The snail-eating snakes *Dipsas brevifacies*, *Sibon sanniolus*, and *Tropidodipsas sartorii* are among the most commonly encountered species during the ongoing nocturnal snake surveys being conducted by the authors. The road-killed specimens are collected and later dissected to generate data on the diet and reproduction of the species. Furthermore, having large sample sizes of species from a single area allows the authors to study individual variation in morphology without the issue of geographical variation. Pictured here is an adult individual of *Sibon sanniolus*, a small, slender snake with a specialized diet of snails. © Gunther Köhler

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The Chetumal Snake Census: generating biological data from road-killed snakes. Part 2. *Dipsas brevifacies, Sibon sanniolus,* and *Tropidodipsas sartorii*

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Abstract: We present data and observations on the snake species *Dipsas brevifacies*, *Sibon sanniolus*, and *Tropidodipsas sartorii* 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, Mexico, monitoring, population dynamics, Quintana Roo, reproduction, road-kills, snake survey

Resumen: Presentamos datos y observaciones sobre las especies de serpientes *Dipsas brevifacies*, *Sibon sanniolus* y *Tropidodipsas sartorii* 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, Mexico, mortalidad por atropello, muestreo y monitoreo de serpientes, dinámica poblacional, Quintana Roo, reproducción

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INTRODUCTION

In a previous article (Köhler et al., *This volume*), 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 snail-eating snakes, 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 100 specimens of *Dipsas brevifacies*, 70 of *Sibon sanniolus*, and 40 of *Tropidodipsas sartorii* (see Appendix 1 for list of specimens examined). For measurements, we use the abbreviations SVL (snout–vent length) and TL (tail length). In the species studied in this article, we found considerable variation in the scalation of the loreal/preocular region. See Fig. 1 for the terminology and designation of scalation types.

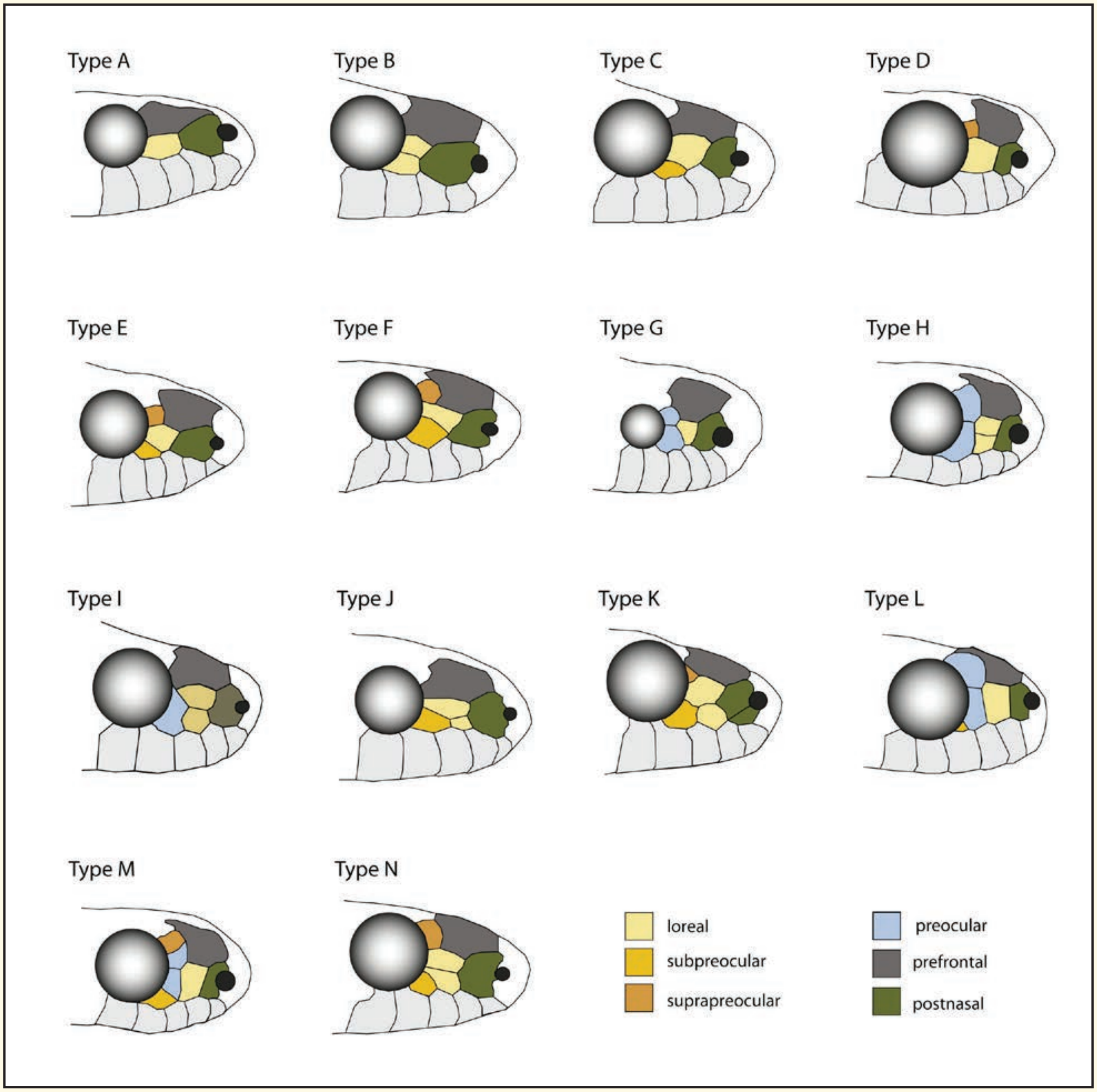

Fig. 1. Terminology and variation of scales in the loreal/preocular region in the snail-eating snakes studied in this article.

SPECIES ACCOUNTS

***Dipsas brevifacies* (Cope, 1866)**

Figs. 2–4

Material: We collected 100 specimens, of which we identified 57 as males, 27 as females, and 16 as indeterminate.

External morphology and coloration: See Table 1 for variation in selected morphometric and scalation characters. The variation in the loreal/preocular region in our material is much greater than previously reported for this species (see Fig. 3 and Table 2).

Diet: None of the preserved specimens of *Dipsas brevifacies* contained identifiable intestinal contents.

