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A new species of *Kora* from Bahia, Brazil (Gastropoda: Pulmonata: Orthalicoidea), with an emended diagnosis of the genus

Rodrigo B. Salvador & Luiz Ricardo L. Simone

Abstract

A new species of land snail was recently found in the municipalities of Carinhanha, Serra do Ramalho and Coribe, western Bahia state, Brazil. It is described herein as *Kora rupestris* **n. sp.** and can be easily recognized from its congeners by its usually narrower shell and aperture, and especially by its protoconch sculpture pattern. In light of this new discovery, new emended diagnosis and description are provided for the genus *Kora*, and two taxa previously described under this genus are excluded, being transferred to the genus *Drymaeus* [*D. iracema* (Simone, 2015) **n. comb.** and *D. terreus* (Simone, 2015) **n. comb.**]. The region where the new species was found consists of a contact zone of the Caatinga and Cerrado biomes. Such regions are proving to be quite diverse and a more thorough knowledge of their fauna is of utmost importance for future conservation efforts.

Keywords: Bulimulidae, Carinhanha, Caatinga, Cerrado, *Kora rupestris* new species.

Zusammenfassung

Eine neue Landschneckenart aus Brasilien wurde kürzlich in den Gebieten von Carinhanha, Serra do Ramalho and Coribe im Westen des Bundesstaates Bahia festgestellt. Sie wird hier als *Kora rupestris* **n. sp.** beschrieben und ist von anderen Arten der Gattung *Kora* leicht zu unterscheiden durch ihre üblicherweise schmalere Schale und Mündung, vor allem aber durch die Skulptierung des Protoconchs. Aufgrund dieser neu entdeckten Art wird eine aktualisierte Diagnose und Beschreibung der Gattung *Kora* gegeben und zwei zuvor in dieser Gattung beschriebene Arten werden in die Gattung *Drymaeus* gestellt [*D. iracema* (Simone, 2015) **n. comb.** und *D. terreus* (Simone, 2015) **n. comb.**]. Die Region, in der die neue Art gefunden worden ist, stellt eine Berührungszone der Caatinga- und Cerrado-Biome dar. Solche Kontaktzonen sind sehr artenreich und eine bessere Kenntnis ihrer Fauna ist von hoher Bedeutung für künftige Naturschutzbestrebungen.

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1 Introduction

Kora Simone, 2012 (Gastropoda: Pulmonata: Orthalicoidea) is an endemic central-eastern Brazilian genus of pulmonate land snails, occurring in the Caatinga biome of the states of Bahia and Minas Gerais (Simone 2015). The genus currently includes four species: *Kora coralina* Simone, 2012 (the type species), *K. iracema* Simone 2015, *Kora nigra* Simone, 2015 and *K. terrea* Simone, 2015. New material from Bahia (and re-examination of the material studied by Simone 2012, 2015) has brought to light yet another species, which is described below. Moreover, in light of this new discovery, an emended diagnosis for the genus *Kora* is provided herein.

Acknowledgements

We are deeply grateful to José Coltro (Femorale) and Maria E. Bichuette (Universidade Federal de São Carlos, Brazil) and their respective teams for the donation of the material studied here; to Daniel C. Cavallari (MZSP) for locating the material of the J. Vaz collection; to Karin Wolf-Schwenninger (SMNS) for her help with ESEM images; to Francisco J. Borrero and an anonymous reviewer for their helpful comments on the manuscript. This work was partly supported by a doctorate grant from CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico, Brazil; proc. #245575/2012-0) to R. B. S.

2 Material and methods

The material of the new species described herein was recovered in the municipalities of Carinhanha and Serra do Ramalho, western Bahia state, Brazil (Fig. 1), and is listed and discussed below. For detailed examination of the protoconch, uncoated samples were mounted on stubs and observed under an Environmental Scanning Electron Microscope (ESEM) in the SMNS.

