

Taxonomic key to the snakes (Squamata: Ophidia) species of the Itajaí Valley, Santa Catarina, Brazil

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Abstract. Snakes represent the richest Reptile group in Brazil, amounting to 412 species and 40% of them are endemic for the country. This great richness combined with the poor taxonomic knowledge makes the identification a difficult process. To correctly identify a specimen, guides, taxonomic revisions, identification keys, and consulting specialists are the most used methods. Identification keys are based on separation and segregation of characters, where the chosen paths lead to the appropriate taxa. These tools are normally used by students and non-taxonomists. Also, they can be very helpful with the general public, where they can identify the species with simple characters. This study aims to develop keys for the snakes from the State of Santa Catarina state, Brazil, focusing on the Itajaí Valley species. We surveyed 351 specimens deposited in Universidade Regional de Blumenau Zoological Collection (CZFURB), Universidade Federal de Santa Catarina (CHUFSC), and Natural History Museum of Capão da Imbuia (MHNCI) herpetological collections. Characters including pholidosis, dentition, and coloration patterns were examined from the 46 snake species registered from Itajaí Valley.

Keywords. Biodiversity; Pholidosis; Taxonomy; Squamata.

INTRODUCTION

Snakes have a major number of species among the Brazilian reptiles (Costa & Bérnils, 2018). With 412 species, this represents more than 50% of the total amount (Nogueira *et al.*, 2020). This abundance ranks Brazil in third place of countries with most reptile species (Uetz *et al.*, 2020). To study some species or deposit it in a zoological collection, first, it is necessary the correct identification of the animal (Papavero, 1994). There is a variety of options to correctly identify any species, the most used are consulting specialists, bibliography, taxonomic keys, and surveillance in biological collections (Ferrarezzi & Monteiro, 2001). Taxonomic keys are based on separation and segregation of characters, in a way that the choices lead to the correct identification (Papavero, 1994). These tools are normally used by students, also, they can be helpful for non-taxonomists or the general public (Di Nicola, 2019). There are few books (Peters & Orejas-Miranda, 1970; Dixon *et al.*, 1993; Quintela & Loebmann, 2009; Bernarde, 2014), journal articles (Dixon, 1989; Zaher *et al.*, 2008; Passos *et al.*, 2009; Abegg *et al.*, 2016), monographs (Di-Bernardo, 1992)

and non-published works (Ferrarezzi & Monteiro, 2001) providing keys for Brazilian species, yet, most of them are outdated. For the state of Santa Catarina, the studies about snakes are based on records of geographic distributions (Fortes *et al.*, 2010; Kunz *et al.*, 2011), chromatic anomalies (Sueiro *et al.*, 2010), field guides (Oliveira *et al.*, 2020) and surveys in zoologic collections (Bérnils *et al.*, 2001; Althoff, 2014). Bérnils *et al.* (2001) listed 46 species of snakes for the Itajaí Valley region; however, they provided no identification keys for such species. Thus, this study aims to develop identification keys for species of snakes from Itajaí Valley.

MATERIAL AND METHODS

Study region

The Itajaí Valley is located in the state of Santa Catarina, southern Brazil, between the latitudes 26°27'S and 27°53'S and longitudes 48°38'W and 50°29'W. Its total area amounts to 15.000 km² and includes 55 municipalities (Aumond *et al.*, 2018) (Fig. 1).

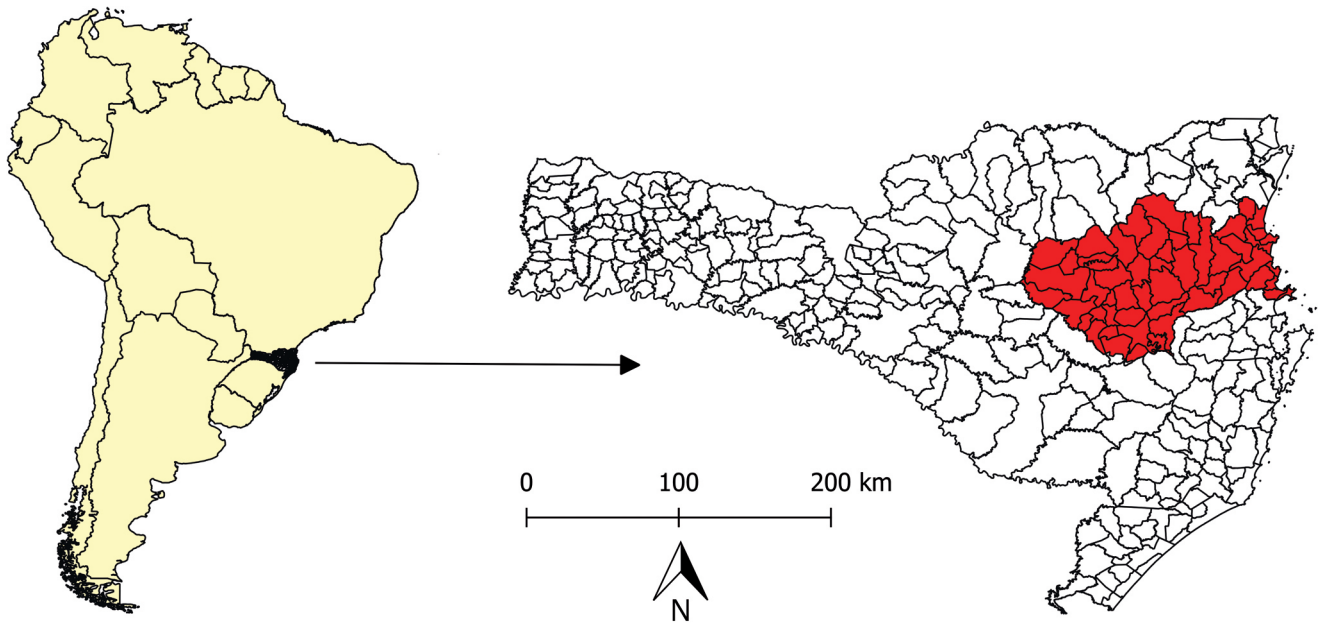


Figure 1. Map of the Itajaí Valley location.

Data Collection

We listed 46 species from Itajaí Valley, based on Bérnils *et al.* (2001) and surveyed the Zoologic Collection of the Universidade Regional de Blumenau (CZFURB), Blumenau, Santa Catarina, Brazil; Herpetological Collection of the Museu de História Natural Capão da Imbuia (MHNCI), Curitiba, Paraná, Brazil and Universidade Federal de Santa Catarina (UFSC, CHUFSC), Florianópolis, Santa Catarina, Brazil. Characters including pholidosis and color patterns were analyzed. Scale counting follow Dowling (1951) and Dixon & Kofron (1983) for *Liotyphlops beui* (Amaral, 1924).

Species identifications

We followed the nomenclature of Costa & Bérnils (2018) and nomenclatural modifications posterior to this publication, like the transfer of *Mastigodryas bifossatus* (Raddi, 1820) to the genus *Palusophis* (Montingelli *et al.*, 2019) and synonymization, such as *Sibynomorphus* with *Dipsas* (Arteaga *et al.*, 2018), and *Uromacerina ricardinii* (Peracca, 1897) with *Cercophis auratus* (Schlegel, 1837). The bibliography used for the identification of the specimens is listed in Table 1, Appendix I.

RESULTS AND DISCUSSION

We examined 351 specimens housed in the collections. The specimens were predominantly from the State of Santa Catarina and Itajaí Valley (Appendix II). Due to the species distribution, some records might have been unavailable for the region. Also, to complement the database, some specimens from other states were included in this study, since they are known to occur in the Itajaí Valley.

Taxonomic key

The key is mainly based on the count of scale rows around the neck, mid-body, and near the cloaca. Examination of dentition, head shields, number of ventral and subcaudal scales, and the condition of dorsal scales (smooth, keeled, or with apical pits) (Fig. 2) are other characters used. Color patterns were only used in cases where one or more pholidosis values were analogous between species. “Background color” indicates the color between dorsal rings, marks, and bands (Di Nicola, 2019). “Rings” refers to a circular band, which surrounds both dorsal and ventral scales “bands” refers to transverse markings on the body (Rasmussen *et al.*, 2011). Thus, the key is accompanied by figures to aid the identification process.

