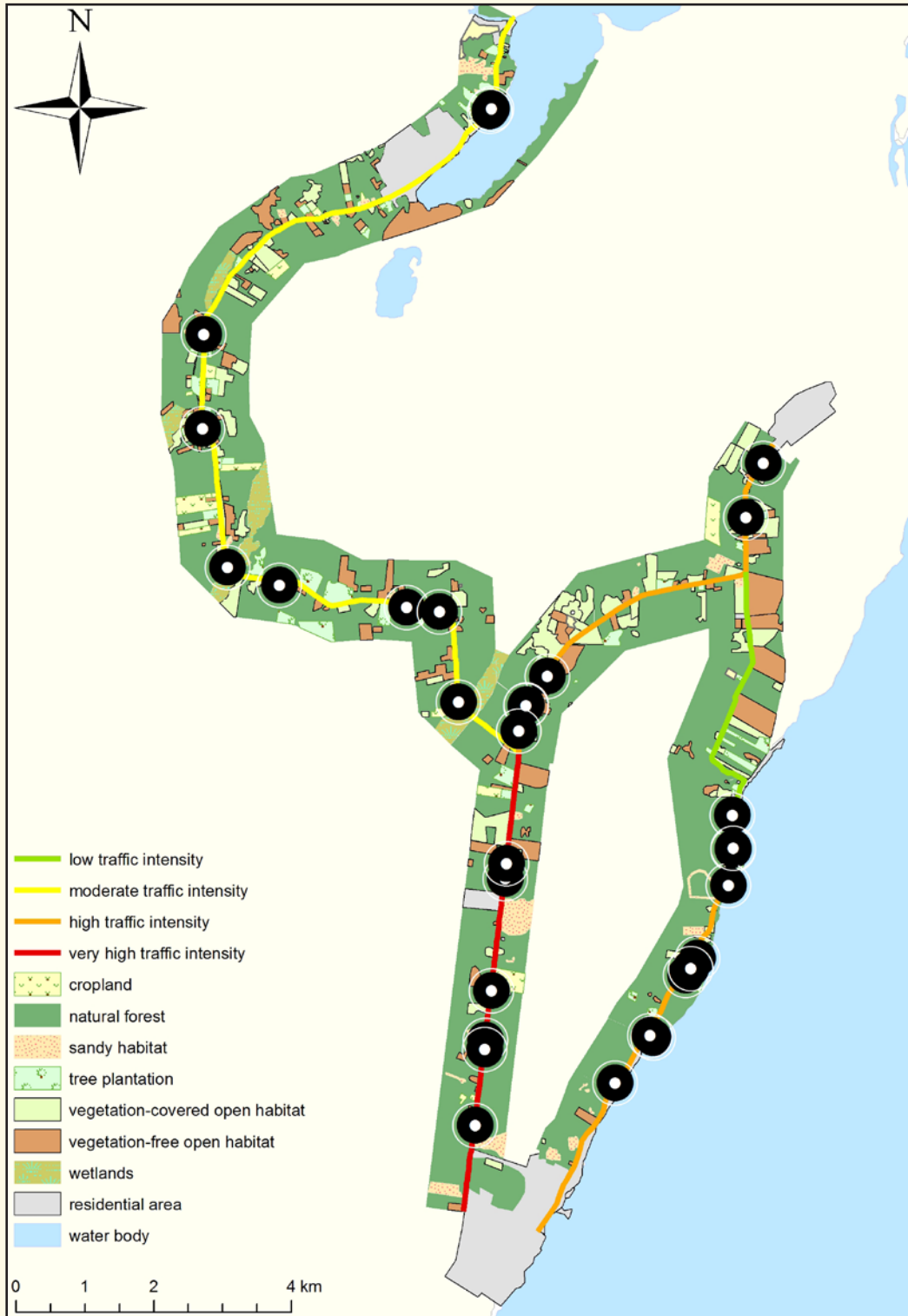


Fig. 4. Spatial distribution of the collected specimens (black dots with white centers) of *Leptodeira frenata* along the transect.

Ninia sebae (Duméril, Bibron, & Duméril 1854)

Figs. 5–6

Material: We collected 50 specimens of *Ninia sebae* (Fig 5), of which we identified 27 as males, 18 as females, and 5 as indeterminate.

External morphology: See Table 1 for variation in selected morphometric and scalation characters.