Furthermore, in order to present emended generic diagnosis and description of the genus *Kora*, all available material described in the genus *Kora* was analyzed (see Simone 2012, 2015 for more detailed information on these lots): *Kora*

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Fig. 1. Map showing the presently known distribution of *Kora rupestris* n. sp., the municipalities of Carinhanha (type locality), Serra do Ramalho and Coribe. – Abbreviations of neighboring states: MA, Maranhão; PI, Piauí; PE, Pernambuco; AL, Alagoas; SE, Sergipe; TO, Tocantins; GO, Goiás; MG, Minas Gerais; ES, Espírito Santo.

corallina: MZSP 103910 (holotype; Bahia state, Santa Maria da Vitória); MZSP 103911 (paratype; from type locality); MZSP 103912 (paratype; from type locality); MZSP 103913 (paratypes; 32 shells; from type locality); MZSP 104033 (> 50 shells; from type locality); MNHN IM-2012-37362 (paratypes; 2 shells; from type locality); MNRJ 30377 (paratypes; 2 shells; from type locality); USNM 1157009 (paratypes; 2 shells; from type locality). – *Kora iracema*: MZSP 104964 (holotype; Bahia state, São Desidério). – *Kora nigra*: MZSP 106232 (holotype; Bahia state, Serra do Ramalho); MZSP 104839 (paratypes; 5 shells; unknown provenance, but likely from type locality); MZSP 106241 (paratype; from type locality); MZSP 106250 (paratypes; 2 shells; from type locality). – *Kora terrea*: MZSP 106215 (holotype; Minas Gerais state, Presidente Olegário).

Abbreviations

D	shell greatest width
d	aperture width
H	shell length
h	aperture height
S	spire (excluding aperture)
S'	spire (excluding body whorl)

Acronyms of Institutions

MNHN	Museé National d'Histoire Naturelle (Paris, France)
MNRJ	Museu Nacional da Universidade Federal do Rio de Janeiro (Rio de Janeiro, Brazil)
MZSP	Museu de Zoologia da Universidade de São Paulo (São Paulo, Brazil)
SMNS	Staatliches Museum für Naturkunde Stuttgart (Stuttgart, Germany)
USNM	National Museum of Natural History, Smithsonian Institution (Washington D. C., USA).

3 Systematics

Superfamily Orthalicoidea
Family Bulimulidae
Genus *Kora* Simone, 2012

Type species: *Kora corallina* Simone, 2012; Recent, Brazil.

Included taxa: *Kora corallina* Simone, 2012 (Figs. 2, 12–14); *K. nigra* Simone, 2015 (Fig. 3); *K. rupestris* n. sp. (Figs. 4–11, 15–17).

Original diagnosis (Simone 2012: 432)

"Outline fusiform; spire tall, somewhat turriform. Protoconch simple, paucispiral, ornamented by scanty axial cords. Umbilicus narrow. Peristome somewhat away from longitudinal axis of spire. Peristome deflected. Inner lip with strong, oblique tooth in middle level."

Emended diagnosis

Shell conical-fusiform. Color initially lighter, becoming darker towards aperture; light-colored subsutural spiral band always present. Protoconch (~ 2 whorls) initially smooth, becoming sculptured by well-marked sinuous axial ribs later on, which gradually increase in strength until they become similar to teleoconch sculpture; proportion of whorls with and without sculpture pattern varies interspecifically and ribs of "transitional" strength might not be present. Transition from proto- to teleoconch not clearly marked. Teleoconch sculptured by sinuous prosocline axial ribs. Aperture broad, slightly expanded laterally, away from the shell axis. Peristome reflexed. Columellar lamella oblique. Umbilicus narrow, but well-marked.

Discussion

The set of diagnostic features of the genus *Kora* allows a clear distinction from other orthalicoid genera. The main characters are analyzed below; the most important of which is the protoconch sculpture pattern.

Shell: The shell seems to be conservative within the genus, with all species displaying a conical-fusiform shell, differing only in its proportions and absolute size. As already pointed out by Simone (2012), the degree of intraspecific conchological variation of *Kora* species is not high (*K. corallina* is known from several dozens of specimens): the variation in size is small, but shape can go from narrower to broader shells, the latter sometimes also with a broader aperture.