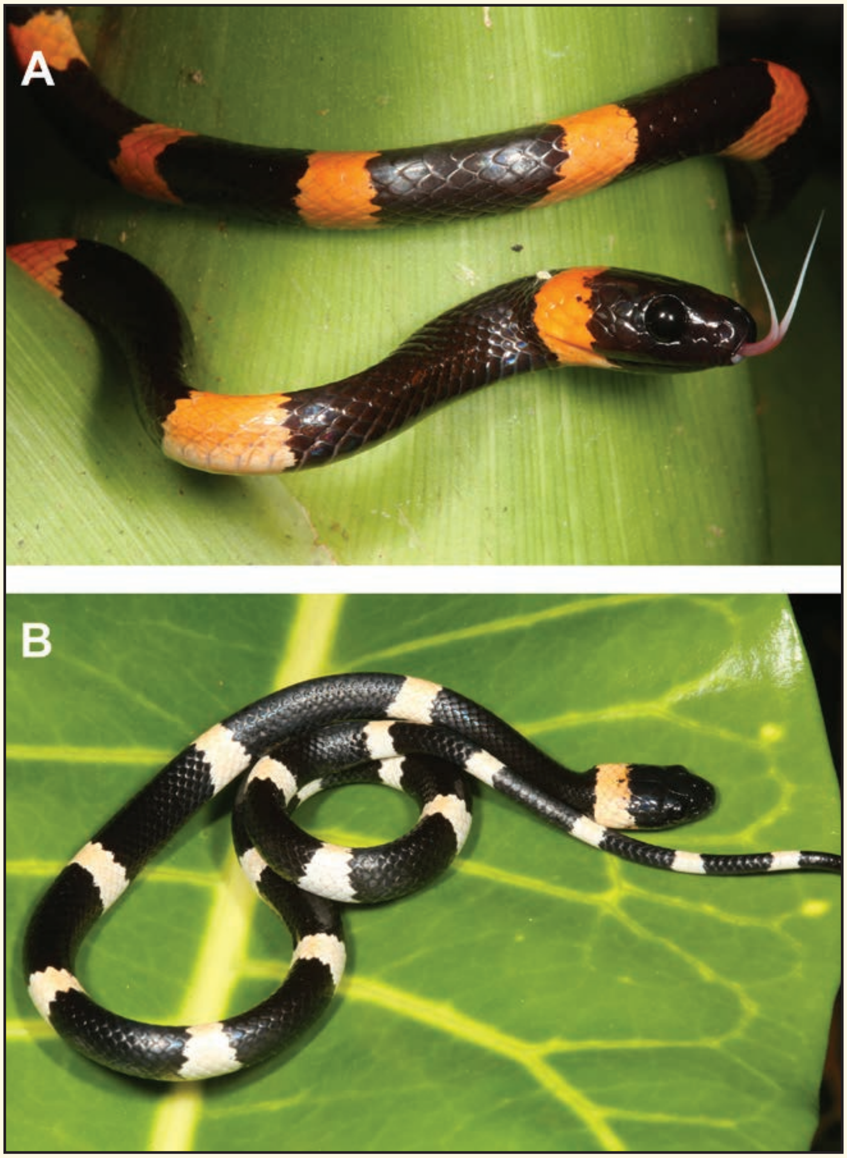

Fig. 2. *Dipsas brevifacies* in life. (A) an adult (GK-5139); and (B) a juvenile (GK-5163). © Gunther Köhler

Table 1. Selected measurements, proportions, and scale characters in *Dipsas brevifacies*, *Sibon sanniolus*, and *Tropidodipsas sartorii*. Range is followed by mean value and standard deviation (in parentheses). SVL = snout–vent length; and TL = tail length.

Character		***Dipsas brevifacies*** ♂ 57 ♀ 27	***Sibon sanniolus*** ♂ 42 ♀ 13	***Tropidodipsas sartorii*** ♂ 12 ♀ 22
SVL (mm)	Males	185–415 (323.29 ± 44.32)	155–386 (260.21 ± 40.39)	285–552 (429.67 ± 84.91)
	Females	221–400 (325.31 ± 39.92)	232–290 (261.35 ± 17.18)	255–756 (427.29 ± 122.74)
TL / SVL	Males	0.275–0.429 (0.372 ± 0.033)	0.230–0.516 (0.390 ± 0.049)	0.190–0.298 (0.245 ± 0.030)
	Females	0.300–0.459 (0.362 ± 0.043)	0.297–0.463 (0.354 ± 0.042)	0.197–0.256 (0.230 ± 0.014)
Ventrals	Males	150–181 (171.06 ± 5.81)	145–171 (157.87 ± 6.05)	198–215 (206 ± 6.16)
	Females	155–181 (170.63 ± 6.36)	145–167 (158.88 ± 6.36)	207–229 (221 ± 8.28)
Subcaudals	Males	73–99 (83.32 ± 6.06)	65–95 (79.21 ± 6.01)	52–55 (53 ± 1.29)
	Females	71–95 (81.77 ± 8.27)	64–84 (72.50 ± 7.29)	43–55 (48 ± 6.25)
Number of dorsal scales rows at midbody		15 (15.0 ± 0.0)	15 (15.0 ± 0.0)	17 (17.0 ± 0.0)
Number of dorsal scales rows anterior to vent		15 (15.0 ± 0.0)	15 (15.0 ± 0.0)	17 (17.0 ± 0.0)
Cloacal scute		undivided	undivided	undivided
Number of loreal scales		0–2 (0.3 ± 0.5)	0–1 (0.770 ± 0.43)	0–2 (0.44 ± 0.53)
Number of preocular scales		0–4 (1.51 ± 1.09)	0–3 (1.78 ± 0.96)	0–3 (2.18 ± 0.94)
Number of postocular scales		2–4 (2.88 ± 0.45)	2–3 (2.02 ± 0.13)	2–3 (2.07 ± 0.25)
Number of anterior temporals		1–3 (1.95 ± 0.33)	1–2 (1.26 ± 0.44)	1 (15.0 ± 0.0)
Number of posterior temporals		1–3 (2.86 ± 0.37)	2–3 (2.12 ± 0.33)	1–2 (1.95 ± 0.22)
Number of supralabials		8–11 (9.15 ± 0.48)	7–9 (8.39 ± 1.47)	7–9 (7.57 ± 0.71)
Number of infralabials		8–12 (10.31 ± 1.59)	7–10 (9.11 ± 0.74)	7–9 (8.3 ± 1.02)

Table 2. Frequency distribution of variation in the loreal/preocular region in *Dipsas brevifacies*, *Sibon sanniolus*, and *Tropidodipsas sartorii.* See Fig. 1 for illustration of scalation types.

Type	*D. brevifacies*	*S. sanniolus*	*T. sartorii*
A	14.3%	0.0%	0.0%
B	14.3%	0.0%	0.0%
C	28.4%	0.0%	0.0%
D	0.0%	8.5%	13.2%
E	4.8%	0.0%	44.7%
F	3.6%	0.0%	0.0%
G	2.4%	61.0%	26.3%
H	0.0%	1.7%	0.0%
I	2.4%	0.0%	0.0%
J	14.3%	0.0%	0.0%
K	14.3%	0.0%	0.0%
L	0.0%	25.4%	13.2%
M	0.0%	3.4%	0.0%
N	1.2%	0.0%	2.6%