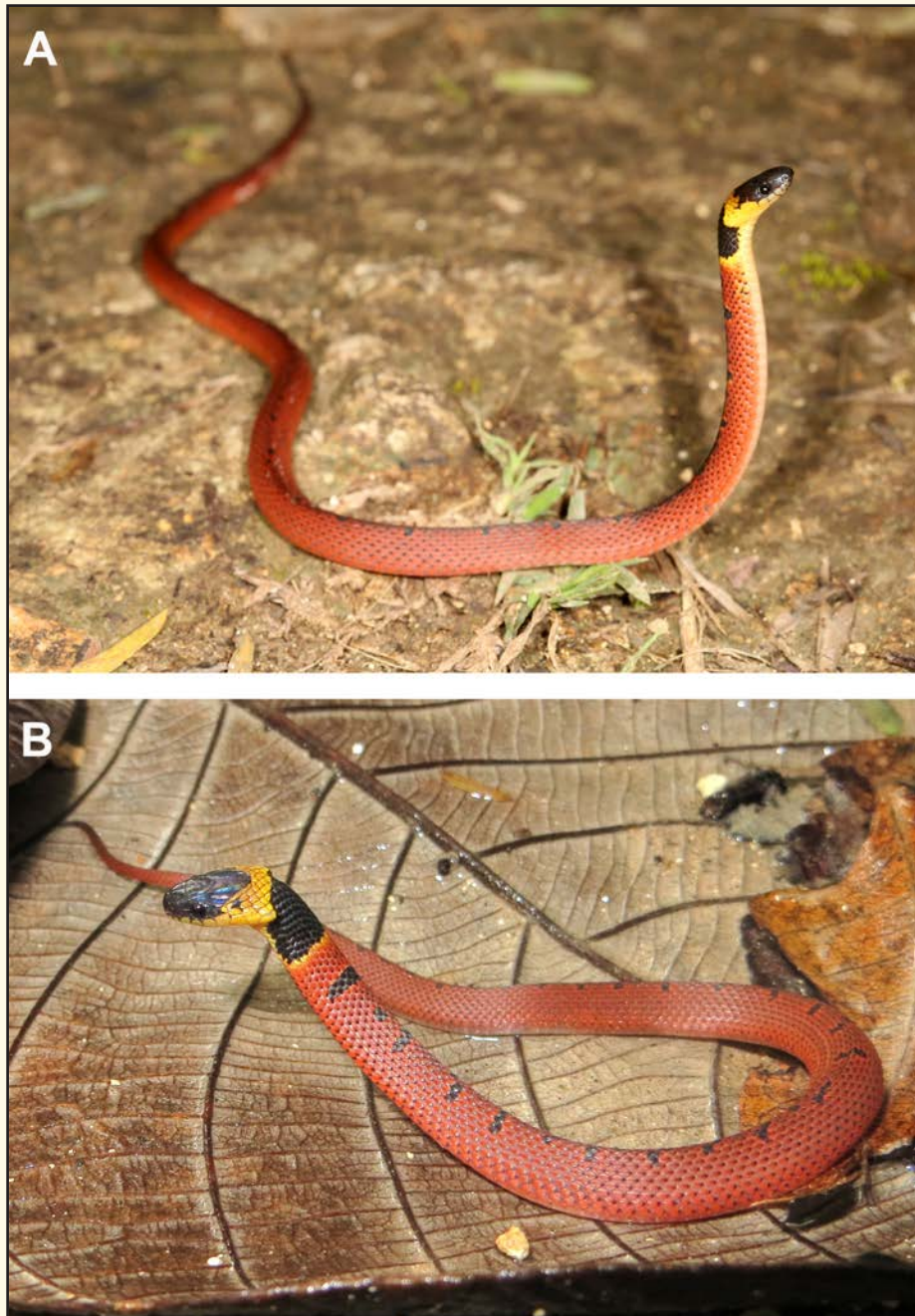


Fig. 5. *Ninia sebae* in life. (A) SMF 99640; and (B) an adult from near Chetumal (not collected). Both specimens exhibited the cobra-like defense behavior typical of this species. © Gunther Köhler (A) and J. Rogelio Cedeño-Vázquez (B)

Diet: Several specimens of *Ninia sebae* (i.e., ECO-CH-H 3108, 3494, SMF 99639–40) contained earthworms or their remains in their gastrointestinal tract whereas undigested parts of arthropods were detected in quite a few individuals (i.e., ECO-CH-H 3192, 3494, 3606, SMF 99640–41, 100585); and in the gut of ECO-CH-H 3108 we also identified the remains of a snail shell.

Reproduction: The dissection of 13 male and 6 female specimens of *Ninia sebae* yielded data on reproduction (also see Fig. 6). The relative testis size (ratio of testis length \times width/SVL) in the 12 males was 0.039–0.231 (0.100 ± 0.045). We found the largest relative testis size (0.231) in a specimen collected in October, and the one with the smallest value (0.039) in a specimen preserved in June. The relative ovary size (ratio of ovary length \times width/SVL) in the 6 females was 0.059–0.180 (0.107 ± 0.045). We detected the largest relative ovary size (0.180) in a female collected in October, and the lowest value (0.059) in a female collected in September. The number of vitellogenic follicles per side ranged from 4 to 10 (6.2 ± 1.94). The follicle length was 1.5–4.7 (2.66 ± 0.99), and the follicle width 0.57–2.01 (1.18 ± 0.38). We counted the highest and the lowest number of follicles, respectively, in females collected in October, and found the largest and the smallest follicles, respectively, in females collected in July. None of our specimens contained oviducal eggs.