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Color: Both *K. corallina* and *K. rupestris* n. sp. have initially light-colored shells, which become clearly darker towards the aperture. *Kora nigra* is more uniformly colored, although the same pattern may be observed. Variation in overall coloration and color pattern is seen only interspecifically in *Kora* (at least in the presently available material). A great amount of variation (both inter- and intraspecific) is common in other orthalicoid genera, such as, for instance, *Drymaeus* Albers, 1850 and *Leiostracus* Albers, 1850, but is minimal in others, such as *Plekocheilus* Guilding, 1828 and *Dryptus* Albers, 1860 (e. g., Simone 2006; Breure & Mogollón Avila 2010; Borrero & Breure 2011; Salvador & Cavallari 2013; Salvador et al. 2015). A constant feature of the genus seems to be a lighter-colored spiral band right below the suture.

Aperture: A reflexed peristome is found in all presently-known species of *Kora*. This is not exclusive of *Kora* and can be seen in many orthalicoid genera (e. g., Simone 2006), although this feature is not necessarily constant throughout each genus.

Apertural barriers: The columellar lamella seen in *Kora* is a recurrent feature in orthalicoid families (and its presence/absence may vary within some genera) and might not be very useful for diagnosis and phylogenetic analyses. As pointed out by Simone (2012), other Brazilian orthalicoid genera with a similar lamella are *Dryptus*, *Plekocheilus* and *Eudolichotis* Pilsbry, 1896. A similar lamella is known in the family at least since the Late Paleocene or Early Eocene, as shown by the fossil genus *Itaborahia* Maury, 1935, from Rio de Janeiro state (Salvador & Simone 2013).

Protoconch: The most characteristic feature of the genus *Kora* is the protoconch. The protoconch (~ 2 whorls) is initially smooth, becoming sculptured by well-marked sinuous axial ribs later on, which gradually increase in strength until they become similar to teleoconch sculpture. The exact numbers of smooth and sculptured whorls varies interspecifically (Figs. 12–17). The transition from proto- to teleoconch is weakly marked.

On the one hand, both *K. corallina* (Figs. 12–14) and *K. nigra* have the first ~ ¼ whorl smooth; the next ~ 1½ whorl is sculptured by faint axial striae; close to the final ~ ¼ whorl, these striae become more strongly marked, equal to the teleoconch's ribs. On the other hand, *K. rupestris* n. sp. (Figs. 15–17) has the first 1½ to 1¾ whorl smooth; the last ½ to ¼ whorl has the same strong axial ribs as the teleoconch. This means that the "transitional" faintly striated region is not usually present in *K. rupestris* n. sp., but a single specimen shows very faint axial striae immediately before the onset of the thicker teleoconch-like ribs.

This axial sculpture pattern of the protoconch is similar to that of the genus *Naesiotus* Albers, 1850 and *Rabdotus* Albers, 1850, with its sinuous and well-marked axial ribs (Breure 1978, 1979; Breure & Coppois 1978). Nevertheless, these two genera show the entire protoconch covered in ribs, contrary to *Kora*, which has a smooth region before the beginning of the ribbed area. Finally, as pointed out by Simone (2012), *Neopetraeus* von Martens, 1885 also has axial riblets similar to *Kora*, but its protoconch is also sculptured by fine spiral striae, giving it a reticulate appearance (Breure 1979).

In addition, the protoconchs of *Naesiotus* spp. exhibit a lower number of axial ribs than those of *Kora*; the number of axial ribs in the protoconch of *Rabdotus* spp. is intermediate between those of species of *Naesiotus* and *Kora* (Breure 1978, 1979). The pattern of the protoconch sculpture, closely reminiscent of *Naesiotus* and *Rabdotus*, might indicate the placement of the genus *Kora* in the family Bulimulidae (as per Breure & Romero 2012) instead of the originally proposed allocation in Orthalicidae (Simone 2012). Protoconch sculpture tends to be a good indicative of the relationship between taxa, but the family Bulimulidae also counts with genera with very distinct protoconch patterns, such as *Drymaeus* (Breure 1978, 1979; Breure & Romero 2012). As such, the importance of this character in the classification of the Orthalicoidea remains somewhat uncertain.