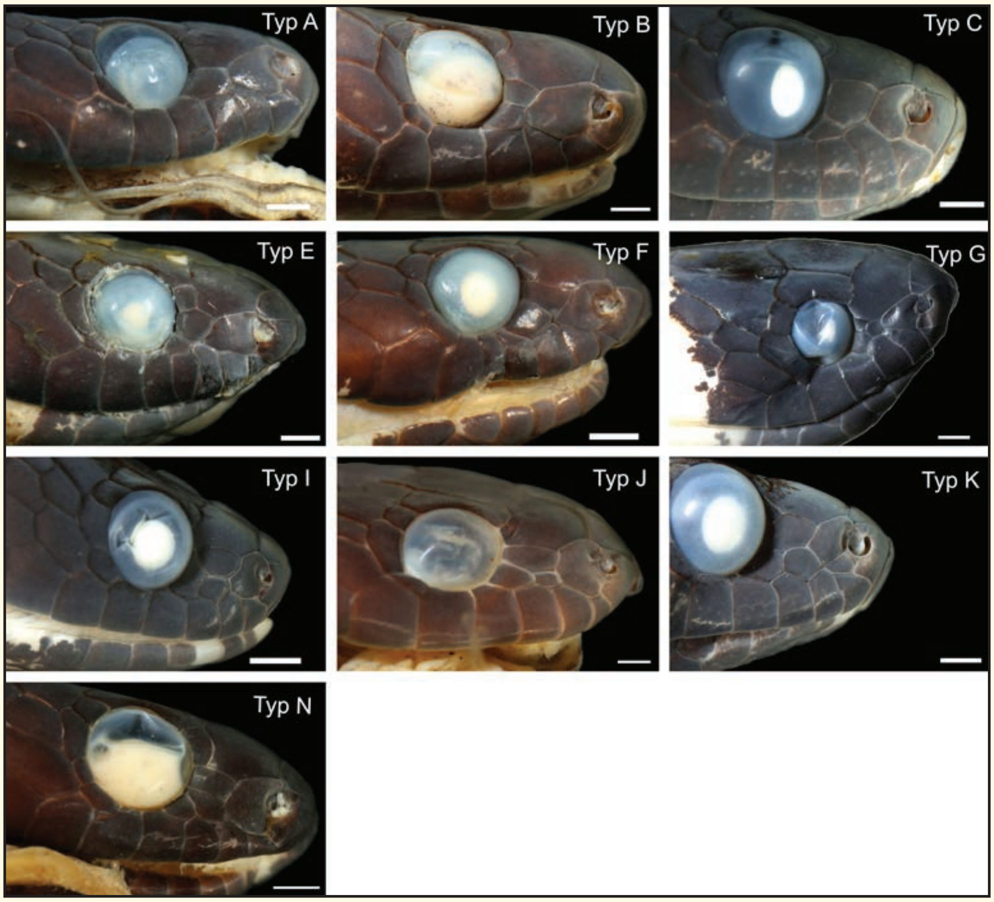

Fig. 3. Variation of scales in the loreal/preocular region in *Dipsas brevifacies*. Type designation corresponds to Types in Fig. 1. Scale bars equal 1.0 mm.

Reproduction: The dissection of 11 male and 11 female specimens of *Dipsas brevifacies* yielded data on reproduction (also see Fig. 4). The relative testis size (ratio of testis length × width/SVL) in the 11 males was 0.014–0.131 (0.070 ± 0.034). We found the largest relative testis size (0.131) in a specimen collected in October, and the one with the smallest value (0.014) in a specimen preserved in February. The relative ovary size (ratio of ovary length × width/SVL) in the 11 females was 0.045–0.218 (0.149 ± 0.057). We detected the largest relative ovary size (0.218) in a female collected in October, and the lowest value (0.045) in a female collected in July. The number of vitellogenic follicles per side ranged from 4 to 8 (7.0 ± 1.98). The follicle length was 3.1–4.6 (3.88 ± 0.54), and the follicle width 1.8–3.4 (2.75 ± 0.71). We counted the highest number of follicles (8) in females collected in July, and the lowest number in females preserved in June. We found the largest follicles in females collected in October, and the smallest ones in those preserved in June. Four specimens contained oviducal eggs, with a clutch size ranging from 3 to 4 eggs (average 3.25). We collected these females in the months of June, July, and August.

Seasonality: See Figure 5 for the temporal distribution of the 91 road-killed individuals of *Dipsas brevifacies* over a six-year period. We collected very few individuals during the winter months (November through January), and found the majority during the warmer months.

Distribution in the transect: We collected this species throughout the 39 km road transect (Fig. 6). We found 2.6% of the specimens near cropland, 2.9% near residential areas, 16.5% in areas surrounded by vegetation-free open habitat, 4.4% near wetlands, 13.2% in areas surrounded by vegetation-covered open habitat, 11.0% adjacent to tree plantations, 4.4% in areas surrounded by open, sandy habitat, and 45.0% adjacent to natural forest. The few individuals we encountered alive (9) either were crawling across the road or were found in the low vegetation bordering the road.

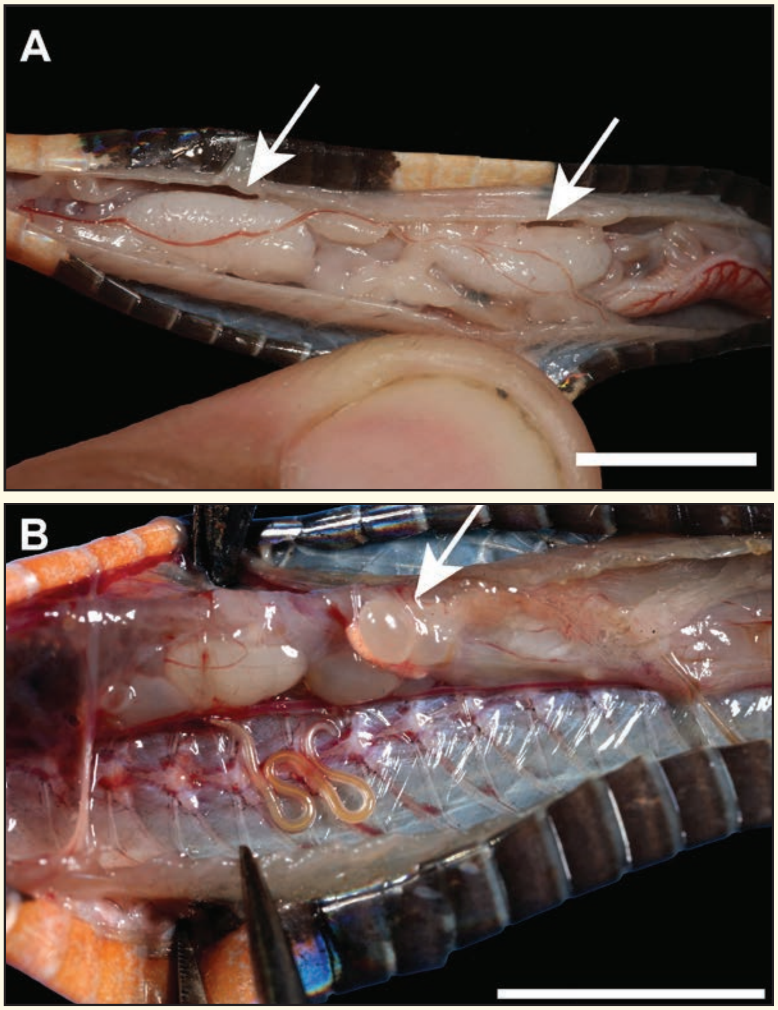

Fig. 4. Specimens of *Dipsas brevifacies* dissected to study their gonads. (A) A male (SMF 99599); and (B) a female (SMF 100257). The testes and follicles, respectively, are indicated by arrows. © Gunther Köhler

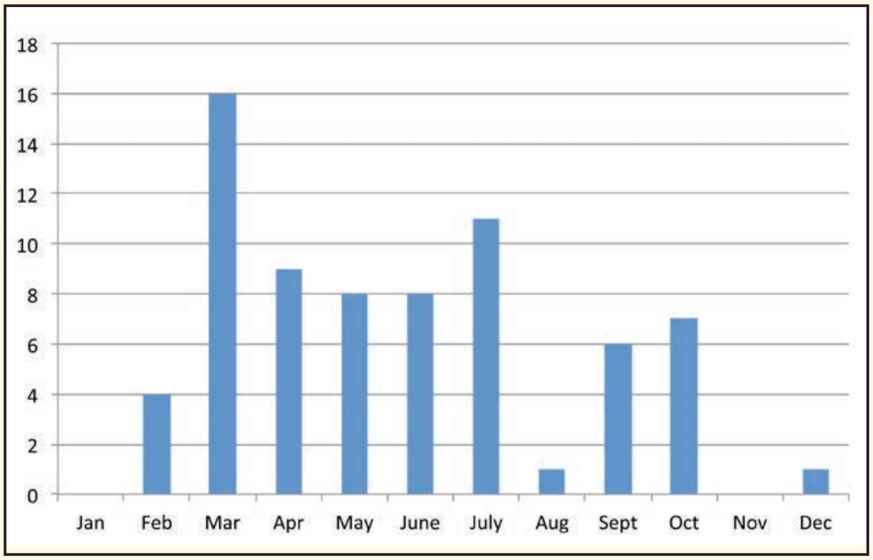

Fig. 5. Diagram showing the frequency distribution of collected specimens of *Dipsas brevifacies* during the course of the year.

