New defensive behaviour of the false coral snake
Oxyrhopus rhombifer Duméril, Bibron & Duméril, 1854
(Serpentes, Dipsadidae) in south-eastern Brazil

Novos comportamentos defensivos da falsa-coral
Oxyrhopus rhombifer Duméril, Bibron & Duméril, 1854
(Serpentes, Dipsadidae) no sudeste do Brasil

Clodoaldo Lopes de Assis¹, Jhonny José Magalhães Guedes¹,
Letizia Miriam Gomes de Jesus¹, Renato Neves Feio¹

¹ Museu de Zoologia João Moojen, Departamento de Biologia Animal, Universidade Federal de Viçosa, Vila Gianetti, n° 32, 36570-900 – Viçosa, Minas Gerais, Brazil

Corresponding author: Clodoaldo Lopes de Assis (clodoassis@yahoo.com.br)

Academic editor: P. Lehmann | Received 17 November 2019 | Accepted 28 January 2020 | Published 19 March 2020

Citation: Assis CL, Guedes JJM, Jesus LMG, Feio RN (2020) New defensive behaviour of the false coral snake Oxyrhopus rhombifer Duméril, Bibron & Duméril, 1854 (Serpentes, Dipsadidae) in south-eastern Brazil. Neotropical Biology and Conservation 15(1): 71–76. https://doi.org/10.3897/neotropical.15.e48564

Abstract

Anti-predator mechanisms are essential for species survival and the description of defensive behaviour may improve our understanding about the ecology, biology and evolution of species. Herein, we describe new anti-predator behaviour for the False Coral Snake Oxyrhopus rhombifer in south-eastern Brazil, through direct observation of a juvenile specimen under laboratory settings. We recorded 10 types of defensive behaviour, seven of which are new records for this species and one of them (body vibration) is the first report for Brazilian snakes. Such behaviour may be explained by ontogeny or physical constraints. We highlight that O. rhombifer may be capable of recognising different threat levels imposed by predators and, accordingly, adjusting its defensive behaviour.

Resumo

Mecanismos antipredadores são essenciais para sobrevivência das espécies e descrever comportamentos defensivos pode melhorar nosso entendimento sobre a ecologia, biologia e evolução das espécies. Aqui, fornecemos dados sobre novos comportamentos antipredadores para a falsa-coral Oxyrhopus rhombifer...
Predatory pressures evolutionarily shaped the responses of prey, which can display either avoidance mechanisms by removing themselves from the predators foraging field or anti-predator mechanisms to reduce the odds of predation when occupying the same habitat (Brodie et al. 1991). Several anti-predator mechanisms are known for snakes, which aim to avoid detection, injuries and, ultimately, death (Greene 1988). The current knowledge about anti-predator mechanisms are still scarce for many species, but has increased annually with descriptions of, for example, new defensive behaviour (e.g. Pereira et al. 2018, Fiorillo et al. 2019, Guedes et al. 2017). The availability of such data is crucial for a better understanding of species ecology, biology and evolution (e.g. Greene 1988; Sazima and Abe 1991, Pereira et al. 2018).

The genus *Oxyrhopus* (Serpentes: Dipsadidae) is comprised of 14 species with coral-like colouration, distributed across Central and South America (Costa and Bénils 2018, Uetz et al. 2019). Amongst them, *O. rhombifer* Duméril, Bibron & Duméril, 1854 is known to occur in Argentina, Paraguay, Uruguay, Bolivia and in all Brazilian biomes (Nogueira et al. 2019). This species is a terrestrial snake, mainly found in the Cerrado, dirty fields and forest borders (Sawaya et al. 2008). Besides its aposematic colouration, this species exhibits other anti-predator mechanisms, such as cloacal discharge, body flattening, struggling (Sawaya et al. 2008), erratic movements and hiding the head (Marques et al. 2015). Herein, we describe a new defensive behaviour displayed by *O. rhombifer* in south-eastern Brazil.