Finally, the protoconchs of *Kora iracema* Simone, 2015 and *K. terrea* Simone, 2015 exhibit a completely reticulated sculpture pattern, thus lacking the characteristic protoconch of *Kora*. This conformation is characteristic of the genus *Drymaeus* (Breure 1979). Moreover, their overall shell shape, aperture shape, lack of a strong columellar fold, and greatly reflexed peristome are also befitting of the genus (Breure 1978, 1979; Simone 2006). As such, both species are here transferred to this genus as *Drymaeus iracema* (Simone, 2015) n. comb. and *D. terreus* (Simone, 2015) n. comb.

Kora rupestris **n. sp.**
(Figs. 4–11, 15–17)

Kora corallina: Simone 2015 [in part]: 53 (figs. 14, 22).

Holotype: MZSP 121416 (A. Bianchi col., VIII.2012; Figs. 4–7, 15–17).

Paratypes: MZSP 121441 (2 shells, from type locality; A. Bianchi col., VIII.2012; Figs. 8–9).

Additional material: MZSP 106230 (1 shell; Serra do Ramalho municipality, Gruna das Três Cobras; 14°19′S 43°47′W; alt. 440 m; M. E. Bichuette col., 10.IX.2008; Fig. 10). MZSP 107996 (1 shell; Coribe municipality; J. Vaz collection; M. U. T. Rodrigues col., I.1980; Fig. 11).

Type locality: Brazil, Bahia, Carinhanha municipality (city center coordinates: 14°18′18″S 43°45′54″W), under rocks on Canabrava Hill. Unfortunately, more precise locality data, such as coordinates and altitude, were not recorded by the collector.

Etymology

From the Latin "rupestris", meaning "of rock", "montane". Reference to the rocky mount where the types were collected.

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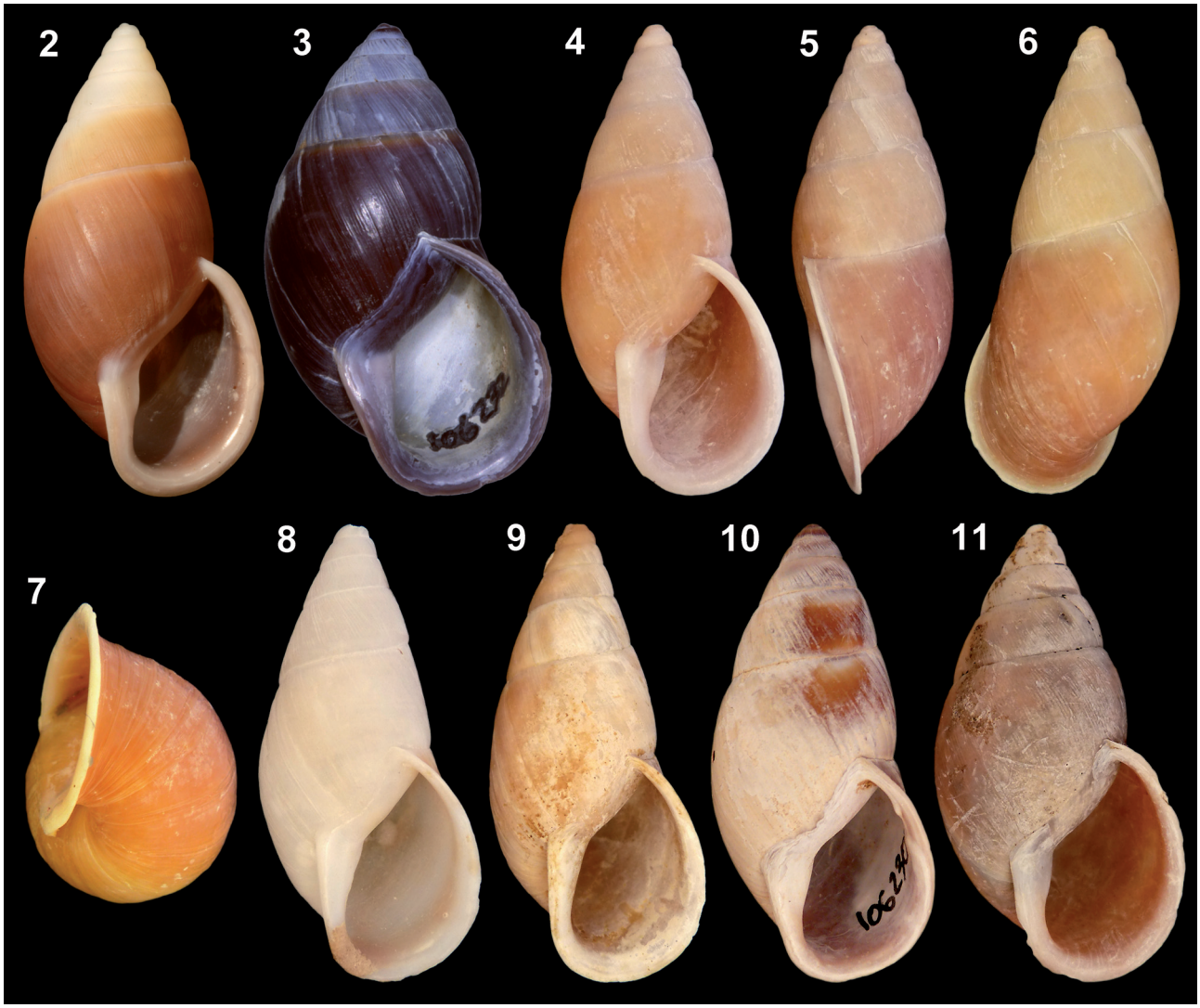