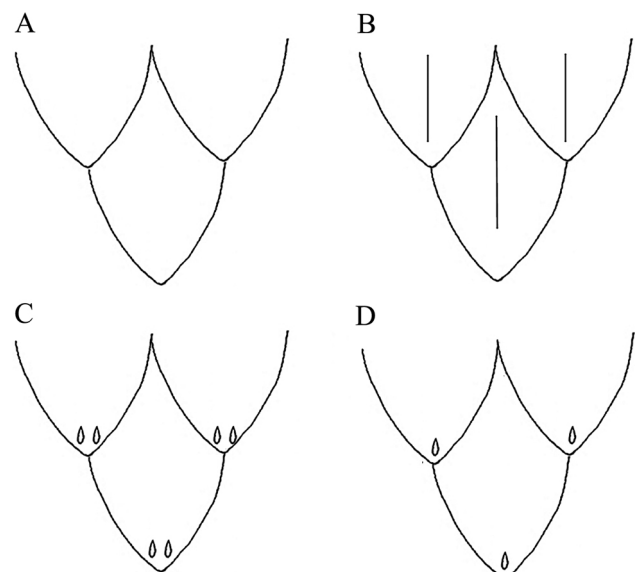


Figure 2. Overview of dorsal scales (A) smooth (B) keeled (C) with two apical pits (D) with one apical pit.

Key to the snake species of Itajaí Valley

| | | |
|-----|---|---|
| 1. | Dorsal and ventral scales indistinct (Fig. 3A) | <i>Liotyphlops beui</i> |
| — | Dorsal and ventral scales distinct (Fig. 3B) | 2 |
| 2. | Loreal pit present (Fig. 4) | 3 |
| — | Loreal pit absent | 4 |
| 3. | Presence of rattle at the tip of the tail | <i>Crotalus durissus</i> Linnaeus, 1758 |
| — | Absence of rattle at the tip of the tail | 5 |
| 4. | Proteroglyphous dentition (Fig. 5A) | 7 |
| — | Aglyph or opistoglyph dentition (Fig. 5B-C) | 8 |
| 5. | Supralabials with large white blotches; dorsum with trapezoidal shapes outlined by white lines | <i>Bothrops neuwiedi</i> Wagler, 1824 |
| — | Supralabials without blotches; dorsum with triangular shapes | 6 |
| 6. | Inverted-v dorsal shapes poorly outlined that eventually merge in the vertebral row of scales. The area occupied by the space between the dorsal shapes is about 1,5-2 times bigger than the shapes | <i>Bothrops jararaca</i> (Wied, 1824) |
| — | Triangular dorsal shapes highly outlined, without merging in the vertebral row. The area occupied by the space between the dorsal shapes is similar to the size of the dorsal shapes | <i>Bothrops jararacussu</i> Lacerda, 1884 |
| 7. | Black dorsal rings grouped in triads (Fig. 6A) | <i>Micrurus altirostris</i> (Cope, 1859) |
| — | Black dorsal rings in monads (Fig. 6B) | <i>Micrurus corallinus</i> (Merrem 1820) |
| 8. | Dorsal rows even in the mid-body | 9 |
| — | Dorsal rows odd in the mid-body | 10 |
| 9. | Anal plate single | 11 |
| — | Anal plate divided | 12 |
| 10. | Subcaudals single | <i>Pseudoboa haasi</i> (Boettger, 1905) |
| — | Subcaudals paired | 14 |
| 11. | Black/dark brown coloration, dorsal rows 10-10-08 | <i>Chironius laevicollis</i> (Wied, 1824) |
| — | Black and yellow coloration, dorsal rows 16-16-10 | <i>Spilotes pullatus</i> (Linnaeus, 1758) |
| 12. | More than 300 ventrals + caudals | <i>Chironius foveatus</i> Bailey 1955 |
| — | Less than 300 ventrals + caudals | 13 |
| 13. | Dorsals 12-12-10 or 12-10-10, dorsal pattern dark green, two dark dorsal stripes with a lighter stripe between them (color pattern can change to blue in preserved specimens) | <i>Chironius bicarinatus</i> (Wied, 1820) |
| — | Dorsals 12-10-08, dorsal pattern uniform olive green and/or brown, without a vertebral stripe | <i>Chironius exoletus</i> (Linnaeus, 1758) |
| 14. | Anal plate single | 15 |
| — | Anal plate divided | 16 |
| 15. | Dorsal rows 15 at mid body | 17 |
| — | Dorsal rows 19 or 21 at mid body | 18 |
| 16. | Internasal single | 22 |
| — | Internasals paired | 23 |
| 17. | Dorsal rows in 17-15-15 or 16-15-15 | <i>Dipsas albifrons</i> (Sauvage, 1884) |
| — | Dorsal rows in 15-15-15 | |
| 18. | Dorsal pattern with black rings | 19 |
| — | Dorsal pattern uniform or with a white nuchal collar | <i>Clelia plumbea</i> (Wied, 1820) |
| 19. | Dorsum with white and/or red background, and black rings (background can be yellowish in preserved specimens). Dorsal rings invade the ventral scales (Fig. 8A) | <i>Oxyrhopus clathratus</i> Duméril, Bibron & Duméril, 1854 |
| — | Dorsum with white and/or red background, and black rings (background can be yellowish in preserved specimens). Dorsal rings don't invade the ventral scales (Fig. 8B) | <i>Oxyrhopus rhombifer</i> Duméril, Bibron & Duméril, 1854 |
| 20. | Dorsum brown, black or dark-grey, with a reticulated pattern | <i>Atractus reticulatus</i> (Boulenger 1885) |
| — | Dorsum with clearly defined blotches | 21 |
| 21. | Belly with dark brown large blotches (Fig. 7A) | <i>Dipsas ventrimaculata</i> (Boulenger 1885) |
| — | Belly dotted and/or with dark brown small blotches (Fig. 7B) | <i>Dipsas neuwiedi</i> (Hering 1911) |
| 22. | Dorsal scale rows in 19-19-17 | <i>Helicops carinicaudus</i> (Wied, 1824) |
| — | Dorsal scale rows in 19-19-19 or 17-17-15 | <i>Helicops infrataeniatus</i> (Jan, 1865) |
| 23. | Dorsal scale rows with reduction | 24 |
| — | Dorsal scale rows without reduction | 25 |
| 24. | Dorsal scales keeled | 26 |
| — | Dorsal scales smooth | 27 |
| 25. | Dorsal rows 19-19-19 | <i>Xenodon guentheri</i> Boulenger, 1894 |
| — | Dorsal rows 15-15-15 or 17-17-17 | 39 |
| 26. | Dorsal rows 21 at mid-body | <i>Tropidodryas serra</i> (Schlegel, 1837) |
| — | Dorsal rows 19 at mid-body | 28 |
| 27. | Scales with apical pits | 29 |