On 27 November 2017, a juvenile male *Oxyrhopus rhombifer* was collected by local collectors in the municipality of Paula Cândido (precise locality unknown; the following coordinates refer to the municipality’s centroid: 20.8508S, 42.9806W, WGS84), state of Minas Gerais, Brazil. The region is part of the Atlantic Forest biome (*sensu* IBGE 2019) and the dominant vegetation type is classified as seasonal semi-deciduous forests, currently composed of small secondary forest fragments embedded in a matrix of pastures and eucalyptus plantations (Veloso et al. 1991). The specimen was donated to the Museu de Zoologia João Moojen at Universidade Federal de Viçosa, state of Minas Gerais, Brazil (MZUFV 2485; 336 mm SVL). The observations occurred under laboratory settings (air temperature 18 °C), on the same day as the capture of the individual, which had recently preyed on a liz-
ard *Hemidactylus mabouia* Moreau de Jonnès, 1818 (69 mm SVL). We simulated a predation attempt (Fig. 1A) with an increasing threat level (see Roth and Johnson 2004) by first letting the specimen notice our presence, then approaching it with our hands and finally handling the animal.

Afterwards, we released the snake on to the laboratory bench and let it notice our presence. The animal remained motionless at first, then performed a pronounced dorsoventral flattening of the anterior part of the body (Fig. 1B), raised its tail, adopted an S-shaped posture (Fig. 1C, D), raised the first third of the body and performed brief body vibrations. Then we approached the snake, which remained with the same posture and body vibrations. When we touched the animal (not handling), it remained with the S-shaped posture, keeping the first third of the body elevated and the dorsoventral flattening (however, less accentuated) and started to display erratic movements, false strikes and locomotor escape. When handled, the snake only struggled. We filmed just a few of these types of behaviour, which are deposited in the Fonoteca Neotropical Jacques Vielliard (ZUEC-VID 783). The specimen was euthanised by an intraperitoneal injection of 2% lidocaine, fixed in formalin 10%, preserved in 70% alcohol and deposited in the herpetological collection of the MZUFV.

We observed a great variation in the defensive repertoire of the juvenile *Oxyrhopus rhombifer*, where, amongst the ten types of behaviour recorded, only three were already known for this species. Amongst the five types of behaviour described in literature, only two of them were not shown – cloacal discharges and hiding the head (Table 1). Recent feeding can influence the snake's defensive behaviour (Herzog and Bailey 1987) and the fact that the specimen had recently fed upon a lizard may have caused physical limitations and affected its response to the predation risk. Moreover, defensive responses in snakes decrease as body size increases – i.e. generally, juveniles exhibit a broader set of defensive behaviour than adults (Sweet 1985, Gutzke et al. 1993, Shine et al. 2002; Roth and Johnson 2004), considering that small predators, that could easily kill a small snake, may not be able to capture, subdue and feed on a large one (Carrier 1996, Roth and Johnson 2004). Therefore, some types of behaviour, described in this study, may be either explained by physical constraints or ontogeny (e.g. being exclusive to juveniles).

Some types of behaviour reported for *Oxyrhopus rhombifer*, such as erratic movements, tail display, dorsoventral flattening and immobility, are typical of coral snakes of the genus *Micrurus* (Sazima and Abe 1991; Marques et al. 2019). These similarities might represent behavioural convergences, as *O. rhombifer* also shares an aposematic colour pattern similar to the true coral snakes colouration patterns, reinforcing the mimicry hypothesis between these two groups of snakes (Sazima and Abe 1991). Regarding body vibrations, this is yet an unknown anti-predator behaviour for Brazilian snakes, this being the first record to the best of our knowledge. There are fossorial snakes that, when threatened, produce low frequency body vibrations that can rapidly propagate through the soil, reaching other snakes and acting as an alarm system (Young et al. 2014). However, *O. rhombifer* is a terrestrial snake and, maybe, such behaviour could actually represent a defensive signal against non-visually orientated predators.
Figure 1. Some defensive types of behaviour displayed by the juvenile *Oxyrhopus rhombifer* (MZUFV 2485). A) simulation of a predation attempt; B) elevation and dorsoventral body compression of the anterior portion of the body; and C, D) S-shaped posture.