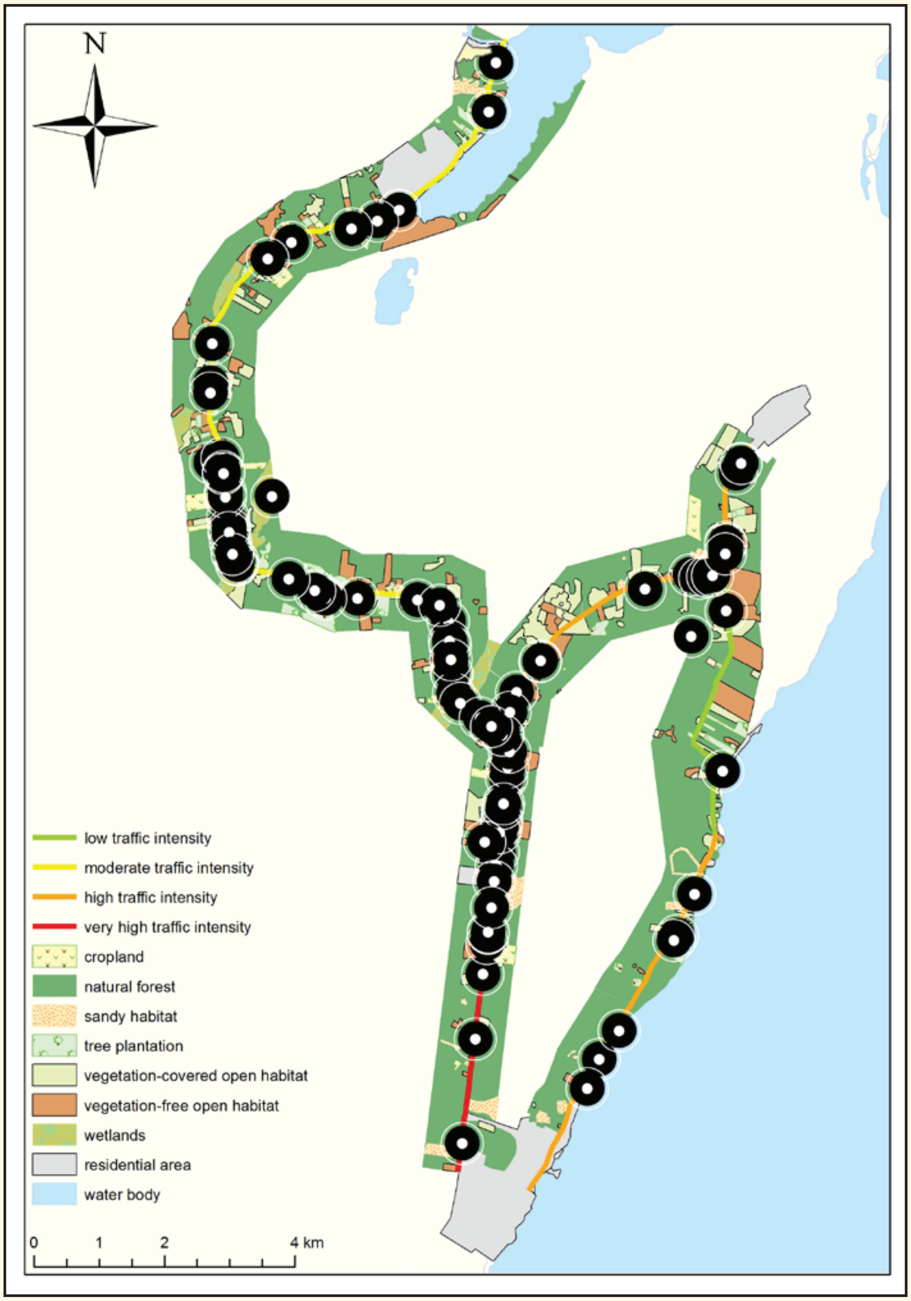

Fig. 6. Spatial distribution of the collected specimens (black dots with white centers) of *Dipsas brevifacies* along the transect.

Sibon sanniolus (Cope, 1866)

Figs. 7–9

Material: We collected 70 specimens, of which we identified 47 as males, 13 as females, and 10 as indeterminate.

External morphology and coloration: See Table 1 for variation in selected morphometric and scalation characters. Fig. 8 depicts the considerable variation in the loreal/preocular region in this species (also see Table 2).

Diet: None of the preserved specimens of *Sibon sanniolus* contained identifiable intestinal contents.

Reproduction: The dissection of 11 male and 3 female specimens of *Sibon sanniolus* yielded data on reproduction (Fig. 9). The relative testis size (ratio testis length × width/SVL) in the 11 males was 0.041–0.133 (0.077 ± 0.031). We found the largest relative testis size (0.133) in a specimen collected in October, and the one with the smallest value (0.041) in one preserved in August. The relative ovary size (ratio ovary length × width/SVL) in the 11 females was 0.045–0.218 (0.149 ± 0.057). One female, collected in May, contained three vitellogenic follicles on one side. Two specimens contained oviducal eggs, one with a total clutch size of 3, the other of 4. We collected these females in the months of February and July, respectively.

Seasonality: See Fig. 10 for the temporal distribution of the 61 road-killed individuals of *Sibon sanniolus* 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.

Fig. 7. *Sibon sanniolus* (SMF 99649) in life. © Gunther Köhler

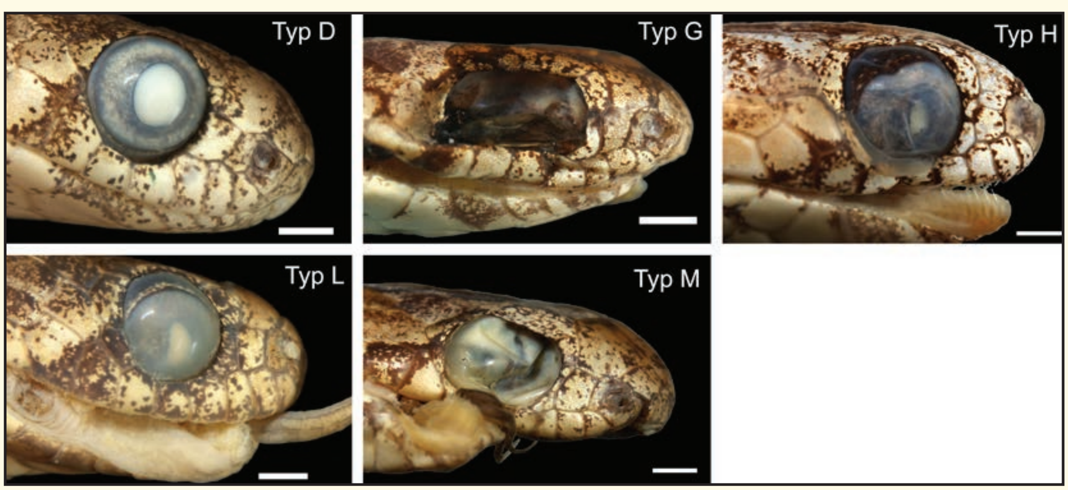

Fig. 8. Variation of scales in the loreal/preocular region in *Sibon sanniolus*. The type designation correspond to Types in Fig. 1. Scale bars equal 1.0 mm. © Gunther Köhler