| | |
|---|---|
| — Scales without apical pits..... | 30 |
| 28. Color pattern emerald green uniform (color pattern can change to blue in preserved specimens) | <i>Philodryas aestiva</i> (Duméril, Bibron & Duméril, 1854) |
| — Color pattern light brown and checkered | <i>Thamnodynastes hypoconia</i> (Cope, 1860) |
| 29. Dorsum with green unicolor pattern (color pattern can change to blue in preserved specimens) | <i>Philodryas olfersii</i> (Lichtenstein, 1823) |
| — Dorsum olive-green, light brown or greenish-grey, base and tip of the scales outlined by black color..... | <i>Philodryas patagoniensis</i> (Girard, 1858) |
| 30. Number of subcaudals: 100 or more..... | 31 |
| — Number of subcaudals: < 100..... | 32 |
| 31. Dorsal rows 15-15-11 or 15-13-11 | <i>Dendrophis aurata</i> Schlegel, 1837 |
| — Dorsal rows 21-21-17 or 19-19-15 | 33 |
| 32. Scales with apical pits..... | 34 |
| — Scales without apical pits..... | <i>Erythrolamprus miliaris</i> (Linnaeus, 1758) |
| 33. Dorsal rows 21-21-17..... | <i>Tropidodryas striaticeps</i> (Cope, 1870) |
| — Dorsal rows 19-19-15..... | <i>Thamnodynastes strigatus</i> (Günther, 1858) |
| 34. Dorsal rows 21 at mid-body | <i>Xenodon newwiedii</i> Günther, 1863 |
| — Dorsal rows 19 or 17 at mid-body | 35 |
| 35. Dorsal rows 19-19-17..... | <i>Xenodon merremii</i> (Wagler in Spix, 1824) |
| — Dorsal rows 19-19-15 or 17-17-15 | 36 |
| 36. Dorsal pattern greenish brown or golden-brown uniform, with two dark dorsal stripes | <i>Gomesophis brasiliensis</i> (Gomes, 1918) |
| — Dorsal pattern checkered, banded or with scattered blotches | 37 |
| 37. Dorsal rows 17-17-15..... | <i>Tomodon dorsatus</i> Duméril, Bibron & Duméril, 1854 |
| — Dorsal rows 19-19-15..... | 38 |
| 38. Yellowish mark on top of the head, shaped as "U", "X", "Y" or "W" | <i>Erythrolamprus almadensis</i> (Wagler in Spix, 1824) |
| — Top of the head uniform, without marks | <i>Erythrolamprus poecilogyrus</i> (Wied, 1824) |
| 39. Dorsal rows 15-15-15..... | 40 |
| — Dorsal rows 17-17-17..... | 41 |
| 40. Black head, white nuchal collar, vertebral zone red colored, ventral and pleural zones black colored | <i>Phalotris reticulatus</i> (Peters, 1860) |
| — Brown head with a post-orbital stripe, dorsal bands shaped like an hourglass; | the tail is darker and the bands are rectangular..... |
| | <i>Palusophis bifossatus</i> (Raddi, 1820) |
| 41. > 130 Subcaudal scales | <i>Imantodes cenchoa</i> (Linnaeus, 1758) |
| — < 130 Subcaudal scales | 42 |
| 42. Dorsum bright green, with a copper vertebral stripe, belly red colored..... | <i>Erythrolamprus jaegeri</i> (Günther, 1858) |
| — Dorsum brown, without a copper vertebral stripe..... | 43 |
| 43. A well-defined line along the <i>canthus rostralis</i> , ranging from the snout to the postoculars..... | <i>Taeniophallus bilineatus</i> Fischer (1885) |
| — Without a well-defined line along <i>canthus rostralis</i> , postocular region may present a poorly defined light band..... | 44 |
| 44. < 140 ventral scales..... | <i>Taeniophallus persimilis</i> (Cope, 1869) |
| — > 140 ventral scales..... | 45 |
| 45. Body with a wavy yellowish lateral line; two parallel bright yellow circular blotches isolated in the nuchal region coming from the lateral stripe <i>Echinanthera undulata</i> Wied (1824) | |
| — Body with a straight lateral line outlined with small yellow dotted lines; Lateral line color light brown; two bright yellow parallel circular blotches in the nuchal region merging with the color of supralabials and ventral scales..... | <i>Echinanthera cyanopleura</i> Cope (1869) |

The compiled species are represented by five families, with Dipsadidae amounting to the major number of species (33), followed by Colubridae (6), Viperidae (4), Elapidae (2), and Anomalepididae (1).

Family Anomalepididae Taylor, 1939

Only one species of this family occurs in the region (Bérnills *et al.*, 2001). *Liotyphlops beui* can be recognized by the indistinct dorsal and ventral scales; they are all cycloids and have the same size (Dixon & Koffron 1983).

Family Colubridae Opperl, 1811

For the Vale do Itajaí the species of the genera *Chironius* and *Spilotes* can be recognized by the even number of scale rows (Amaral, 1929; Dixon *et al.*, 1993, and *Palusophis bifossatus* by its body coloration and 15 scale rows at mid-body (Montingelli *et al.*, 2019).

Family Elapidae Boie, 1827

Members of this family show proteroglyphous dentition and the absence of a loreal scale Ferrarezzi (1994). The American elapids carry a body coloration composed of shades of yellow, black, white, and red, outlined by black or dark-brown rings or blotches (Campbell & Lammar, 2004).

Family Dipsadidae Bonaparte, 1838

This family stands as a monophyletic group (Zaher *et al.*, 2009), but with a high number of unsupported clades within its subfamilies (Zaher *et al.*, 2019). It is di-

vided into 14 tribes and 18 genera classified as *incertae sedis* (Zaher *et al.*, 2009).

***Dendrophis aurata* Schlegel, 1837**

This species does not belong to any tribe, therefore being classified as *incertae sedis* (Zaher *et al.*, 2009). *Dendrophis aurata* can be distinguished from the oth-

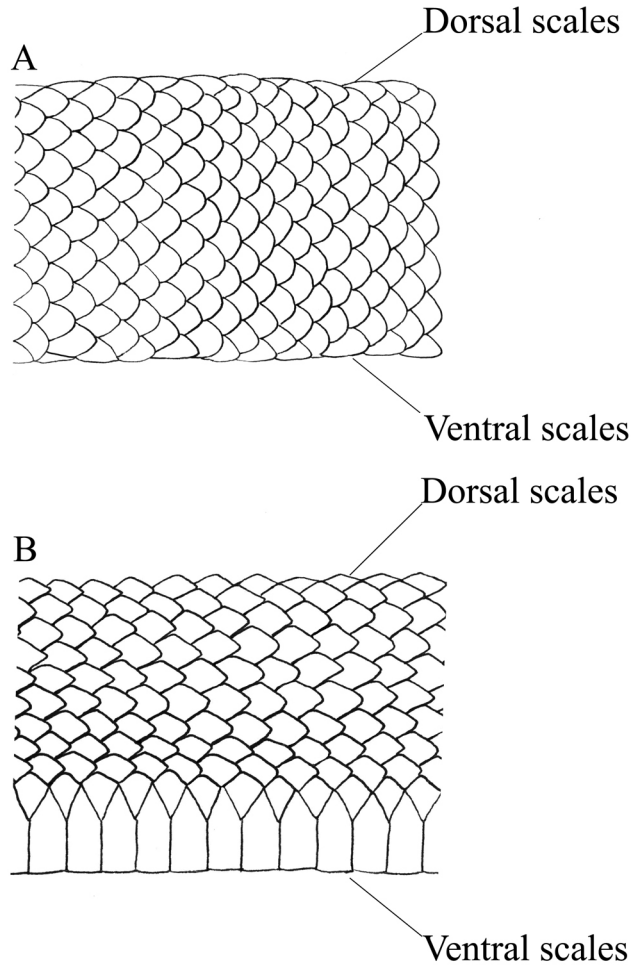


Figure 3. Lateral view of a general snake: (A) indistinct dorsal and ventral scales (B) distinct dorsal and ventral scales.

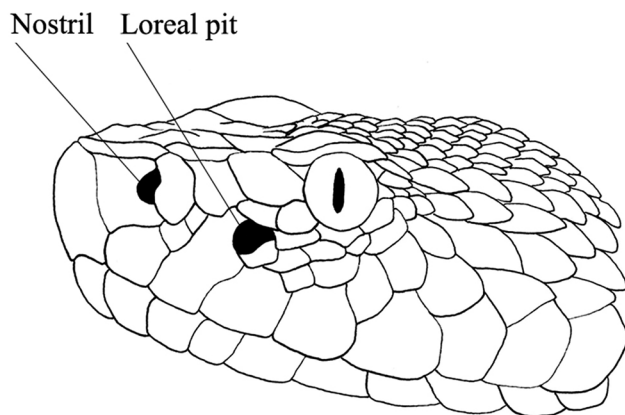


Figure 4. Lateral view of the head of a general Viperidae, showing the loreal pit.

er species by showing dorsal scale rows in 17-15-13, 15-15-11, or 15-13-11 (Hoge, 1957; Hoogmoed *et al.*, 2019).