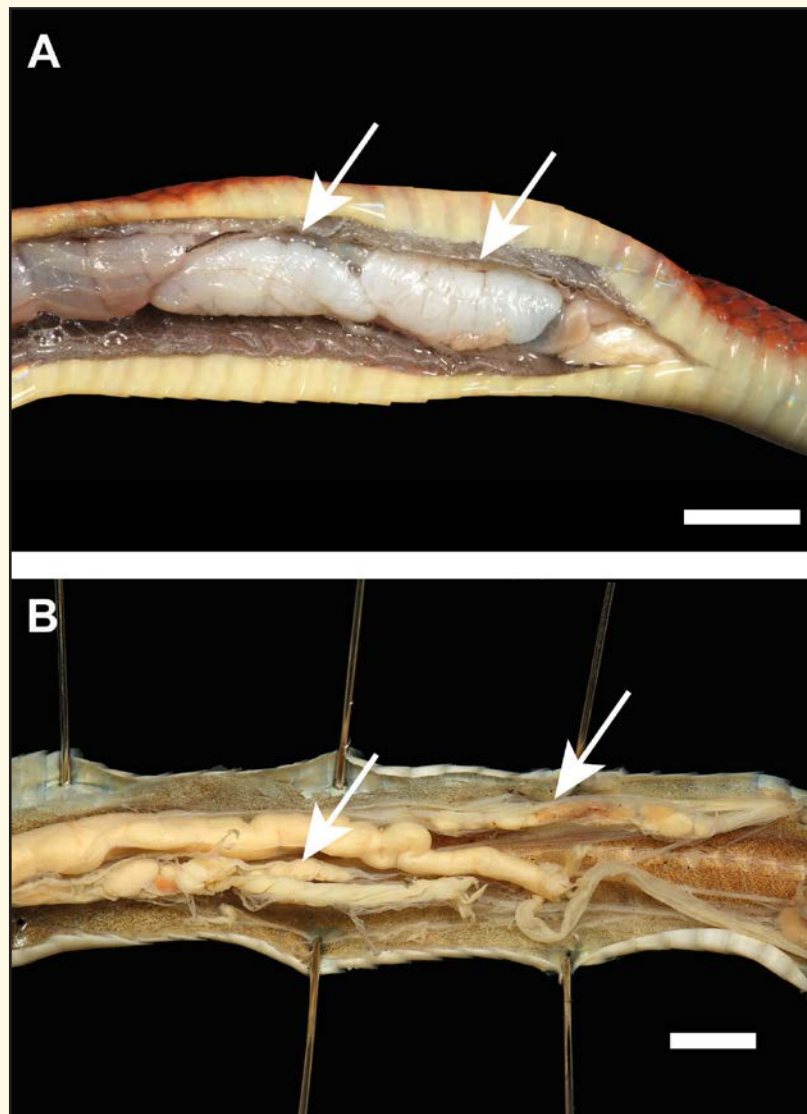



Fig. 6. Specimens of *Ninia sebae* dissected to study their gonads. (A) A male (SMF 99640); and (B) a female (ECO-CH-H 2924). The testes and ovaries, respectively, are indicated by arrows. Scale bar = 5 mm.  © Gunther Köhler

Seasonality: See Figure 7 for the temporal distribution of the 50 individuals of *Ninia sebae* encountered on our road transect over a six-year period. The months with the highest numbers of collected individuals were during the winter (October, November, January), which is in contrast to the pattern observed in most other species we collected in this study.

Distribution in the transect: We recorded this species throughout the 39 km road transect (Fig. 8). We found 3.1% of the specimens near cropland, 6.2% near residential areas, 7.8% in areas surrounded by vegetation-free open habitat, 1.6% near wetlands, 17.0% in areas surrounded by vegetation-covered open habitat, 17.0% adjacent to tree plantations, 2.3% in areas surrounded by open, sandy habitat, and 45.0% adjacent to natural forest. The few individuals we encountered alive (10) were crawling across the road.

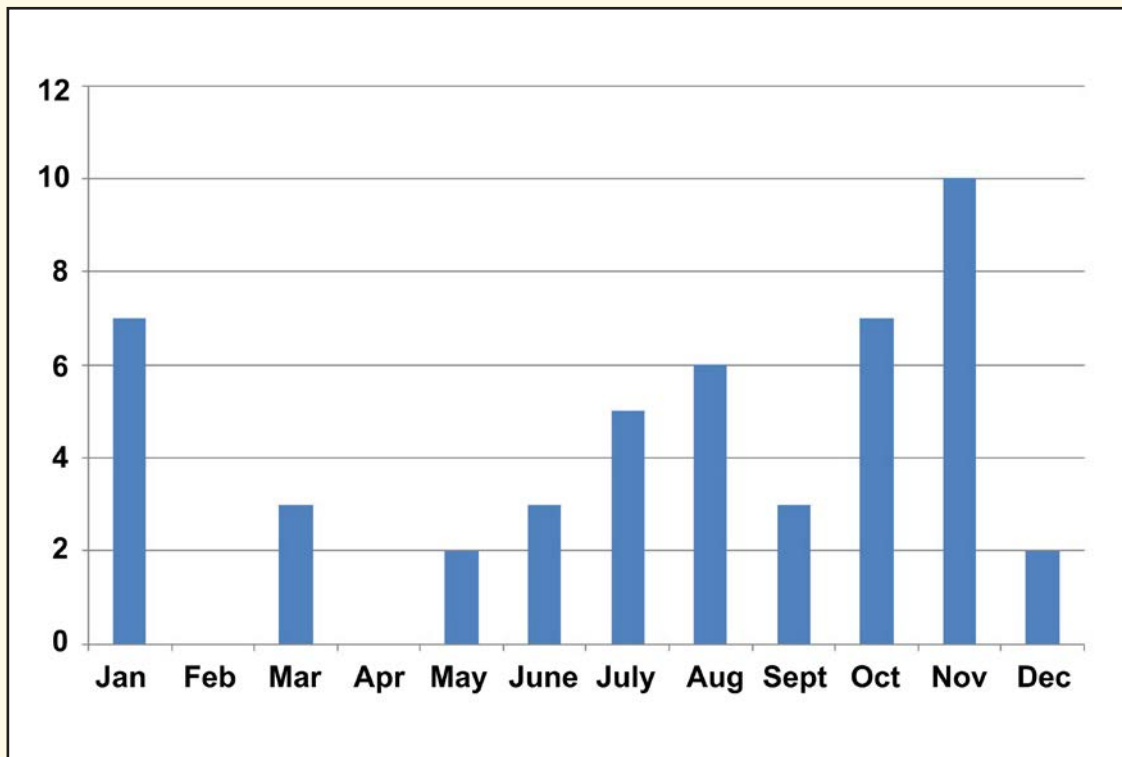


Fig. 7. Diagram showing the frequency distribution of collected specimens of *Ninia sebae* during the course of the year.