Figs. 2–11. *Kora* spp. from Bahia state, apertural (2–4, 8–11), umbilical (7), lateral (5), and dorsal (6) views. – **2**. *K. corallina* (holotype, MZSP 103910; H = 43.4 mm). **3**. *K. nigra* (holotype, MZSP 106232; H = 30.1 mm). – **4–7**. *K. rupestris* n. sp. (holotype, MZSP 121416; H = 37.7 mm). – **8**. *K. rupestris* n. sp. (paratype #1, MZSP 121441; H = 35.5 mm). **9**. *K. rupestris* n. sp. (paratype #2, MZSP 121441; H = 33.3 mm). **10**. *K. rupestris* n. sp. (MZSP 106230; H = 34.2 mm). **11**. *K. rupestris* n. sp., apertural view (MZSP 107996; H = 35.6 mm).

Distribution

Known only from the type locality and the neighboring municipalities of Serra do Ramalho to the north and Coribe to the west (Fig. 1).

Habitat

Caatinga shrublands.

Diagnosis

Shell slender. Shell color comprised of light tones of brown. Protoconch sculpture pattern: first 1½ to 1¾ whorl smooth; last ½ to ¼ whorl sculptured by well-marked axial striae. Aperture narrow.

Description

Shell large (~ 35 mm), conical-fusiform, slender; greatest width on body whorl; shell width ~ 2/5 shell length (Figs. 4–6, 8–11). Shell color light brown; last whorl increasingly darker; narrow stripe immediately below the suture slightly lighter than remainder of whorl (Figs. 4–6). Peristome white. Spire angle usually ca. 45°, but up to ca. 50° in broader specimens. Protoconch (~ 2 whorls; Figs. 15–17) rounded; first 1½ to 1¾ whorl smooth; last