Tribe Hydropsini Dowling, 1975

Externally, this tribe can be recognized by the eyes and nostrils directed to the top of the head (Costa *et al.*, 2016), single internasal scale, divided anal plate, and partially or entirely keeled dorsal scales (Peters & Orejas-Miranda 1970).

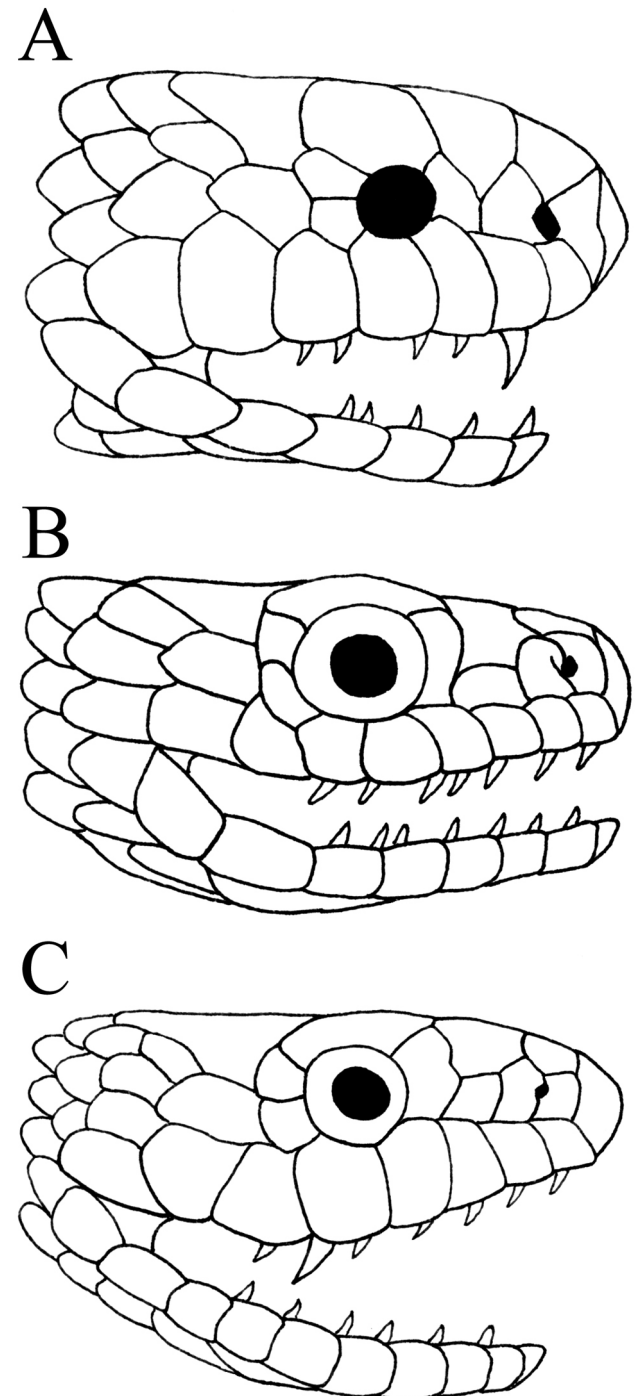


Figure 5. Lateral view of general snake heads showing different dentitions (A) proteroglyph (B) aglyph and (C) opisthoglyph.

Tribe Philodryadini Cope, 1886

Zaher *et al.* (2009) designed a putative synapomorphy for this tribe, that the body of the hemipenis is bigger than the lobes, with the non-sulcated face covered almost entirely by two lines of enlarged chalice. In the Itajaí Valley, *Philodryas* is the only genus from this tribe (Bérnils *et al.*, 2001). The species are recognized by their slender body, round pupil, posterior reduction of dorsal scales rows, and opisthognathous dentition (Vanzolini, 1980; Quintela & Loebmann, 2009).

Tribe Tropicodryadini Zaher *et al.*, 2009

Members from this tribe have a bi-calyculate and non-capitated hemipenis, with calycular regions directed laterally and intrasulcal area with two lines of enlarged spines (Zaher *et al.*, 2009). This tribe is composed only by the sister species *Tropicodryas serra* (Schlegel 1837) and *Tropicodryas striaticeps* (Cope 1870). They share the following characters: dorsal scale rows in 21-21-17, 8-9 supralabials, 10 infralabials, and 3 + 3 post-oculars (Thomas & Dixon, 1977).

Tribe Dipsadini Bonaparte, 1838

In the Itajaí Valley, *Atractus* and *Dipsas* are the representant genera of this tribe. Recently occurred the synonymization of *Sibynomorphus* with *Dipsas* (Arteaga *et al.*, 2018), however, this change can still be premature (Zaher *et al.*, 2019). *Atractus reticulatus* can be distinguished by its tribe members by the dorsal rows 15-15-15, smooth scales, dorsum with reticulated pattern, and venter immaculate (Passos *et al.*, 2010). *Dipsas* species can be distinguished from *Atractus* by the following characteristics: dorsal formula 17-15-15 or 16-15-15 for *Dipsas albifrons* and 15-15-15 with dorsal pattern with clearly defined blotches for *Dipsas neuwiedi* and *D. ventrimaculata* (Peters & Orejas-Miranda, 1970).

Tribe Echinantherini Zaher *et al.*, 2009

This tribe is represented by the genera *Echinanthera* and *Taeniophallus* (Zaher *et al.*, 2009), they have hemipenis unilobed and uni capitate. *Sulcus spermaticus* is divided relatively distally in the calyculate area, and there