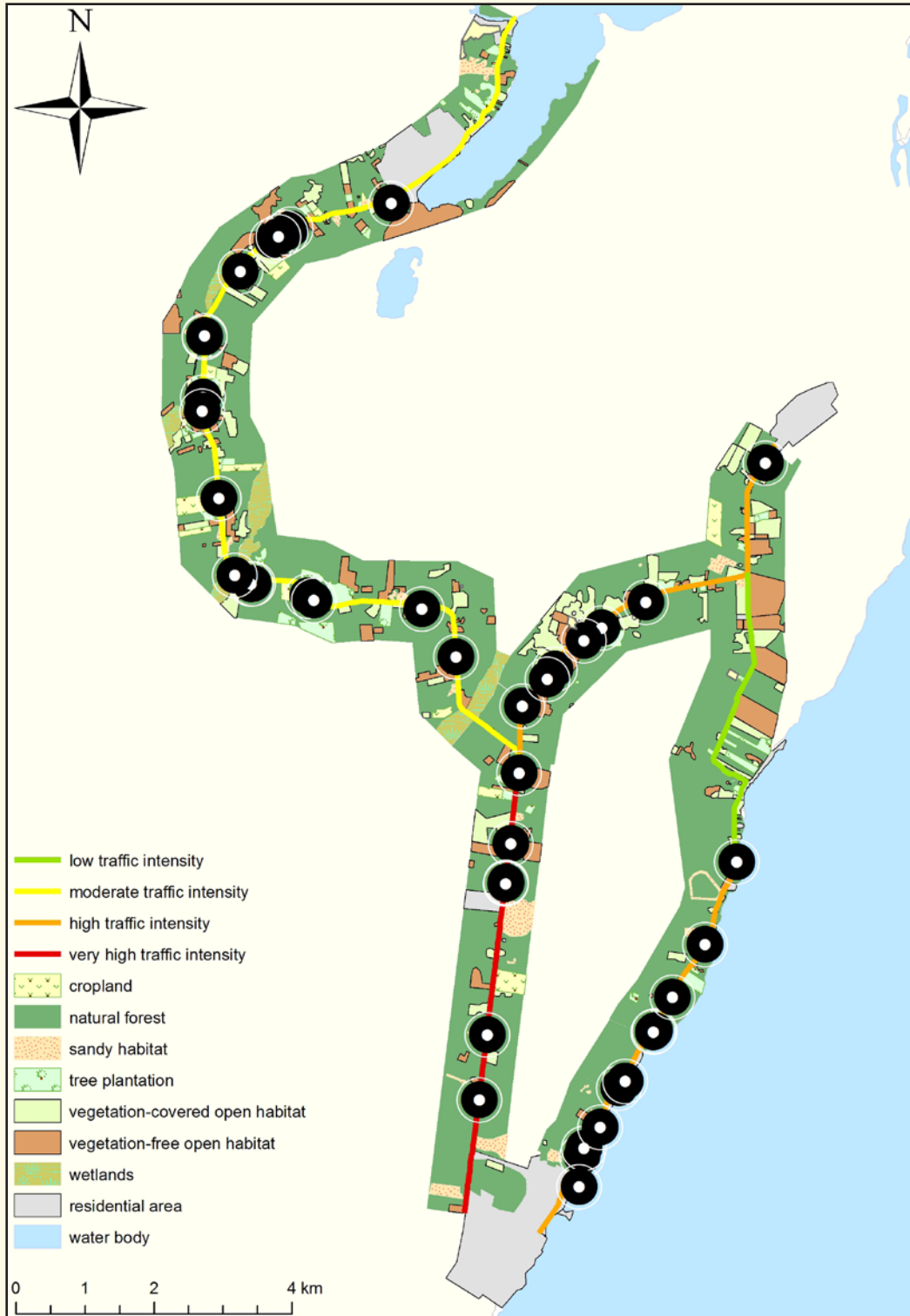


Fig. 8. Spatial distribution of collected specimens (black dots with white centers) of *Ninia sebae* along the transect.

***Micrurus diastema* (Duméril, Bibron, & Duméril 1854)**

Figs. 9–11

Material: We collected 25 specimens of *Micrurus diastema* (Fig. 9), of which we identified 13 as males, 8 as females, and 4 as indeterminate.

External morphology: See Table 1 for variation in selected morphometric and scalation characters.

Diet: Several of the preserved specimens of *Micrurus diastema* contained identifiable intestinal contents. SMF 99635 contained the remains of a smaller conspecific (SMF 99636; Fig. 10A) and SMF 100564 (SVL 357 mm) had eaten an adult *Ficimia publia* (SMF 101253, body length 252 mm, head missing; Fig. 10B). The specimen ECO-CH-H 3194 contained a Blind Swamp Eel (*Ophisternon infernale*) in its stomach (Fig. 10C). In the gastrointestinal tract of a specimen (field number PBG 277, now lost) we found a specimen of *Ninia sebae* as well as a centipede.



Fig. 9. *Micrurus diastema* in life. (A) ECO-CH-H 2932; and (B) an adult (not collected).

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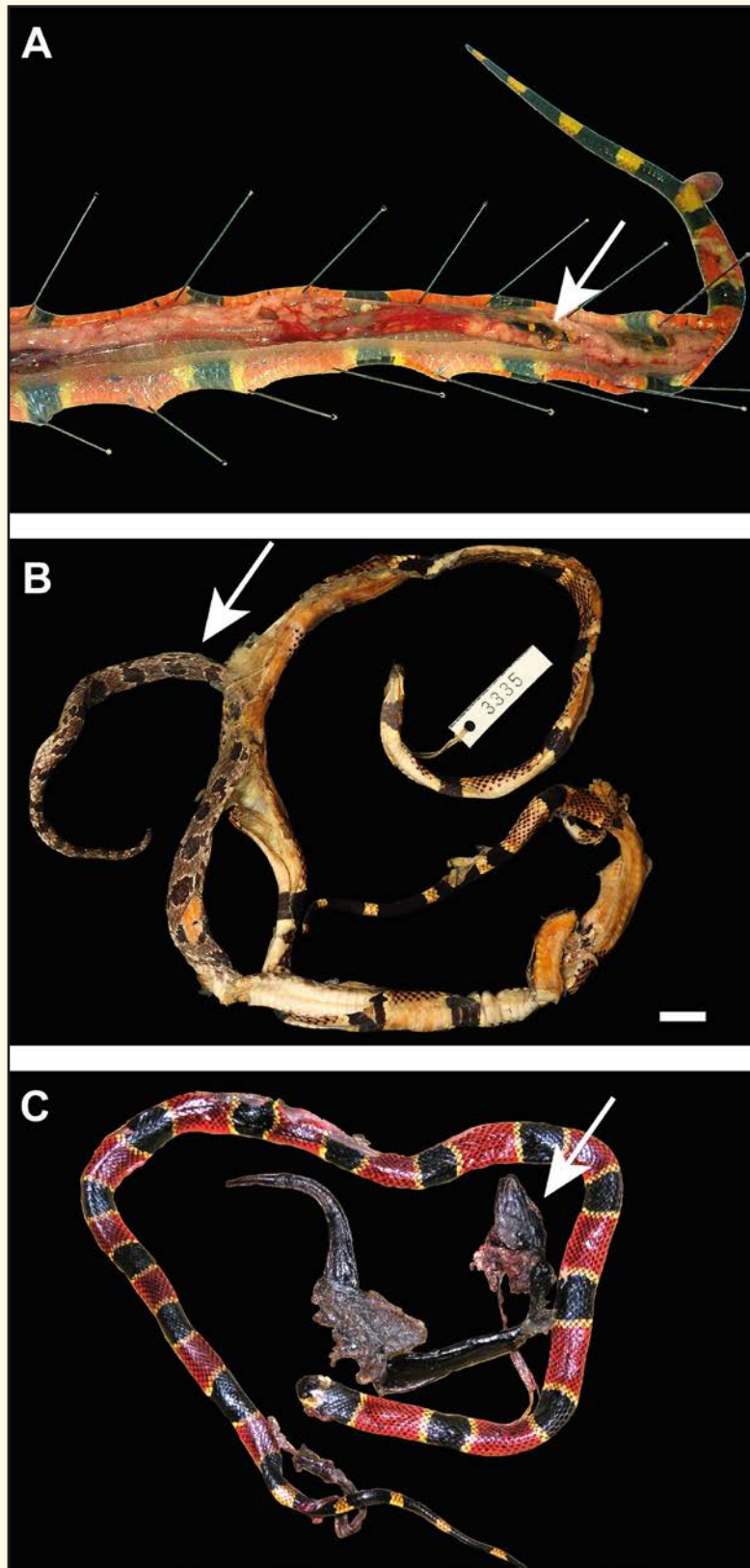