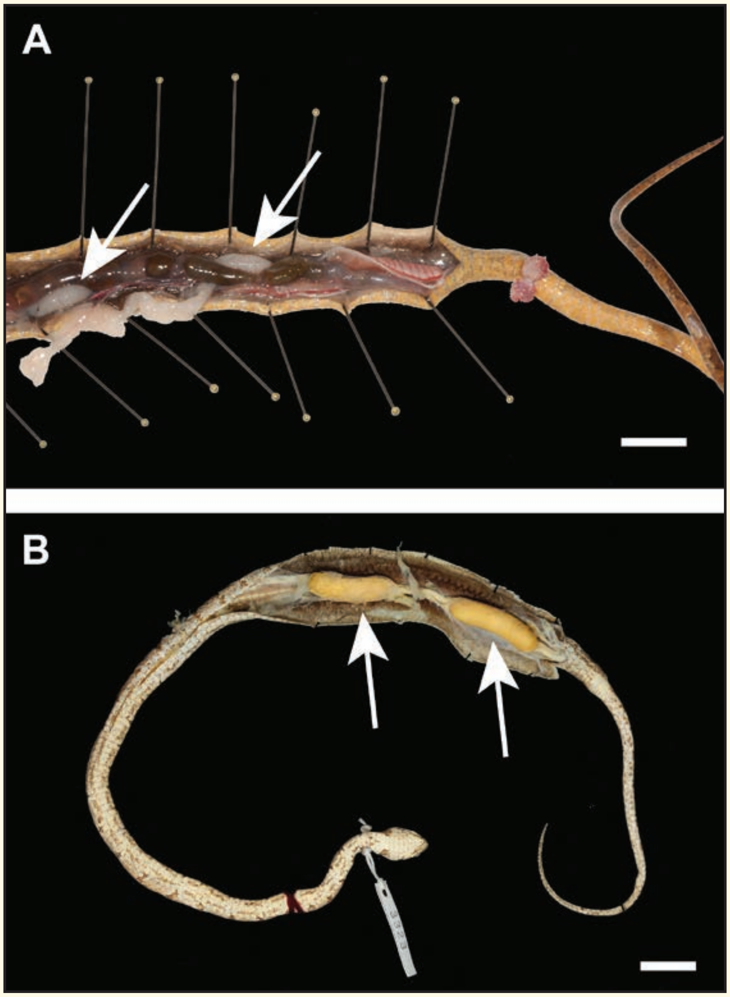

Fig. 9. Specimens of *Sibon sanniolus* dissected to study their gonads. (A) A male (SMF 99649); and (B) a female (SMF 100321). The testes and eggs, respectively, are indicated by arrows. © Gunther Köhler

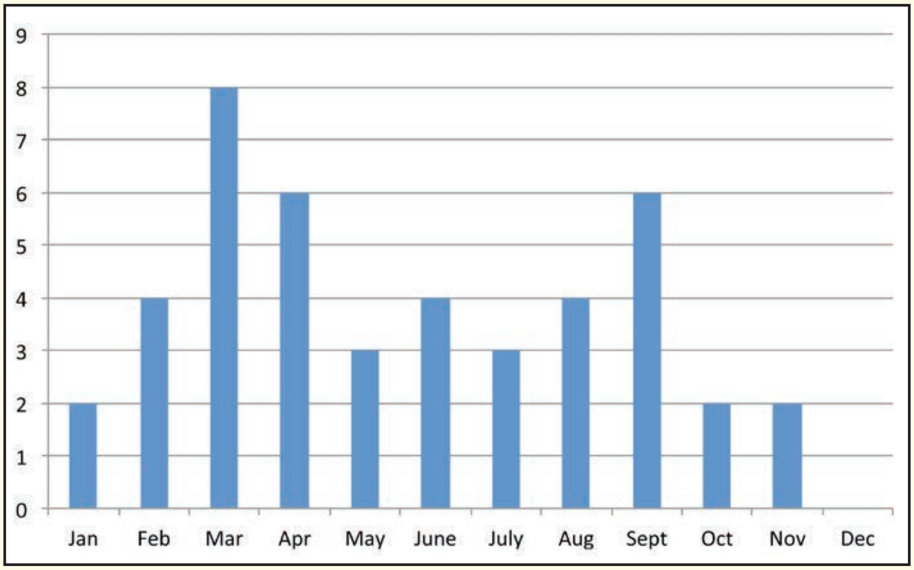

Fig. 10. Diagram showing the frequency distribution of collected specimens of *Sibon sanniolus* during the course of the year.

Distribution in the transect: We collected this species throughout our 39 km road transect (Fig. 11). We found 2.2% of the specimens near cropland, 1.1% near residential areas, 9.5% in areas surrounded by vegetation-free open habitat, 8.4% near wetlands, 19.6% in areas surrounded by vegetation-covered open habitat, 15.6% adjacent to tree plantations, 2.8% in areas surrounded by open, sandy habitat, and 40.8% adjacent to natural forest. The few individuals we encountered alive (9 specimens) either were crawling across the road or found in the low vegetation bordering the road.