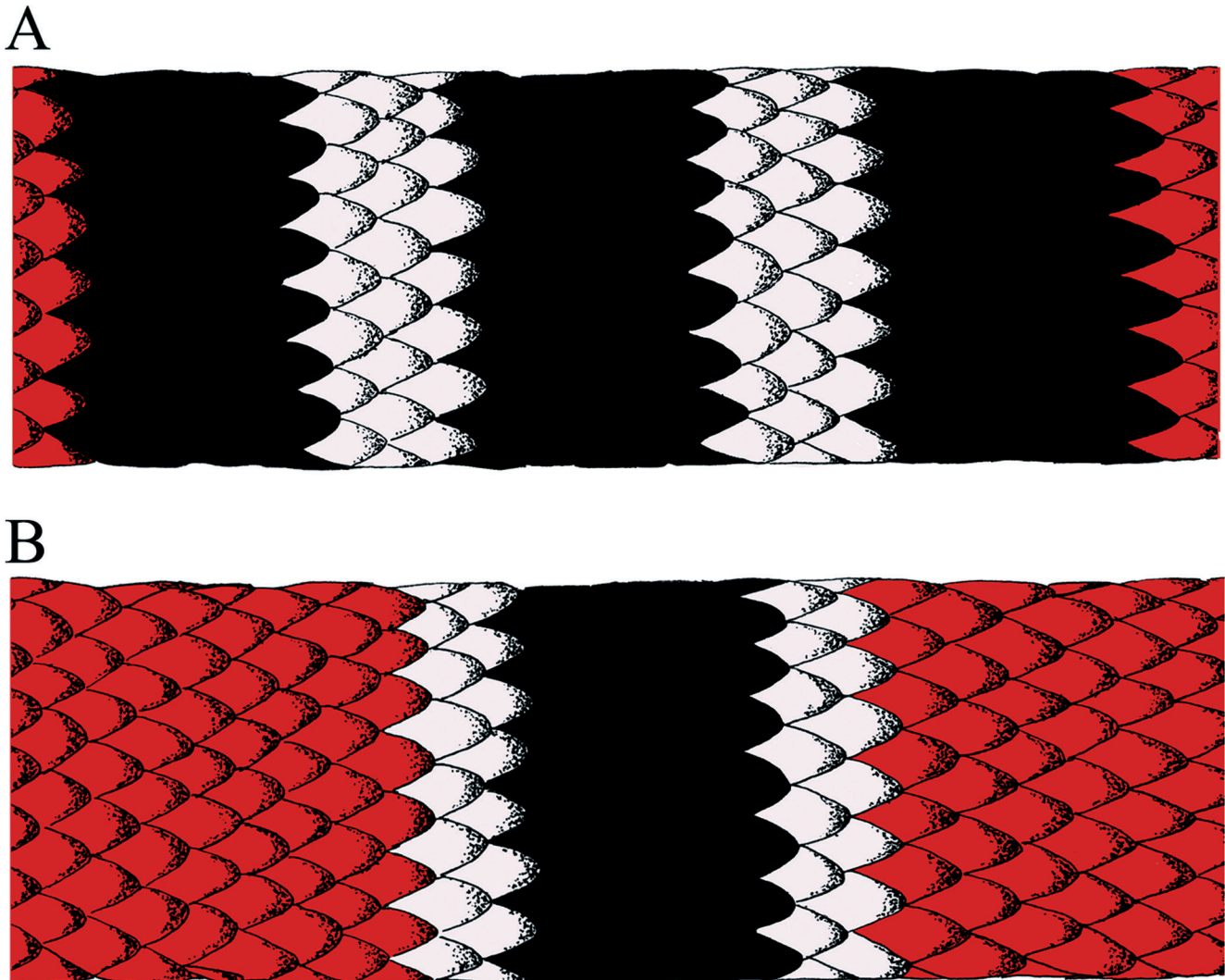


Figure 6. Comparative lateral view of coral snakes midbody: (A) *Micrurus altirostris* (Cope 1859), showing rings grouped in triads and (B) *Micrurus corallinus* (Merrem 1820) showing rings grouped in monads.

is a large nude area in the asulcate side of the hemipenial body (Zaher *et al.*, 2009). Both genera are morphologically similar, with a slender body, aglyphous dentition, and circular pupils (Di-Bernardo, 1992). *Taeniophallus bilineatus* can be distinguished from the other species by the number of ventral scales (> 140) (Di-Bernardo & Lema, 1990), and the other species from this tribe can be identified by its cephalic and dorsal marks (Di-Bernardo, 1992; Di-Bernardo & Lema, 1986).

Tribe Imantodini Myers, 2011

In the Itajaí Valley *Imantodes cenchoa* Linnaeus (1758) is the only representative species from this tribe (Bérnils *et al.*, 2001). It can be distinguished from the other species by the following characters: brown saddle-shaped dorsal blotches outlined by a lighter halo and light brown

background color. Dorsal rows in 19-17-17 or 17-17-17, 229-263 ventral scales, 141-173 subcaudal scales, and 8-12 infralabials (Missassi & Prudente, 2015).

Tribe Elapomorphini Jan, 1862

Members of this tribe have cephalic shields fused, reduced eyes, and strengthened skulls due to fossorial habits (Ferrarezzi, 1993). In the Itajaí Valley, *Phalotris reticulatus* is the only representative species from this tribe (Bérnils *et al.*, 2001). Specimens show dorsal scale rows 15-15-15; black head followed by a yellowish nuchal collar, the dorsal color background is red with three longitudinal black stripes, one in the vertebral zone, and the other two in the pleural zones. It has a black cloacal ring, the venter is yellowish, with black semilunar blotches (Quintela & Loebmann, 2009).

A



B

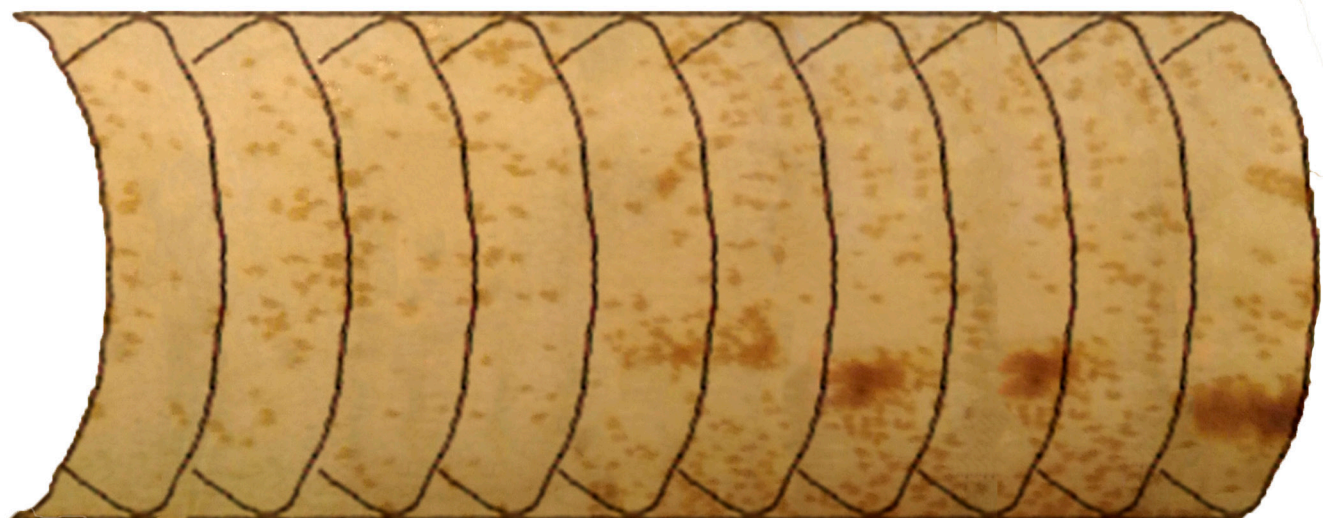
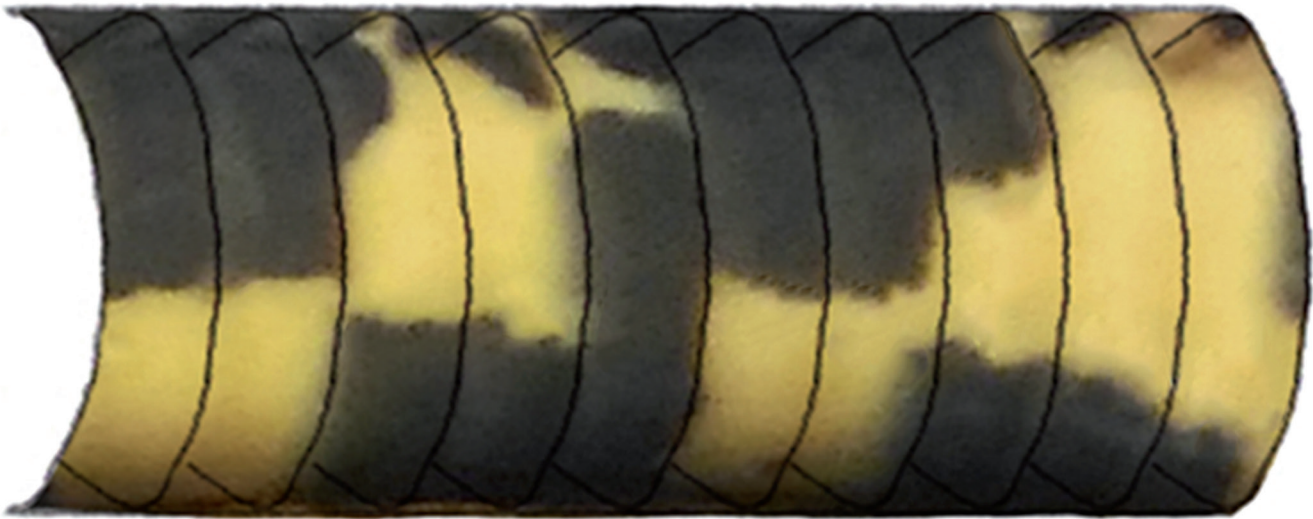


Figure 7. Comparative ventral view of: (A) *Dipsas ventrimaculata* (Boulenger, 1885) and (B) *Dipsas newwiedi* (Ihering, 1911).