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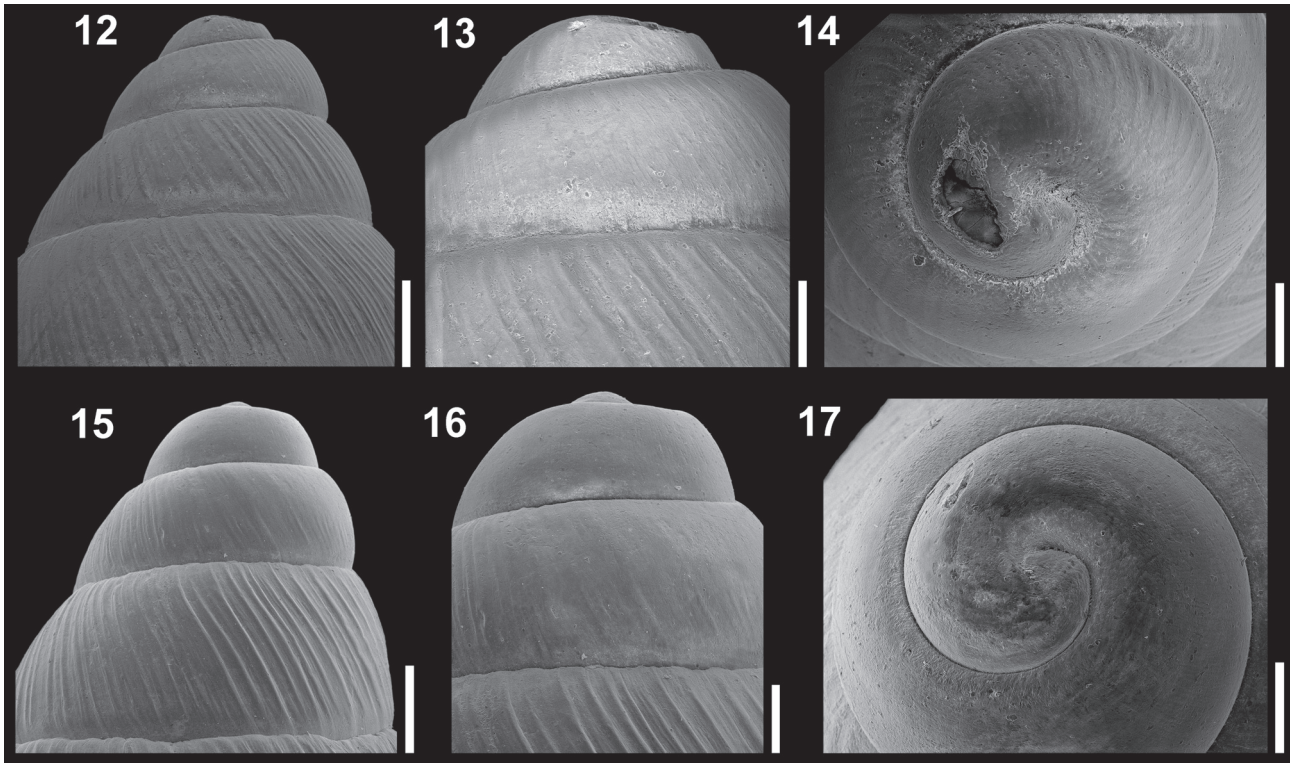

Figs. 12–17. *Kora* spp. from Bahia state, lateral (12–13, 15–16), and apical (14, 17) views. – **12**. *K. corallina*, proto- and teleoconch sculpture (paratype, MZSP 103913). **13**. Same, in higher magnification, showing the transition from faint to more marked sculpture. **14**. Same, showing the transition from smooth to faintly sculptured protoconch. **15**. *K. rupestris* n. sp., lateral view of proto- and teleoconch sculpture (holotype, MZSP 121416). **16**. Same, in higher magnification, showing the transition from smooth to sculptured protoconch. **17**. Same, showing the almost entirely smooth protoconch. – Scales: 1 mm (12, 15), 0.5 mm (13–14, 16–17).

½ to ¼ whorl sculptured by well-marked axial striae (same as teleoconch); transition to teleoconch not clearly marked, prosocline, simple. Teleoconch sculptured by sinuous prosocline axial striae (Fig. 15). Whorl profile lightly convex. Suture well-marked, but not deep. Body whorl almost ⅔ shell length. Aperture oval, prosocline, proportionately large, slightly expanded laterally away from shell axis; aperture ~ ½ shell length, ~ ⅔ shell width. Columellar lamella well-marked, variable in size, oblique to shell axis (Figs. 4, 8–11). Peristome greatly reflexed. Umbilicus narrow (Fig. 7).

Measurements (in mm). Holotype: 6½ whorls; H = 37.7; D = 16.3; S = 19.4; S' = 13.7; h = 18.2; d = 11.4. – Paratype #1: 6¼ whorls; H = 35.5; D = 15.3; S = 18.6; S' = 12.4; h = 16.5; d = 10.7. – Paratype #2: 6¼ whorls; H = 33.3; D = 14.8; S = 17.1; S' = 12.2; h = 16.5; d = 10.2. – MZSP 106230: 6¼ whorls; H = 34.2; D = 15.9; S = 17.9; S' = 12.0; h = 15.9; d = 11.1. – MZSP 107996: 6½ whorls; H = 35.6; D = 18.2; S = 18.3; S' = 13.1; h = 17.6; d = 12.1.