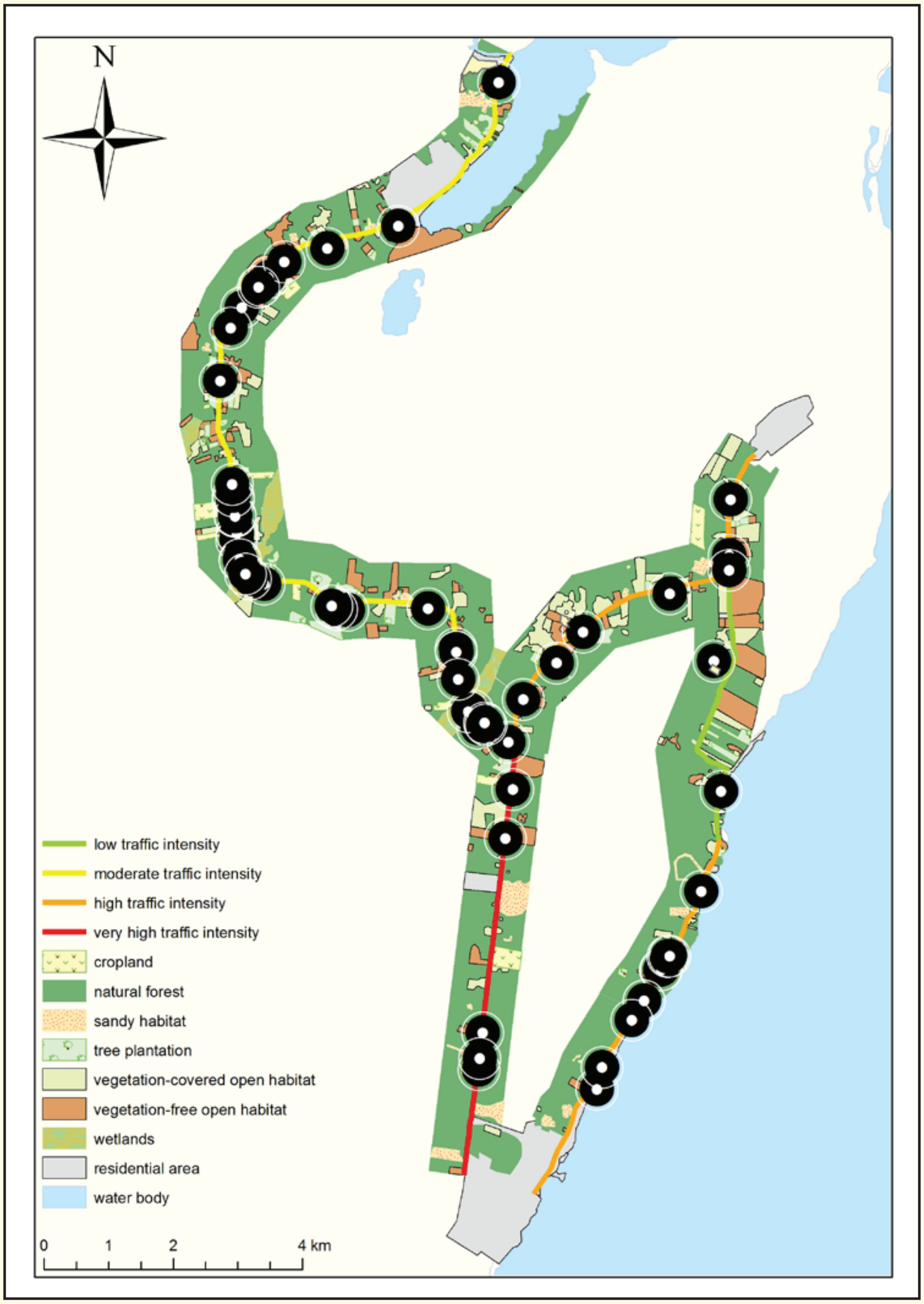

Fig. 11. Spatial distribution of collected specimens (black dots with white centers) of *Sibon sanniolus* along the transect.

***Tropidodipsas sartorii* Cope, 1863**

Figs. 12, 13

Material: We collected 40 specimens, of which we identified 12 as males, 22 as females, and 6 as undeterminate.

External morphology and coloration: See Table 1 for variation in selected morphometric and scalation characters. Fig. 13 depicts the considerable variation in the loreal/preocular region in this species (see also Table 2).

Diet: We found the remains of a slug (length 19.9 mm, diameter 5.7 mm) in the intestine of one specimen of *Tropidodipsas sartorii* (PBG 290).

Fig. 12. A *Tropidodipsas sartorii* in life. (A) An adult (not collected); and (B) an adult (SMF 99670). © Gunther Köhler

Reproduction: The dissection of 5 male and 3 female specimens of *Tropidodipsas sartorii* yielded data on reproduction. The relative testis size (ratio testis length × width/SVL) in the 5 males was 0.038–0.220 (0.135 ± 0.067). We found the largest relative testis size in a specimen collected in October, and the one with the smallest value in a specimen preserved in November. The relative ovary size (ratio of ovary length × width/SVL) in the 3 females was 0.117–0.358 (0.270 ± 0.133). We detected the largest relative ovary size in a female collected in August, and the lowest value in a female collected in September. We determined the number of vitellogenic follicles in three females, two collected in August that contained 14 follicles (size 6.5 mm × 3.1 mm) and another with 20 follicles (size 6–7 mm × 2–3 mm; Fig. 14), respectively, and the third specimen, collected in October, contained 11 follicles (size 11.9 mm × 3.9 mm). One individual (SMF 100362) preserved in September contained eight oviducal eggs.

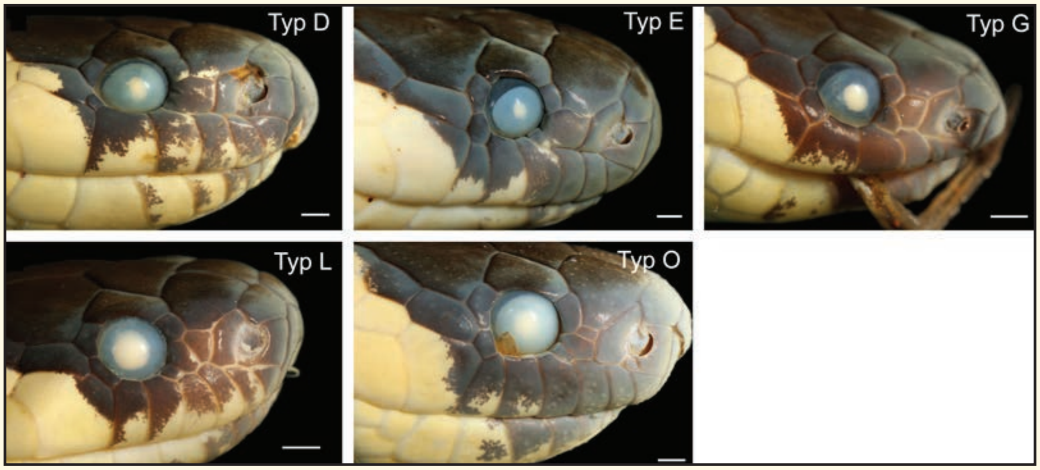

Fig. 13. Variation of scales in the loreal/preocular region in *Tropidodipsas sartorii*. The type designation correspond to Types in Fig. 1. Scale bars equal 1.0 mm.
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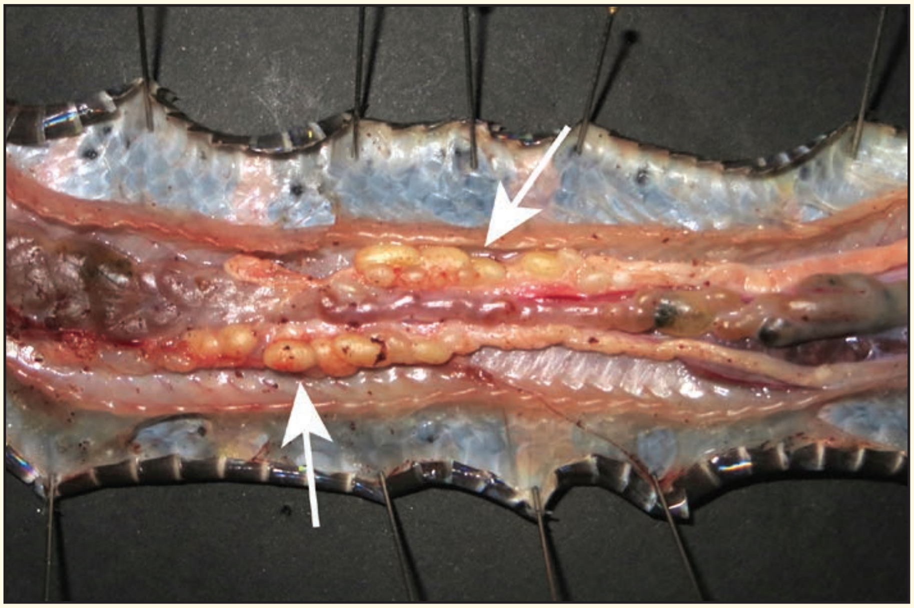

Fig. 14. A female (ECO-CH-H 3733) of *Tropidodipsas sartorii* dissected to study the gonads; the follicles are indicated by arrows.
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Seasonality: See Fig. 15 for the temporal distribution of the 37 road-killed individuals of *Tropidodipsas sartorii* 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, especially from July through October.