Fig. 10. *Micrurus diastema* with prey items in the gastrointestinal tract. (A) SMF 99635 with the remains of a smaller conspecific (SMF 99636; arrow); (B) SMF 100564 with an adult individual of *Ficimia publia* (SMF 101253; arrow); and (C) ECO-CH-H 3194 with a Blind Swamp Eel (*Ophisternon infernale*) (arrow). Scale bar = 10 mm. © Gunther Köhler (A, B), and J. Rogelio Cedeño-Vázquez (C)

Reproduction: The dissection of 3 male and 5 female specimens of *Micrurus diastema* yielded data on reproduction (also see Fig. 11). The relative testis size (ratio of testis length \times width/SVL) in the 3 males was 0.010–0.110 (0.047 ± 0.035). We found the largest (0.110) and the smallest (0.010) relative testis size, respectively, in males collected in August. The relative ovary size (ratio of ovary length \times width/SVL) in the 5 females was 0.021–0.150 (0.077 ± 0.040). We detected the largest (0.150) and the smallest (0.021) relative ovary size, respectively, in females collected in June. The number of vitellogenic follicles per side ranged from 1 to 6 (3.4 ± 2.06). The follicle length was 2.0–3.6 (2.80 ± 0.46), and the follicle width 1.2–2.8 (1.80 ± 0.51). We counted the highest number of follicles (6) in females collected in July and October, and the lowest number in females preserved in June and November. None of our specimens contained oviducal eggs.

Seasonality: See Figure 12 for the temporal distribution of the 25 individuals of *Micrurus diastema* encountered on our road transect over a six-year period. We collected very few individuals during the winter months (December through February), and found the majority during the warmer months.

Distribution in the transect: We recorded this species throughout the 39 km road transect (Fig. 13). We found 4.2% of the specimens near cropland, 6.9% near residential areas, 6.9% in areas surrounded by vegetation-free open habitat, 9.7% near wetlands, 18.1% in areas surrounded by vegetation-covered open habitat, 4.2% adjacent to tree plantations, 2.8% in areas surrounded by open, sandy habitat, and 47.2% adjacent to natural forest. The few individuals we encountered alive (4) either were crawling across the road or were found in the low vegetation bordering the road.

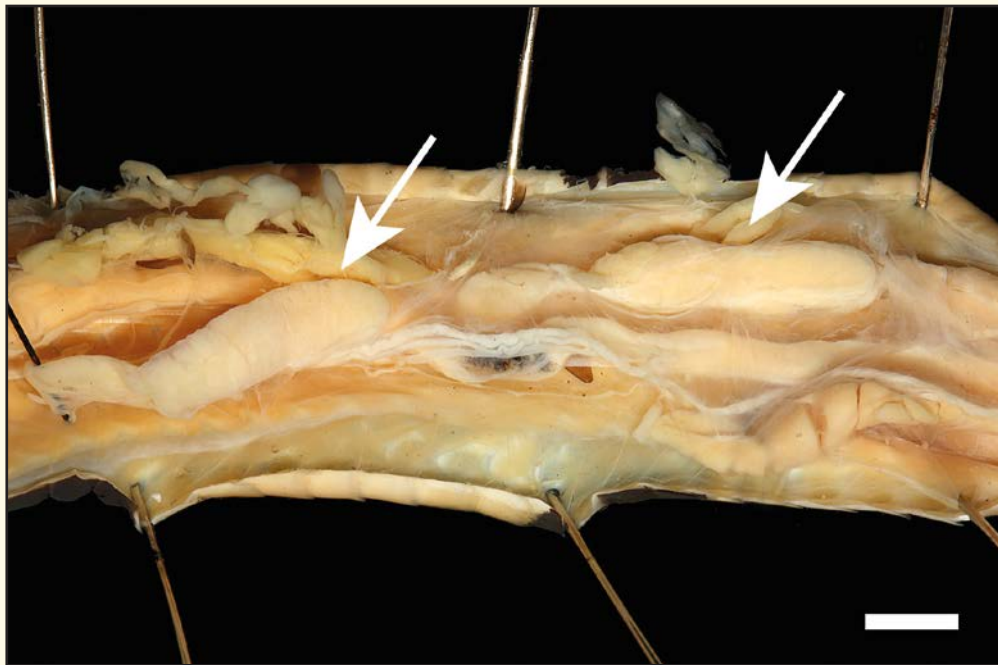


Fig. 11. A male specimen of *Micrurus diastema* (ECO-CH-H 3127) dissected to study its gonads. The testes are indicated by arrows. Scale bar = 5 mm.