Table 1. Defensive types of behaviour reported for *Oxyrhopus rhombifer*.

| Defensive mechanisms                          | Reference                        |
|----------------------------------------------|----------------------------------|
| Immobility                                   | Present study                    |
| Dorsoventral body compression                 | Sawaya et al. 2008, present study|
| Tail display                                 | Present study                    |
| Elevation of the first third of the body     | Present study                    |
| Body vibration                               | Present study                    |
| S-shaped posture                             | Present study                    |
| Erratic movements                            | Marques et al. 2015, present study|
| False strike                                 | Present study                    |
| Cloacal discharges                           | Sawaya et al. 2008               |
| Hiding the head                              | Marques et al. 2015              |
| Locomotor escape                             | Present study                    |
| Struggle                                     | Sawaya et al. 2008, present study|

We observed differences in defensive strategies by the specimen *Oxyrhopus rhombifer* according to the threat level imposed. While only observing the snake, it made what is known as warning displays (Sazima 1992) – e.g. dorsoventral flattening and S-shaped posture – which is reinforced by the aposematic colouration pattern. The dorsoventral flattening behaviour, for example, creates an illusion of having a larger body size (Tozetti et al. 2009), which may discourage predators from striking
Defensive behaviors of the *Oxyrhopus rhombifer*

at their prey. Behaviour such as false bites, erratic movements and locomotor escape, exhibited after we touched the animal, are actions more related to an offensive defence (Gehlbach 1970; Greene 1988; Sazima 1992). These types of behaviour may either warn predators about the dangers of making contact or that the prey will not be easily captured, thus discouraging any predation attempt (Dugatkin 2013). Therefore, we highlight that *O. rhombifer* may be capable of recognising different threat levels imposed by predators and adjusting its defensive behaviour accordingly.

**Acknowledgements**

We thank ICMBio for licence permits (#10504–1) and Pablo Lehmann for managing the submission process of our manuscript. Paul David Alfonso Gutierrez-Cardenas and Renato Augusto Martins reviewed the ms and provided useful comments.

**References**

Brodie Jr ED, Formanowicz Jr DR, Brodie ED III (1991) Predator avoidance and antipredator mechanisms: Distinct pathways to survival. Ethology Ecology and Evolution 3(1): 73–77. https://doi.org/10.1080/08927014.1991.9525390

Carrier DR (1996) Ontogenetic Limits on Locomotor Performance. Physiological Zoology 69(3): 467–488. https://doi.org/10.1086/physzool.69.3.30164211

Costa HC, Bérnils RS (2018) Répteis do Brasil e suas Unidades Federativas: Lista de espécies. Herpetologia Brasileira 7: 11–51.

Dugatkin LA (2013) Principles of Animal Behavior (3rd Edition). WW Norton & Company Press, New York, 672 pp.

Fiorillo BF, Rossi GN, Martins M (2019) Additional defensive behaviours of *Dipsas mikanii* (Schlegel, 1837) and *Taeniophallus occipitalis* (Jan, 1863) (Serpentes: Dipsadidae). Herpetology Notes 12: 359–362.

Gehlbach FR (1970) Death-Feigning and Erratic Behaviour in Leptotyphlopod, Colubrid, and Elapid Snakes. Herpetologica 26: 24–34.

Greene HW (1988) Antipredator Mechanisms in Reptiles. In: Gans C, Huey RB (Eds) Biology of the Reptilian. Alan R. Liss, New York, 1–152.

Guedes JJM, Assis CL, Silva DH, Feio RN (2017) New records and notes on defensive behavior of *Thamnodynastes rutilus* (Prado 1942). Neotropical Biology and Conservation 12(2): 154–158. https://doi:10.4013/nbc.2017.122.09

Gutzke WH, Tucker C, Mason RT (1993) Chemical recognition of kingsnakes by crotalines: Effects of size on the ophiophagous defensive response. Brain, Behavior and Evolution 41(3–5): 234–238. https://doi.org/10.1159/000113844

Herzog HA, Bailey BD (1987) Development of Antipredator Responses in Snakes: II. Effects of Recent Feeding on Defensive Behaviors of Juvenile Garter Snakes (*Thamnophis sirtalis*). Journal of Comparative Psychology 101(4): 387–389. https://doi.org/10.1037/0735-7036.101.4.387
Marques OAV, Eterovic A, Nogueira CC, Sazima I (2015) Serpentes do Cerrado: guia ilustrado. Holos Editora, Ribeirão Preto, São Paulo, 251 pp.