Differential diagnosis

Kora rupestris n. sp. can be easily diagnosed by its different protoconch sculpture pattern (see the discussion of the genus, above, for the comparison with *K. corallina* and *K. nigra*). Moreover, *K. rupestris* n. sp. (Figs. 4, 8–11) has a more slender shell and spire than *K. corallina* (Fig. 2) and *K. nigra* (Fig. 3), which also results in a slightly narrower aperture; both *K. corallina* are and *K. nigra* are very broad, as also reflected in their greater spire angle values of 45–50° (*K. corallina*) and 60–65° (*K. nigra*). However, there are more slender specimens of *K. corallina*, which present the same shell length/width ratio as *K. rupestris* n. sp. Such specimens may be diagnosed by size (besides the protoconch), as the shell of *K. rupestris* n. sp. is smaller than that of *K. corallina*, having approximately ¾ of the shell length of the latter, with no overlap in their size ranges. *Kora rupestris* n. sp. is slightly larger than *K. nigra*, although some doubtful specimens of the latter (MZSP 104839) are in the upper size range of *K. corallina*. Furthermore, *K. rupestris* n. sp. shows ½ to ¾ less whorl in the teleoconch, when compared to *K. corallina*, although it has the same whorl count as *K. nigra*. Finally, the color pattern of *K. rupestris* n. sp. (Fig. 4) is similar in nature to that of *K. corallina* (Fig. 2), but it is usually comprised of overall lighter tones of brown; *K. nigra* has a more homogenous dark coloration (Fig. 3).

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The single specimen (MZSP 106230) recovered in a cavern and identified by Simone (2015: figs. 14, 22) as *K. corallina*, in fact belongs to *K. rupestris* n. sp. It agrees with *K. rupestris* n. sp. in size, overall shape and, more importantly, the protoconch sculpture pattern. This single specimen is slightly broader than the type specimens of *K. rupestris* n. sp., with a narrower umbilicus, proportionately smaller aperture and displaying a stronger white parietal callus. Nevertheless, this same kind and extent of variation is seen in the type series of *K. corallina*, and is thus considered here intraspecific variation of *K. rupestris* n. sp.

4 Concluding remarks

Carinhanha and Serra do Ramalho municipalities, the known distribution of *Kora rupestris*, are located in western Bahia state (Fig. 1), on the west banks of the São Francisco River. It is an interesting region, consisting of a contact zone of the Caatinga and Cerrado biomes, with the hypoxerophytic forests of the former and stretches of the open deciduous forest of the latter (Sá et al. 2003). The climate is considered tropical dry (semiarid), with a dry winter season and rain concentrated on the end of spring and beginning of summer. It is a limestone-rich region, which seems to be favorable for land snails, perhaps especially for those with sturdy shells (e. g., Salvador & Simone 2014).

The Caatinga biome, despite being usually considered of low biodiversity levels, is now revealing an amazing array of species, across all main terrestrial and freshwater taxa and including several endemic species (e. g., Tabarelli & Silva 2002). Nevertheless, there are still proportionally few works on this fauna, which is often not included in conservation measures (e. g., Silva et al. 2003). This is especially troubling, since circa 20 % of the Caatinga is already considered degraded (Sá et al. 2003) and continental mollusks are considered the most imperiled group of animals, with the highest extinction rates (Lydeard et al. 2004; Régnier et al. 2008). The more arid habitats are normally seen as an adverse place for land snails (which depend so much on preserving water), but it appears that the Caatinga may still hide many new snails (e. g., Salvador & Simone 2014; Simone 2015). This is especially true due to the limestone-rich environments of this biome, which allow land snails to thrive, but which are now threatened by mining activities (Simone 2015). Moreover, the specimens of *Kora nigra* and *Drymaeus iracema* (as well as a single specimen of *Kora rupestris*) were found in caves (Simone 2015), which are fragile ecosystems and thus face their own set of environmental problems (Simone 2013; Campos-Filho et al. 2014). A more thorough knowledge of this biome's species is of utmost importance for future conservation efforts.

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