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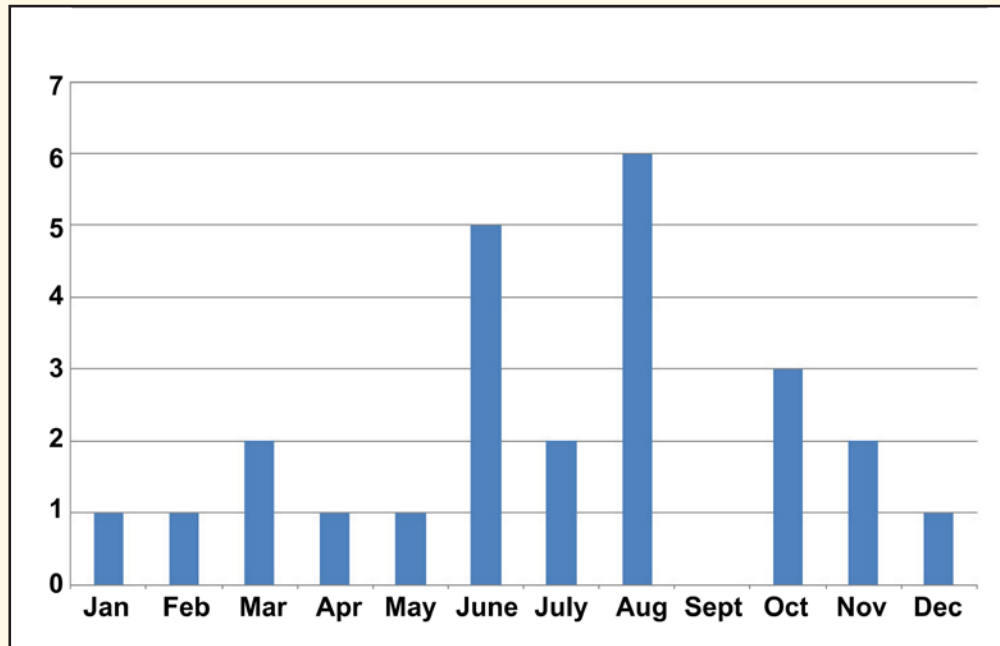


Fig. 12. Diagram showing the frequency distribution of collected specimens of *Micrurus diastema* during the course of the year.

DISCUSSION

We depict the annual number of collected specimens of the three species in Fig. 14. All three species exhibit a decrease in the numbers collected during the years 2011 and 2012, compared to other years of our study so far. Otherwise, we could not detect a clear trend during this six-year period. Regarding the distribution of these three species within the transect, we collected them along the entire transect and found the majority adjacent to natural forest.

Our data agree well with the published morphological and ecological information on these three species of snakes (e.g., Lee, 1996; Campbell, 1998; Köhler, 2008; McCranie, 2011, and references therein). *Ninia sebae* has been reported to feed mostly on earthworms, leeches, slugs, and snails (Greene, 1975; McCranie, 2011, and references therein), which agrees well with our data, but we also found the remains of arthropods in several of the specimens we dissected. Since this species has not been known to prey upon arthropods, it is not clear at this point whether these findings actually represent the remains of prey items of *N. sebae* or were ingested unintentionally (adhering to other prey such as mollusks?). Most of our specimens with very large testis size (relative testis size > 0.10) were collected in the months between September and January, which might indicate mating activity during the winter months. Gravid females and egg laying had been reported in this species in the months of March, April, July to September, and November, which suggests that *N. sebae* produces more than one clutch per year (Goldberg, 2008).

Leptodeira frenata has been reported to feed on frogs, toads, and lizards (Lee, 1996, and references therein), which agrees with our findings. Clutches of 3–7 eggs have been reported in the literature (Stuart, 1935; Himmelstein, 1980), which is congruent with our observations except that one of the females we studied produced a clutch of only two eggs. Including our data, egg laying has been reported in this species in the months of January, February, April, and June (Stuart, 1935; Himmelstein, 1980).

Micrurus diastema, just like all the species in this genus, is known to feed on snakes, caecilians, and eels, and occasionally also consumes lizards (Lee, 1996; Campbell, 1998; McCranie, 2011, and references therein), which is in accordance with our observations. One of our specimens had preyed upon a conspecific. Seib (1985) also reported an instance of cannibalism in this species. Gravid females and clutches have been reported in this species in the months of April and July (Stuart, 1948; McCranie, 2011).