Distribution in the transect: We collected this species throughout most of our 39 km road transect, except for a portion along the Caribbean coast (Section 2 of our transect; Fig. 16). We found 8.1% of the specimens near cropland, 2.7% near residential areas, 17.1% in areas surrounded by vegetation-free open habitat, 4.5% near wetlands, 9.0% in areas surrounded by vegetation-covered open habitat, 8.1% adjacent to tree plantations, 2.7% in areas surrounded by open, sandy habitat, and 47.8% adjacent to natural forest. The few individuals that we encountered alive (3 specimens) either were crawling across the road or found in low vegetation bordering the road.

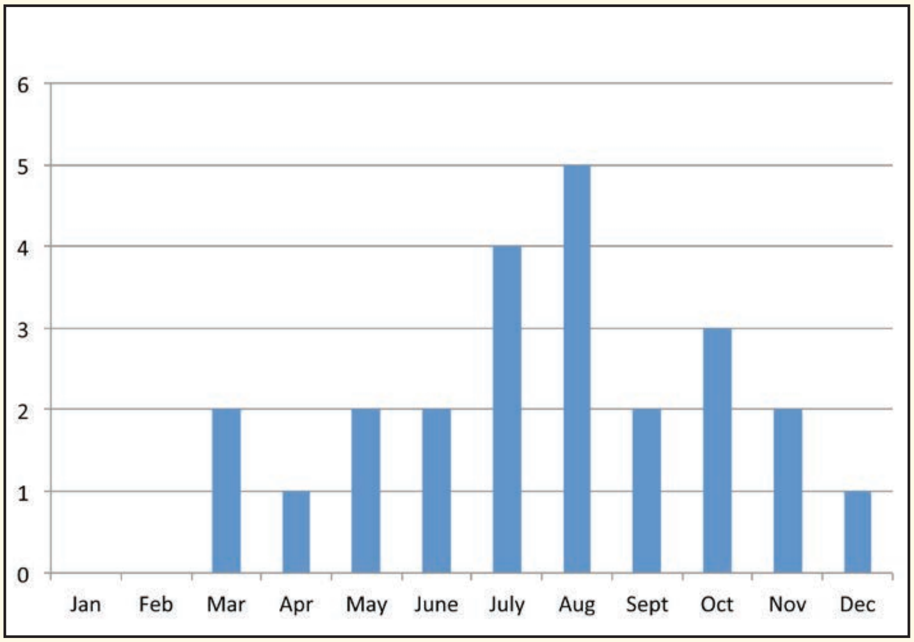

Fig. 15. Diagram showing the frequency distribution of collected specimens of *Tropidodipsas sartorii* during the course of the year.

DISCUSSION

Our data agree well with the published morphological and ecological information on these three species of snakes, although the degree of variation in the scalation of the loreal/preocular region previously has not been covered in detail (Peters, 1960; Kofron, 1982). Lee (1996: 358) used the shape of the pale nuchal band as diagnostic character to distinguish between *Tropidodipsas sartorii* and *T. fasciata* (i.e., nuchal band extending anteriorly on supralabials to beyond the eye in *T. sartorii* vs. not beyond the eye in *T. fasciatus*). In our sample of 37 specimens of *T. sartorii*, however, the nuchal band extends anteriorly on the supralabials to beyond the eye in only one specimen (SMF 100358) and not in the remaining specimens, at least not uninterruptedly—in most specimens, some degree of black pigmentation is present on the supralabials below eye (also see Fig. 13 for variation in this character). Thus, we dismiss this character as a differentiating feature between these two species. All of our specimens of *T. sartorii* contain weakly keeled dorsal scales, a cylindrical body, non-protruding eyes, and displayed reddish-orange bands before preservation, and thus were readily identified as *T. sartorii* (Kofron, 1988).

We recorded most specimens of these three species during the warmer and wetter months of the year. We depict the annual number of collected specimens of the three species in Fig. 17. Except for the high number of individuals of *Dipsas brevifacies* collected during the first year of our study, we could not detect a clear trend during this six-year period. Regarding the distribution of these three species within the transect, except for *T. sartorii* which was absent in Transect Section 2, we collected them along the entire transect and found the majority adjacent to natural forest. These snakes apparently feed exclusively on terrestrial snails and slugs (Dundee et al., 1986; Kofron, 1988; Lee, 1996). *Dipsas brevifacies* has been reported to lay clutches of 2–5 eggs, with 2–3 being most common (Campbell, 1998), and this agrees with our data. The little information available on the reproductive biology of *Sibon sanniolus* indicates that this oviparous snake produces clutches of 2–5 eggs that are deposited during the rainy season and hatch in October and November (Kofron, 1983; Lee, 1996). Therefore, it is noteworthy that one of our specimens collected in February (the dry season), contained mature oviducal eggs. According to Kofron (1987) and Campbell (1998), *Tropidodipsas sartorii* lays clutches of 3–6 eggs late in the dry season or early in the rainy season, which is in accordance with our observations.