A



B

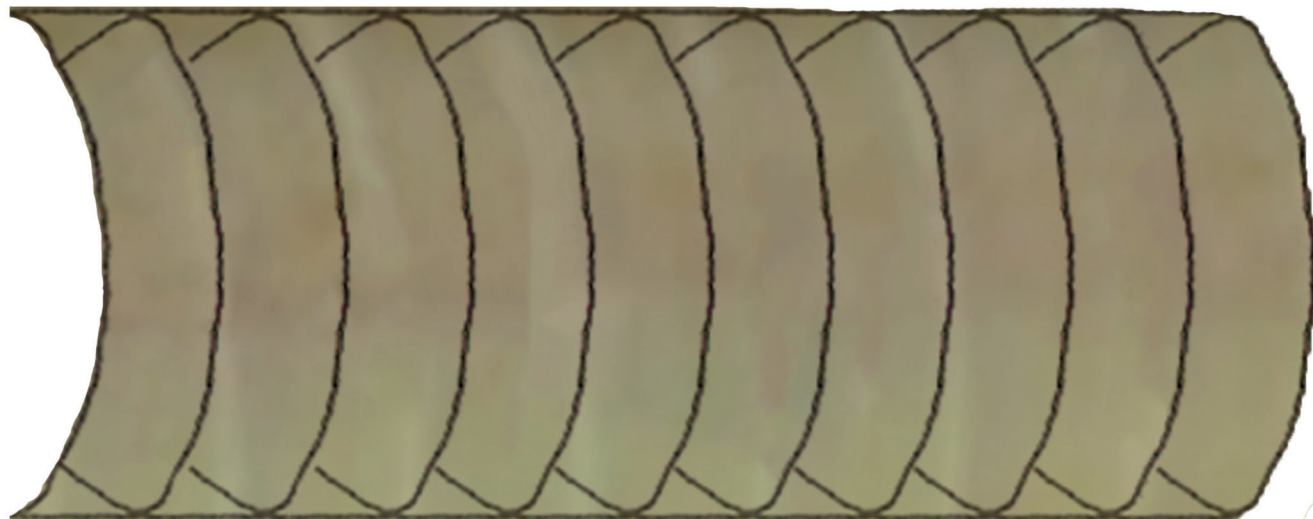


Figure 8. Comparative ventral view of: (A) *Oxyrhopus clathratus* Duméril, Bibron & Duméril, 1854 and (B) *Oxyrhopus rhombifer* Duméril, Bibron & Duméril, 1854.

Tribe Tachymenini Bailey, 1967

Members from this tribe usually have a small size, opisthoglyphous dentition, elliptical pupils, and a post-orbital stripe (Bailey, 1967). In the Itajaí Valley, *Gomesophis*, *Thamnodynastes*, and *Tomodon* are the representant genera from this tribe (Bérnils *et al.*, 2001). *Gomesophis brasiliensis* has dorsal rows in 17-17-15, smooth scales with apical pits, and a brownish-green dorsal color, with stripes (Gonzalez *et al.*, 2014). Species from the genus *Thamnodynastes* show dorsal pattern checkered anteriorly and dorsal rows in 19-19-15 (Franco *et al.*, 2017). Finally, *Tomodon dorsatus* has 17 scale rows at mid-body (Harvey & Muñoz, 2004), grey dorsal background color with dark marks, and black oral and cloacal mucosae (Quintela & Loebmann, 2009).

Tribe Pseudoboini Bailey, 1967

Members of this tribe are oviparous, have smooth scales, bi-calyculate, and bi-capitate hemipenis (Bailey, 1967; Zaher, 1999; Zaher *et al.*, 2009). In the Itajaí Valley, *Clelia*, *Oxyrhopus*, and *Pseudoboa* are the representant genera from this tribe (Bérnils *et al.*, 2001). Specimens from the genus *Clelia* have medium to large size, elliptical pupil, single anal plate, and ontogenetic color variation (Morato *et al.*, 2003). *Pseudoboa* individuals are morphologically similar to *Clelia*, but the difference relies on the subcaudals; In *Pseudoboa* the subcaudals are single, different from *Clelia*, that possess paired subcaudals (Zaher *et al.*, 2008). Also, they have dorsal scales in 19 rows at mid-body (Zaher, 1996; Zaher *et al.*, 2008). *Oxyrhopus* specimens can grow to medium size and show banded or melanic coloration patterns (Bernardo *et al.*, 2012). They

present 19 scale rows at mid-body (Quintela & Loebmann, 2009), 7 or 8 supralabials, 7 to 10 infralabials single anal plate, and paired subcaudal scales (Bernardo *et al.*, 2012).

Tribe Xenodontini Bonaparte, 1845

Members from this tribe have hemipenis with paired apical disks and without calyces and capitular grooves Zaher *et al.* (2009). In the Itajaí Valley, *Erythrolamprus* and *Xenodon* are the representant genera from this tribe (Bérnils *et al.*, 2001). Both genera display body flattening as a defensive strategy (Fraga *et al.*, 2013; Zaher *et al.*, 2009). *Erythrolamprus* shows a great range of color patterns, that can be uniform (Dixon, 1987), striped (Dixon, 1983), and banded (Dixon, 1983). *Xenodon* species have triangular-shaped heads very protruded from the body (Chippaux, 1986), they also show a high level of polychromatism, specifically in *Xenodon merremii* (Cacciali, 2010).

Family Viperidae Oppel, 1811

This group is characterized by solenoglyphous dentition, presence of loreal pits (Campbell & Lammar, 2004; Bernarde, 2014), keeled dorsal scales, and triangular head shape, covered by small scales (Peters & Orejas-Miranda, 1970; Melgarejo, 2009).

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AUTHORS' CONTRIBUTIONS

C.S.W. and L.O.M.G. designed the study. C.S.W. performed the data collection and laboratory studies. C.S.W. prepared the manuscript. L.O.M.G. supervised the manuscript. All authors approved the final manuscript. Authors declare there are no conflicts of interest.

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APPENDIX I

Table 1. Literature used for the species identifications.