Marques OAV, Eterovic A, Sazima I (2019) Serpentes da Mata Atlântica. Guia ilustrado para a Serra do Mar. Editora Ponto, Cotia, São Paulo, 319 p.

Nogueira CC, Argólô AJ, Arzamendia V, Azevedo JA, Barbo FE, Bénils RS, Bolochio BE, Borges-Martins M, Brasil-Godinho M, Braz H, Buononato MA, Cisneros-Heredia DF, Colli GR, Costa HC, Franco FL, Giraudo A, Gonzalez RC, Guedes T, Hoogmoed MS, Marques OAV, Montingelli GG, Passos P, Prudente ALC, Rivas GA, Sanchez PM, Serrano FC, Silva NJ, Strüssmann C, Vieira-Alencar JPS, Zaher H, Sawaya RJ, Martins M (2019) Atlas of Brazilian Snakes: Verified Point-Locality Maps to Mitigate the Wallacean Shortfall in a Megadiverse Snake Fauna. South American Journal of Herpetology 14(sp1): 1. https://doi.org/10.2994/SAJH-D-19-00120.1

Pereira VDO, Menezes FDA, Azevedo WDS, Abegg AD (2018) Repertoire of antipredator displays in Siphlophis longicaudatus (Serpentes: Dipsadidae). Herpetology Notes 11: 157–160.

Roth ED, Johnson JA (2004) Size-based variation in antipredator behavior within a snake (Agkistrodon piscivorus) population. Behavioral Ecology 15(2): 365–370. https://doi.org/10.1093/beheco/arh024

Sawaya RJ, Marques OAV, Martins M (2008) Composição e história natural das serpentes de Cerrado de Itirapina, São Paulo, Sudeste do Brasil. Biota Neotropica 8: 127–149. https://doi.org/10.1590/S1676-0632008000200015

Sazima I (1992) Natural history of the jararaca pitviper, Bothrops jararaca, in Southeastern Brazil. In: Campbel JA, Brodie Jr ED (Eds) Biology of the Pitvipers. Texas, Selva Tyler, 199–216.

Sazima I, Abe AS (1991) Habits of five Brazilian snakes with Coral-Snake pattern, including a summary of defensive tactics. Studies on Neotropical Fauna and Environment 26(3): 159–164. https://doi.org/10.1080/01650529109360848

Shine R, Sun L, Fitzgerald M, Kearney M (2002) Antipredator Responses of Free-Ranging Pit Vipers (Gloydius shedaoensis, Viperidae). Copeia 2002(3): 843–850. https://doi.org/10.1643/0045-8511(2002)002[0843:AROFRP]2.0.CO;2

Sweet SS (1985) Geographic variation, convergent crypsis and mimicry in Gopher Snakes (Pituophis melanoleucus) and Western Rattlesnakes (Crotalus viridis). Journal of Herpetology 19(1): 55. https://doi.org/10.2307/1564420

Tozetti AM, Oliveira RB, Pontes GMF (2009) Repertório defensivo de Xenodon dorbignyi (Serpentes, Dipsadidae). Biota Neotropica 9(3): 157–163. https://doi.org/10.1590/S1676-0632009000300016

Uetz P, Freed P, Hošek J (2019) The Reptile database. http://www.reptile-database.org/ [accessed: 20 January 2020]

Veloso HP, Rangel Filho ALR, Lima JCA (1991) Classificação da vegetação brasileira adaptada a um sistema universal. IBGE, Rio de Janeiro, 112 p.

Young BA, Mathevon N, Tang Y (2014) Reptile Auditory Neuroethology: What Do Reptiles Do with Their Hearing? Insights from Comparative Hearing Research 2014: 323–346. https://doi.org/10.1007/2506_2013_30