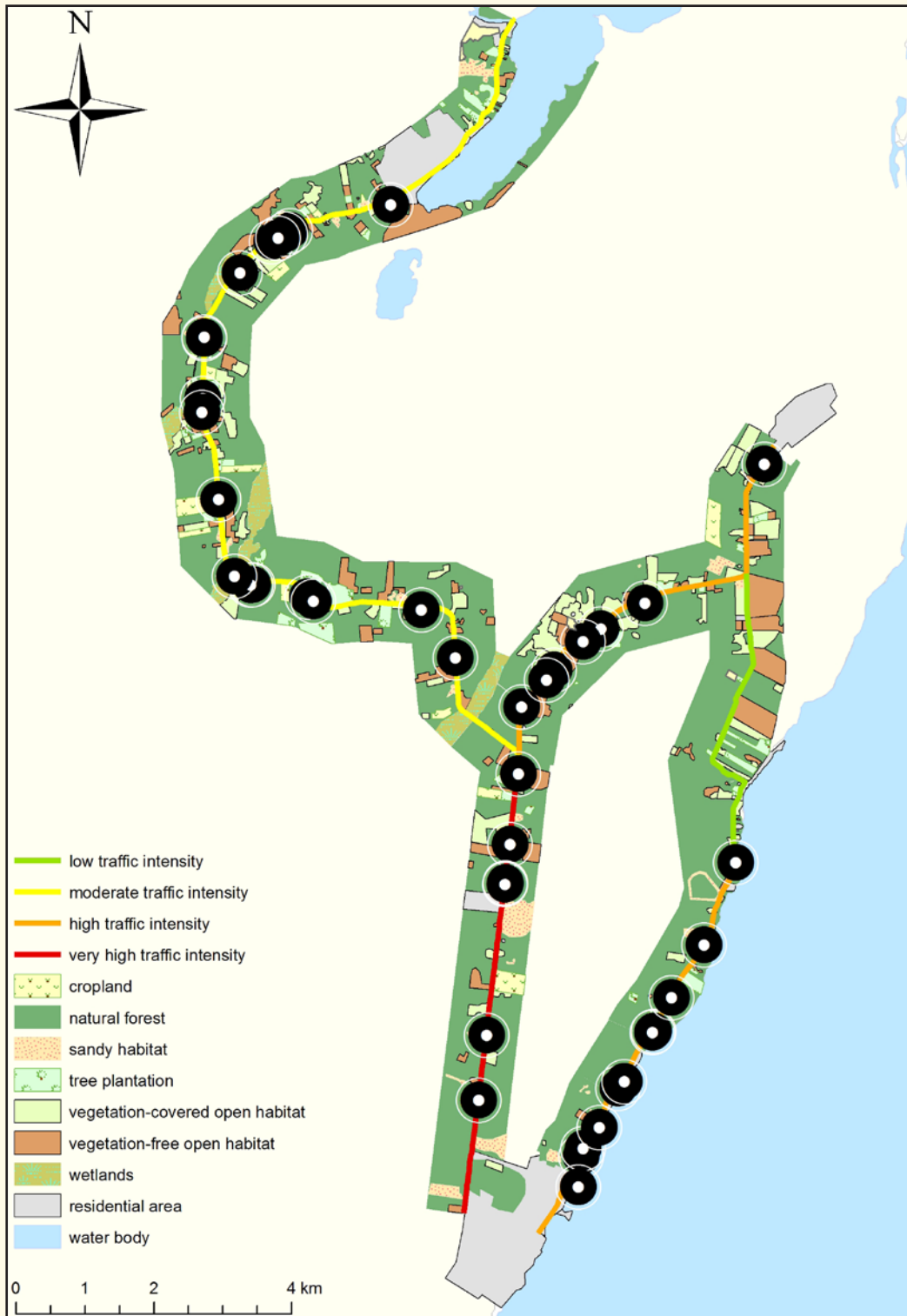


Fig. 13. Spatial distribution of collected specimens (black dots with white centers) of *Micrurus diastema* along the transect.

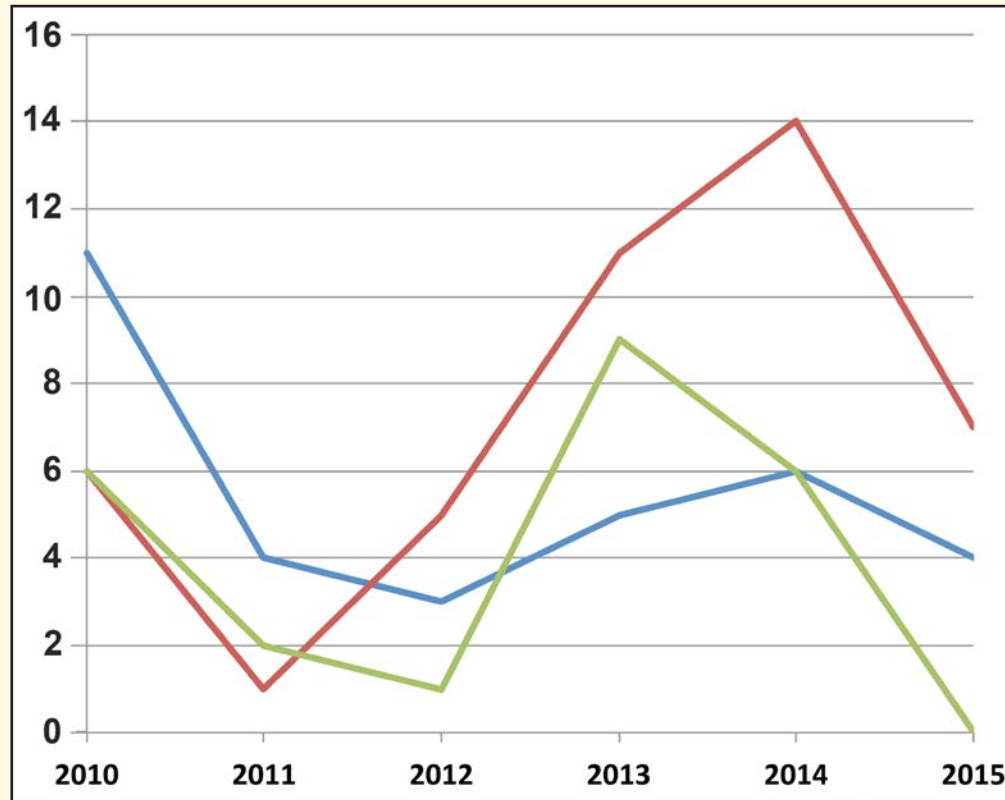


Fig. 14. Graph of the annual number of collected specimens of the three species treated in this paper. *Leptodeira frenata* (blue); *Ninia sebae* (red); and *Micrurus diastema* (green).