| Species | Bibliography |
|------------------------------------|---|
| Anomalepididae | |
| <i>Liotyphlops beui</i> | Dixon & Kofron (1983) |
| Colubridae | |
| <i>Chironius bicarinatus</i> | Dixon <i>et al.</i> (1993); Entiauspe-Neto <i>et al.</i> (2020) |
| <i>Chironius exoletus</i> | Dixon <i>et al.</i> (1993) |
| <i>Chironius foveatus</i> | Dixon <i>et al.</i> (1993) |
| <i>Chironius laevicollis</i> | Dixon <i>et al.</i> (1993) |
| <i>Palusophis bifossatus</i> | Montingelli <i>et al.</i> (2019) |
| <i>Spilotes pullatus</i> | Amaral (1929) |
| Dipsadidae | |
| <i>Attractus reticulatus</i> | Passos <i>et al.</i> (2005); Passos <i>et al.</i> (2010) |
| <i>Clelia plumbea</i> | Zaher (1996) |
| <i>Dipsas albifrons</i> | Peters & Orejas-Miranda (1970) |
| <i>Dipsas neuwiedi</i> | Peters & Orejas-Miranda (1970); Quintela & Loebmann (2009) |
| <i>Dipsas ventrimaculata</i> | Peters & Orejas-Miranda (1970); Quintela & Loebmann (2009) |
| <i>Echinantera cyanopleura</i> | Di-Bernardo (1992) |
| <i>Echinantera undulata</i> | Di-Bernardo (1992) |
| <i>Erythrolamprus almadensis</i> | Dixon (1983); Dixon (1987); Quintela & Loebmann (2009) |
| <i>Erythrolamprus jaegeri</i> | Dixon (1983); Dixon (1987); Quintela & Loebmann (2009) |
| <i>Erythrolamprus miliaris</i> | Dixon (1983); Dixon (1987); Quintela & Loebmann (2009) |
| <i>Erythrolamprus poecilogyrus</i> | Schaefer & Alvarez (1999); Quintela & Loebmann (2009) |
| <i>Gomesophis brasiliensis</i> | Gonzalez <i>et al.</i> (2014) |
| <i>Helicops carinicaudus</i> | Costa <i>et al.</i> (2016) |
| <i>Helicops infrataeniatus</i> | Costa <i>et al.</i> (2016) |
| <i>Imantodes cenchoa</i> | Missassi & Prudente (2015) |
| <i>Oxyrhopus clathratus</i> | Bernardo <i>et al.</i> (2012) |
| <i>Oxyrhopus rhombifer</i> | Quintela & Loebmann (2009) |
| <i>Phalotris reticulatus</i> | Ferrarezzi, (1993); Quintela & Loebmann (2009) |
| <i>Philodryas aestiva</i> | Vanzolini, 1980; Quintela & Loebmann (2009) |
| <i>Philodryas offersii</i> | Vanzolini, 1980; Quintela & Loebmann (2009) |
| <i>Philodryas patagoniensis</i> | Vanzolini, 1980; Quintela & Loebmann (2009) |
| <i>Pseudoboa haasi</i> | Zaher (1996) |
| <i>Taeniophallus bilineatus</i> | Di-Bernardo & Lema, (1990); Di-Bernardo (1992) |
| <i>Taeniophallus persimilis</i> | Di-Bernardo & Lema, (1986); Di-Bernardo, (1992) |
| <i>Thamnodynastes strigatus</i> | Bellini <i>et al.</i> (2013); Franco & Ferreira (2013) |
| <i>Thamnodynastes hypoconia</i> | Bailey <i>et al.</i> (2005); Bellini <i>et al.</i> (2013); Franco & Ferreira (2013) |
| <i>Tomodon dorsatus</i> | Harvey & Muñoz (2004); Quintela & Loebmann (2009); Abegg <i>et al.</i> (2017) |
| <i>Tropidodryas serra</i> | Thomas & Dixon (1977) |
| <i>Tropidodryas striaticeps</i> | Thomas & Dixon (1977) |
| <i>Dendrophis aurata</i> | Hoge (1957); Hoogmoed <i>et al.</i> (2019) |
| <i>Xenodon guenteri</i> | Quintela & Loebmann (2009); Abegg <i>et al.</i> (2016) |
| <i>Xenodon merremii</i> | Peters & Orejas-Miranda (1970); Quintela & Loebmann (2009) |
| <i>Xenodon neuwiedii</i> | Quintela & Loebmann (2009); Abegg <i>et al.</i> (2016) |
| Elapidae | |
| <i>Micrurus altirostris</i> | Di-Bernardo <i>et al.</i> (2007) |
| <i>Micrurus corallinus</i> | Di-Bernardo <i>et al.</i> (2007) |
| Viperidae | |
| <i>Bothrops jararaca</i> | Bernarde (2014) |
| <i>Bothrops jararacussu</i> | Bernarde (2014) |
| <i>Bothrops neuwiedi</i> | Bernarde (2014) |
| <i>Crotalus durissus</i> | Bernarde (2014) |

APPENDIX II

Specimens examined

***Liotyphlops beui* (n = 5)**

BRAZIL: *Santa Catarina*: São Domingos (FURB 11527; 11575; 11654; 21009; 21010).

***Chironius bicarinatus* (n = 10)**

BRAZIL: *Santa Catarina*: Abdon Batista (FURB 11988; 21049); Alfredo Wagner (CHUFSC 788); Blumenau (FURB 2736; 2804); Curitiba (FURB 21182); Indaial (FURB 2121; 2833); São Domingos (FURB 2894); Vidal Ramos (CHUFSC 898).

***Chironius exoletus* (n = 10)**

BRAZIL: *Santa Catarina*: Biguaçu (FURB 21574); Blumenau (FURB 2805; 2989; 11247; 21188); Gaspar (FURB 2604; 11175); Major Gersino (FURB 11307); Not cataloged (FURB 21467); São José (21519).

***Chironius foveatus* (n = 6)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2157; 2785; 2878; 3000; 11136; 11341).

***Chironius laevicollis* (n = 10)**

BRAZIL: *Santa Catarina*: Antônio Carlos/São Pedro de Alcântara (CHUFSC 884); Blumenau (FURB 2619; 21463); Gaspar (FURB 2213; 2869); Ilhota (FURB 21488); Major Gersino (11547); São José (FURB 21515); Timbó (FURB 2816; 2817).

***Palusophis bifossatus* (n = 6)**

BRAZIL: *Paraná*: Carambeí (MHNCI 11240; 11760); Guairá (MHNCI 642; 717); Mandaguari (MHNCI 4620); *Santa Catarina*: Garopaba (MHNCI 717).

***Spilotes pullatus* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2143; 2198; FURB 2211; 2529; 2774; FURB 2784; 11010; 11060); São José (FURB 21514); Vidal Ramos (FURB 11452).

***Dendrophis aurata* (n = 3)**

BRAZIL: *Paraná*: Morretes (MHNCI 672); Pontal Paraná (MHNCI 2180); *Santa Catarina*: Blumenau (FURB 2156).

***Atractus reticulatus* (n = 3)**

BRAZIL: *Santa Catarina*: São José do Cerrito (FURB 21001; 21002; 21003).

***Dipsas albifrons* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2101; 2155; 2162; 2678; 2719; 2829; 2858; Gaspar (FURB 11173); Jaraguá do Sul (FURB 2078); Santo Amaro da Imperatriz (CHUFSC 649).

***Dipsas neuwiedi* (n = 10)**

BRAZIL: *Santa Catarina*: Biguaçu (FURB 21462); Blumenau (FURB 2141; 2220; 2542; 2747; 2752; 2783; 2794; Brusque (FURB 21506); Luis Alves (FURB 11160).

***Dipsas ventrimaculatus* (n = 10)**

BRAZIL: *Santa Catarina*: Chapecó (CHUFSC 1104; 1444); Passos Maia (FURB 11316); *Santa Catarina/Rio Grande do Sul*: Águas de Chapecó/Paial/Alpestre/Itatiba do Sul (FURB 11782; 11785; 11798; 11847; 11856; 11857; 1937).

***Echianthera cyanopleura* (n = 4)**

BRAZIL: *Santa Catarina*: Abdon Batista (FURB 21065) Blumenau (FURB 2674; 2697; 11225).

***Echianthera undulata* (n = 4)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2623); Gaspar (FURB 21536); São Bento do Sul (FURB 21185); Timbó (11572).

***Taeniophallus bilineatus* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2086; 2675; 2849; 11036; 21507; Doutor Pedrinho (FURB 21496); Gaspar (FURB 11183); Ibirama (FURB 21484); Timbó (FURB 21497); Vargem/São José do Cerrito (FURB 21091).

***Taeniophallus persimilis* (n = 2)**

BRAZIL: *Paraná*: Guaratuba (MHNCI 835); Tijucas do Sul (MHNCI 60611).

***Phalotris reticulatus* (n = 2)**

BRAZIL: *Santa Catarina*: Araranguá (MHNCI 3149); Palhoça (CHUFSC 3216).

***Helicops carinicaudus* (n = 5)**

BRAZIL: *Santa Catarina*: Chapecó (FURB 21172); Gaspar (FURB 2537; 11943); Itajaí (FURB 21138); Itapoá (FURB 11587).

***Helicops infrataeniatus* (n = 6)**

BRAZIL: *Santa Catarina*: Abdon Batista (FURB 21048; 21068); Capão Alto (FURB 21118); São Domingos (FURB 11220; 21058); Vargem/São José do Cerrito (FURB 21090).

***Imantodes cenchoa* (n = 3)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2679; 11054); Gaspar (FURB 11168).

***Clelia plumbea* (n = 4)**

BRAZIL: *Santa Catarina*: Florianópolis (CHUFSC 49; 271; 526; 653).

***Oxyrhopus clathratus* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2036; 2153; 2154; 2680; 2690; 2744; 2777; 21522; 21545); Gaspar (FURB 21178).