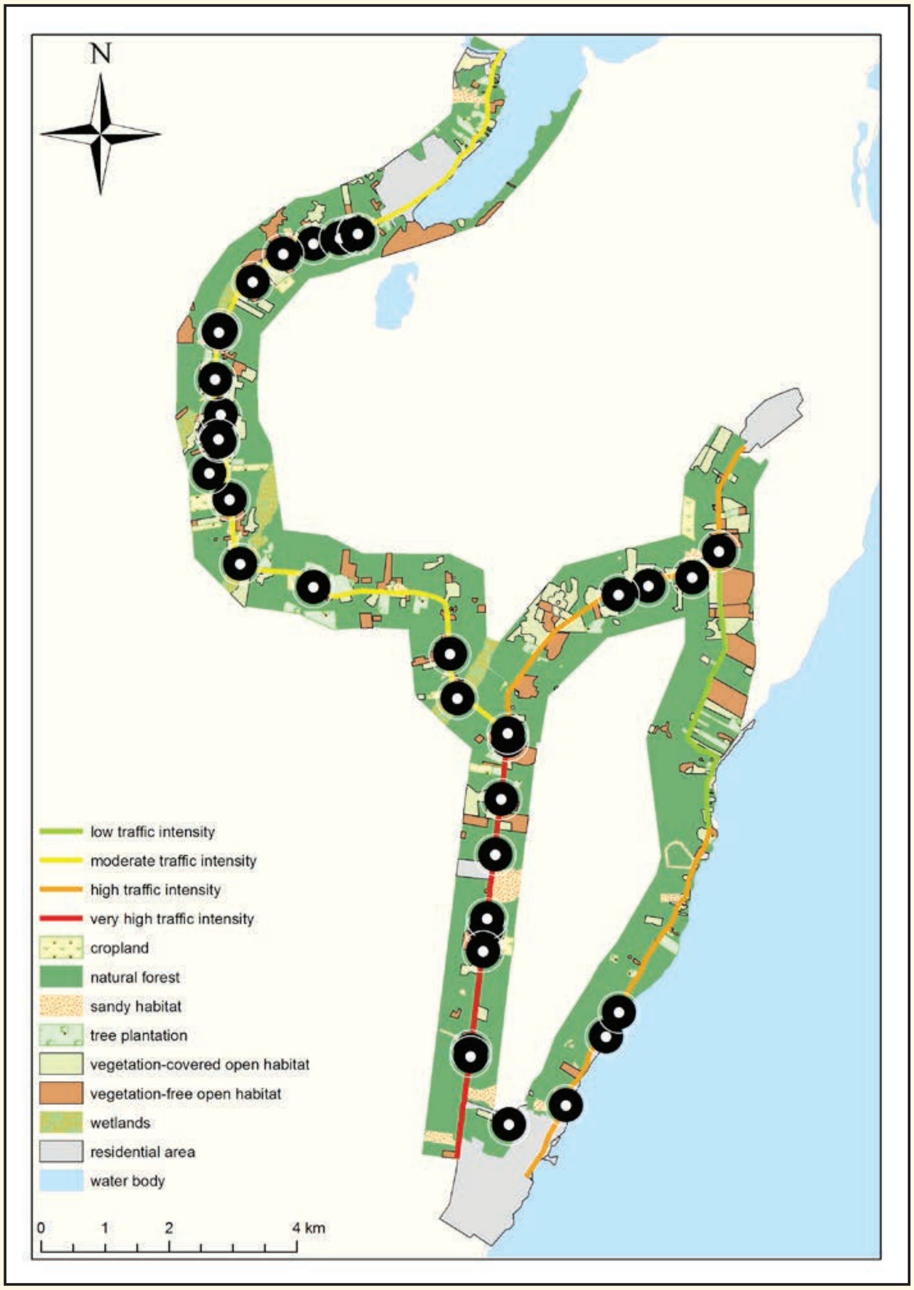

Fig. 16. Spatial distribution of collected specimens (black dots with white centers) of *Tropidodipsas sartorii* along the transect.

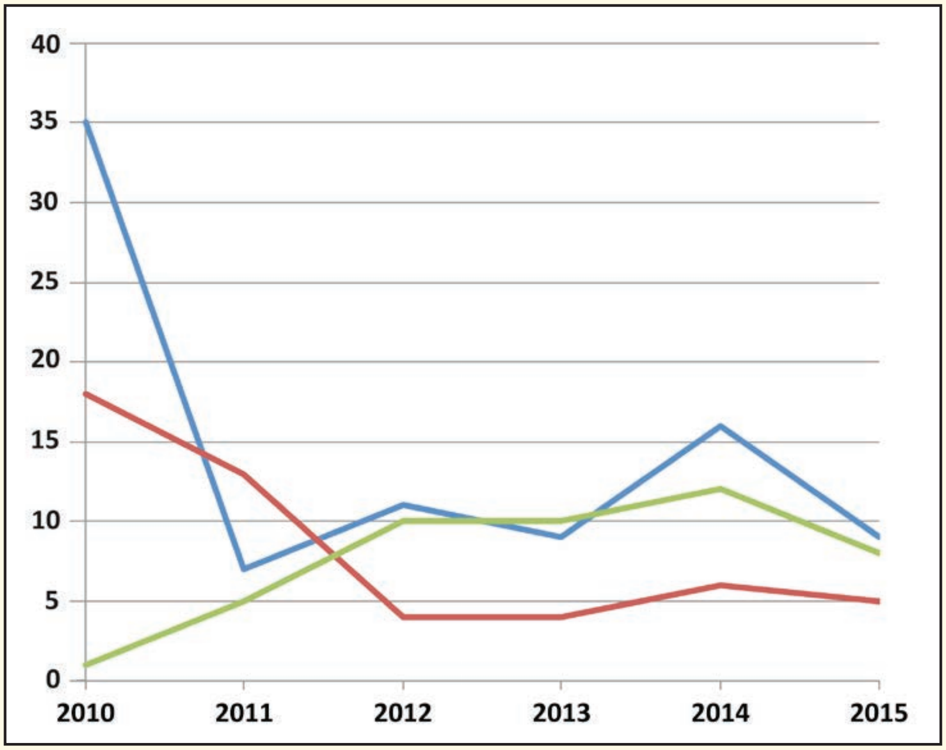

Fig. 17. The annual number of collected specimens of the three species treated in this paper. *Dipsas brevifacies* (blue graph); *Sibon sanniolus* (red graph); and *Tropidodipsas sartorii* (green graph).

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Appendix 1. Specimens examined

Dipsas brevifacies.—**MEXICO:** QUINTANA ROO: between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2899–2902, 2904, 2906, 2908–12, 3044–45, 3048–50, 3052, 3055–56, 3376, 3382, 3386, 3711, 3733, SMF 99599, 99602–03, 100256, 100259–61, 100264–86, 100298–303; between Luis Echeverría and Laguna Guerrero: ECO-CH-H 100257; road to Tres Rìos: ECO-CH-H 2861; coastal road between Calderitas and Ruìnas Oxtankah: ECO-CH-H 2903; between Calderitas and Chetumal: ECO-CH-H 100258; between Calderitas and Ruínas de Oxtankah: ECO-CH-H 3051, 3696, SMF 99600, 100262–63; between Luis Echeverría and Ruínas de Oxtankah: ECO-CH-H 2905, 3116, SMF 100294–96; between Laguna Guerrero and Raudales: ECO-CH-H 3047, 3053; between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 2907, 3043, 3046, 3054, SMF 99601, 100287–93; village of Laguna Guerrero: ECO-CH-H 100297

Sibon sanniolus.—**MEXICO:** QUINTANA ROO: between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2892, 2898, 3088–93, 3095, 3097, 3387, 3391, 3484, 3493, 3689–92, 3699, 3720, SMF 99649, 100309–23, 100517–18; coastal road between Calderitas and Ruìnas de Oxtankah: ECO-CH-H 2891, 2894; between Bacalar and Reforma: ECO-CH-H 3309; between Calderitas and turn to Laguna Guerrero: 2896, 3094, 3703, SMF 100327; between Calderitas and Ruìnas de Oxtankah: SMF 100306–08; between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 2890, 2897, 3096, 3706–07, SMF 100324–26; between Puente de Moctezuma and turn to La Ceiba, Bacalar–Reforma road: ECO-CH-H 3310; village of Laguna Guerrero: ECO-CH-H 2895, 3380.

Tropidodipsas sartorii.—**MEXICO:** QUINTANA ROO: between Bacalar and Reforma: SMF 100519; between Laguna Guerrero and turn to Calderitas: ECO-CH-H 2939, 3058, 3060, 3115, 3158, 3197–98, 3202, 3384, 3608, SMF 99670, 100501–08; between Calderitas and turn to Laguna Guerrero: ECO-CH-H 3374, 3061, 3157, 3158–59, 3510, SMF 100497–98; between Luis Echeverría and turn to Laguna Guerrero: ECO-CH-H 3059, SMF 100304, 100509–11; between Calderitas and Ruínas de Oxtankah: SMF 100499–500; village of Laguna Guerrero: SMF 100512.

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 205 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.

Till Kirstein is a German ecologist who received a Bachelor's degree in life sciences in 2013, and a Master's degree in Ecology and Evolution in 2016, both at Goethe University in Frankfurt/Main, Germany. He wrote both theses at the herpetological section of the Senckenberg Research Institute in Frankfurt/Main, under the advisorship of Gunther Köhler. Till is particularly interested in biodiversity and nature conservation, especially with regard to amphibians and reptiles, and currently works as a freelance writer for an environmental agency and a local newspaper.

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.