Acknowledgments.—Collecting and exportation permits (OFICIO NÚM. SGPA/DGVS/02570/15, OFICIO NÚM. SGPA/DGVS/01629/16, both issued to Fausto Méndez-de la Cruz with extensions to JRCV and GK) were issued by Martin Vargas-Prieto, and Jorge Maksabedian-de la Roquette, Dirección General de Vida Silvestre of Secretaría del Medio Ambiente y Recursos Naturales, México D.F., Mexico. We thank the numerous students who have joined PMBG during his surveys. We are especially grateful to Raymundo Mineros-Ramírez, Dulce M. Noriega-Flores, N. Gabriela Blanco-Campos (Chetumal, Mexico), and Linda Mogk (Frankfurt am Main, Germany) for their help with processing the collected specimens. We also thank Roberto Carlos Barrientos-Medina for kindly identifying the eel preyed upon by a *Micrurus distema*. Finally, we thank the earlier reviewers for the comments they provided for previous sections of the survey, as well as Louis Porras for helpful comments and corrections on the manuscript.

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Appendix 1. Specimens collected.

Leptodeira frenata.—**MEXICO:** QUINTANA ROO: between Calderitas and Ruinas de Oxtankah: ECO-CH-H 3685, 3697–98, 3722, SMF 100550–51; between Calderitas and turn to Laguna Guerrero: ECO-CH-H 2915–16, 3064, 3112, 3257, 3710, 3721, SMF 100557, 100559; between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2946, 3062, 3067, 3109–10, 3114, 3381, 3709, 3656, 3719; between Luis Echeverría and Ruinas de Oxtankah: ECO-CH-H 3375, SMF 100553–54, between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 3063, 3066, 3111, 3113, SMF 100552; coastal road between Calderitas and Ruinas de Oxtankah: ECO-CH-H 2917–18, SMF 100549, 100558; near entrance to Ruinas de Oxtankah: ECO-CH-H 3686; road from Chetumal to Bacalar: ECO-CH-H 3738; village of Laguna Guerrero: ECO-CH-H 3748, SMF 100555–56; between Calderitas and turn to Laguna Guerrero: ECO-CH-H 3715.

Ninia sebae.—**MEXICO:** QUINTANA ROO: 2 km on road from Luis Echeverría to Calderitas: ECO-CH-H 2927; between Calderitas and Ruinas de Oxtankah: ECO-CH-H 3428, SMF 100576–78; between Calderitas and turn to Chetumal: ECO-CH-H 3798; between Calderitas and turn to Laguna Guerrero: ECO-CH-H 2925, 3107, SMF 100572–75; between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2924, 3104–06, 3487, 3494–5, 3737, 3196, 3799, SMF 100579–83; between Luis Echeverría and Ruinas de Oxtankah: ECO-CH-H 3606; between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 3192, 2926, 3486, SMF 99641, 100584–85; coastal road between Calderitas and Ruinas de Oxtankah: SMF 99637–38; near entrance to Ruinas de Oxtankah: SMF 99639–40; near Ruinas de Oxtankah: SMF 101357; village of Laguna Guerrero: ECO-CH-H 3108.

Micrurus diastema.—**MEXICO:** QUINTANA ROO: between Calderitas and turn to Laguna Guerrero: SMF 100563, 100571; between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2932, 3127, 3141–42, 3194, SMF 99634–36, 100564–66; between Luis Echeverría and Ruinas de Oxtankah: ECO-CH-H 3716, SMF 100569; between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 2934, 3140, SMF 100567–68; coastal road between Calderitas and Ruinas de Oxtankah: ECO-CH-H 2933; village of Laguna Guerrero: SMF 100570.





Gunther Köhler received a degree in Veterinary Medicine (Staatsexamen) at the University Gießen, Germany, in 1993, and a Doctoral degree at Goethe University Frankfurt am Main, Germany, in 1995; since that time, he has been the Curator of Herpetology at the Senckenberg Research Institute, Frankfurt am Main, Germany. His research focuses on the Neotropical herpetofauna, primarily that of Central America and Mexico. To date, Gunther has authored or co-authored 27 books and 210 research papers on amphibians and reptiles.



José Rogelio Cedeño-Vázquez completed his Licenciatura in biology at the Universidad Michoacana de San Nicolás de Hidalgo, Morelia, Michoacán, Mexico in 1995, and received his Master's and Doctoral degrees at El Colegio de la Frontera Sur (ECOSUR) in 2002 and 2008, respectively. From 1996 to 2000 he collaborated in several research projects in the Yucatan Peninsula. He was a researcher and instructor in the school of Biology at the Instituto Tecnológico de Chetumal, Quintana Roo, Mexico from 2008 to 2012, and since 2013 has been a faculty member in the Departamento de Sistemática y Ecología Acuática at ECOSUR Unidad Chetumal; he also is the Curator of Herpetology at the Museo de Zoología of ECOSUR. Rogelio is interested in the systematics, ecology, conservation, and management of amphibians and reptiles from the Yucatan Peninsula, and to date has co-authored a book, several book chapters, research notes, and scientific and popular articles. He is a member of the Sistema Nacional de Investigadores (National System of Researchers), of Mexican herpetological associations, and of the IUCN/ SSC-Amphibian and Crocodile Specialist Group.



Manuela Spaeth graduated with a B.Sc. in Biology and recently started her M.Sc. in Ecology and Evolution at the Goethe University Frankfurt, Germany. Manuela is particularly interested in biodiversity, evolution and systematics. During an internship at Gunther Köhler's lab at Senckenberg Museum, her fascination for the field of herpetology amplified.



Pablo M. Beutelspacher-García is an independent researcher. Although Pablo did not pursue a professional career, he is a born naturalist with huge empirical knowledge on the herpetofauna of the Yucatan Peninsula. Pablo's curiosity and passion for reptiles (especially snakes) arose in childhood, when he began making detailed observations on their behavior in order to distinguish between facts and myths. He has collaborated with researchers from El Colegio de la Frontera Sur, Chetumal, Quintana Roo, Mexico, in several research projects involving biodiversity inventories in Campeche, Quintana Roo, and Yucatán, Mexico, and also has co-authored technical reports, and several distribution and natural history notes on amphibians and reptiles.