***Oxyrhopus rhombifer* (n = 6)**

BRAZIL: *Rio Grande do Sul*: Alpestre (FURB 11360); Faxinalzinho (CHUFSC 1272); *Santa Catarina*: Campos Novos (FURB CHUFSC 3839), Guatambu (CHUFSC 1172); Palhoça (CHUFSC 3210) São Joaquim (FURB 21640).

***Pseudoboa haasi* (n = 6)**

BRAZIL: *Paraná*: Carambeí (MHNCI 11766); Catanduvas (MHNCI 8481); Pirai do Sul (MHNCI 14412); Pituruna (MHNCI 14432); Reserva do Iguaçu (MHNCI 5355); *Santa Catarina*: Joinville (FURB 21505).

***Philodryas aestiva* (n = 10)**

BRAZIL: *Santa Catarina*: Água Doce (CHUFSC 615); Alfredo Wagner (CHUFSC 074); Bom Retiro (CHUFSC 1096); Florianópolis (CHUFSC 068; 073; 454; 685); Ipuacu (CHUFSC 676); Palhoça (CHUFSC 2702).

***Philodryas olfersii* (n = 10)**

BRAZIL: *Rio Grande do Sul*: Estrela (FURB 21142); *Santa Catarina/Rio Grande do Sul*: Águas de Chapecó/Paial/Alpestre/Itatiba do Sul (FURB 11753; 11759; 11767); *Santa Catarina*: Guatambu (FURB 11290); Itá (FURB 2574); São Domingos (FURB 2945; 2946; 2947; 11197).

***Philodryas patagoniensis* (n = 10)**

BRAZIL: *Santa Catarina*: Abdon Batista (FURB 21047; 21052); Abdon Batista/Anita Garibaldi (FURB 21061); Alfredo Wagner (CHUFSC 1371); Anita Garibaldi (FURB 21062); Florianópolis (CHUFSC 556; 559); Jaguaruna (CHUFSC 1050); São José (CHUFSC 1154); Vargem/São José do Cerrito (FURB 21094).

***Gomesophis brasiliensis* (n = 10)**

BRAZIL: *Paraná*: Curitiba (MHNCI 745; 14342); Guarapuava (MHNCI 3308); Pirai do Sul (MHNCI 14406); Piraquara (MHNCI 7289; 11793); São Mateus do Sul (MHNCI 1340); União da Vitória (MHNCI 4739); *Santa Catarina*: Caçador (MHNCI 10062); São José dos Pinhais (MHNCI 595).

***Thamnodynastes hypoconia* (n = 8)**

BRAZIL: *Rio Grande do Sul/Santa Catarina*: Águas de Chapecó/Paial/Alpestre/Itatiba do Sul (FURB 11778); *Santa Catarina*: Doutor Pedrinho (FURB 21023; 21024); Guaratuba (FURB 21081); Passos Maia (FURB 21045); São Domingos (FURB 2632; 11219; 11457).

***Thamnodynastes strigatus* (n = 10)**

BRAZIL: *Rio Grande do Sul*: Aratiba (CHUFSC 1286); *Santa Catarina*: Abdon Batista (FURB 21057); Curitiba (CHUFSC 3791); Ipuacu (FURB 2640); São Domingos (FURB 2897; 2898; 2899; 2900; 2902; 11218).

***Tomodon dorsatus* (n = 10)**

BRAZIL: *Santa Catarina*: Arvoredo (FURB 11438); Anitápolis (FURB 11437); Doutor Pedrinho (FURB 11577); Faxinal do Guedes (FURB 11232); São Domingos (FURB 11319; 11321); Tangará (FURB 11562); Timbó (FURB 2835; 2836); Vargem/São José do Cerrito (FURB 21088).

***Tropidodryas serra* (n = 10)**

BRAZIL: *Santa Catarina*: Florianópolis (CHUFSC 385; 487; 541; 561; 586; 626; 719; 818); Porto Belo (CHUFSC 1367); São José (CHUFSC 473).

***Tropidodryas striaticeps* (n = 8)**

BRAZIL: *Santa Catarina*: Antonio Carlos (CHUFSC 194; 820); Blumenau (FURB 2081; 2163; 2192; 2217; 2627; 2773).

***Erythrolamprus almadensis* (n = 5)**

BRAZIL: *Mato Grosso*: Dois Irmãos do Buriti (MHNCI 7888); *Paraná*: Araucária (MHNCI 3675); Ponta Grossa (MHNCI 4440); Salvador (MHNCI 11347); *São Paulo*: Estado de São Paulo (MHNCI 7572).

***Erythrolamprus jaegeri* (n = 9)**

BRAZIL: *Paraná*: Campo Largo (MHNCI 8131); Curitiba (MHNCI 3759; 9170; 10141); Fazenda Rio Grande (MHNCI 11039; 11062); Guarapuava (MHNCI 10028); Quatro Barras (MHNCI 9236); Tijucas do Sul (MHNCI 7542).

***Erythrolamprus miliaris* (n = 10)**

BRAZIL: *Santa Catarina*: Biguaçu (FURB 21455); Blumenau (FURB 2165; 2673; 2859; 11059; 21190; 21477); Gaspar (FURB 21501); Itapoá (CHUFSC 1236); Unknown locality (FURB 21111).

***Erythrolamprus poecilogyrus* (n = 10)**

BRAZIL: *Santa Catarina*: Abdon Batista (FURB 21050); Caxambu do Sul (FURB 11550); Chapecó (FURB 11551); Ipuacu (FURB 2644; 2895); São Domingos (FURB 2554; 11212; 11213; 11214; 11222).

***Xenodon guentheri* (n = 10)**

BRAZIL: *Paraná*: São José dos Pinhais (MHNCI 11737); União da Vitória (MHNCI 1605; 1761; 3994); *Santa Catarina*: Bom Jardim da Serra (CHUFSC 077; 087); Bom Retiro (CHUFSC 3436); Lages (CHUFSC 269; 474); São Cristóvão do Sul (MHNCI 744).

***Xenodon merremii* (n = 10)**

BRAZIL: *Paraná*: Agudos do Sul (MHNCI 2167; 2216; 2217); Campina Grande do Sul (MHNCI 2212); Maringá (MHNCI 3582); Piraquara (MHNCI 2829); São José dos Pinhais (MHNCI 3441); Telêmaco Borba (MHNCI 2444; 2981); Umuarama (MHNCI 3964).

***Xenodon neuwiedi* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2209; 2718; 2775; 2807; 2824; 11126; 11128; 21498); Corupá (FURB 21020); Indaial (FURB 2564).

***Micrurus altirostris* (n = 10)**

BRAZIL: *Rio Grande do Sul/Santa Catarina*: Águas de Chapecó/Paial/Alpestre/Itatiba do Sul (FURB 11772; 11773); *Santa Catarina*: Chapecó (FURB 11478; 11519; 11520); Guatambu (FURB 11291; 11479; 11480); Rio dos Índios (FURB 11451); São Domingos (FURB 21027).

***Micrurus corallinus* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2123; 2534; 2664; 2871; 11172; 11251; 11337; 21136; Indaial (FURB 21511); Pomerode (FURB 21510).

***Bothrops jararaca* (n = 10)**

BRAZIL: *Santa Catarina*: Arvoredo (FURB 11434); Blumenau (FURB 2185; 2199; 2713; 2806; 2877; 2883; 11144; 21030); Ipuacu (FURB 2889).

***Bothrops jararacussu* (n = 10)**

BRAZIL: *Santa Catarina*: Blumenau (FURB 2123; 2149; 2527; 2530; 2628; 2867; 2872; 11747); Brusque (FURB 2038); Gaspar (FURB 2618).

***Bothrops neuwiedi* (n = 2)**

BRAZIL: *Paraná*: Palmas (FURB 11264); *Rio Grande do Sul/Santa Catarina*: Águas de Chapecó/Paial/Alpestre/Itatiba do Sul (FURB 11843).

***Crotalus durissus* (n = 6)**

BRAZIL: *Minas Gerais*: Nova Ponte (FURB 11736; 11737); *Santa Catarina*: Ipuacu (FURB 2605; 11135); São Domingos (FURB 11565; 21026).