

## Short Communication

# Observations on the reproductive ecology of *Siphonops paulensis* BOETTGER, 1892 (Gymnophiona: Caeciliidae) in Bolivia

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**Abstract.** Caecilian amphibians show a remarkable diversity of reproductive modes. Due to their secretive lifestyle, basic information on the natural life history of many species is lacking. Here we present the first detailed observations of a clutch of the oviparous caecilian *Siphonops paulensis*. The clutch, guarded by a female, contained four eggs (mean diameter  $7.68 \pm 0.32$  mm). Two unpigmented hatchlings were recorded after 17 days. The available data on the reproductive biology of South-American *Siphonops* is discussed. Key words. caecilians; oviparity; reproduction.

Caecilians are tropical, limbless, primarily subterranean amphibians (e. g. DUNN 1942, TAYLOR 1968, HIMSTEDT 1996). They show a high diversity of reproductive modes associated with parental care (WAKE 1977, WILKINSON & NUSSBAUM 1998). Some caecilians have the presumed ancestral amphibian life cycle of oviparity with aquatic larvae, as known for many frogs and salamanders (e. g. KUPFER et al. 2005). Other oviparous caecilians have direct development of juveniles with no larval stage. Females of oviparous caecilians guard clutches in terrestrial egg chambers (e. g. SARASIN & SARASIN 1887-1890, SANDERSON 1937, GANS 1961, SESHACHAR et al. 1982, HIMSTEDT 1991, MEASEY et al. 2003, FUNK et al. 2004, KUPFER et al. 2004, MEASEY 2004). Other caecilians are viviparous (MOODIE 1978, WAKE 1980, EXBRAYAT & DELSOL 1985, NUSSBAUM & PFRENDER 1998, MEASEY & DI BERNARDO 2003) with at least two modes of viviparity, characterised by differences in the degree of independence of the newborn (e. g. LOADER et al. 2003). Documenting and interpreting the reproductive diversity and the evolution of parental care of caecilians has been considered key to comparisons with

other amphibians (e. g. WAKE 1977). Here, we present data on reproductive parameters for the oviparous caecilian *Siphonops paulensis* BOETTGER, 1892 from a field site in Bolivia.

*Siphonops paulensis* is a widely distributed South American caecilian. DUNN (1942) and later TAYLOR (1968) list records from Argentina (San Ignacio), Brazil (Rio Grande do Norte, Goiás, Matto Grosso, Rio de Janeiro, Sao Paulo), Paraguay (Guaira and Vil-



Fig. 1. Female *Siphonops paulensis* attending a clutch of eggs (A). Two newborns recently hatched (B).

larica) and Bolivia (Buenavista and Santa Cruz). In Bolivia, *S. paulensis* is distributed in the departments Beni and Santa Cruz, in the Cerrado, Chiquitania Dry Forests and Gran Chaco ecoregions (DE LA RIVA et al. 2000). *Siphonops paulensis* prefers open habitats or loose lowland forest formations, whereas the sympatric *S. annulatus* (MIKAN, 1820) is reported from rainforests, transition lowland forests and Pre-Cambrian Shield Humid forests (DE LA RIVA et al. 2000).

Three adult *S. paulensis* were found in disturbed forest near the Piraf river in the city of Santa Cruz de la Sierra, Departamento Santa Cruz, Bolivia. The area is one of the last remnants of the riverside forest of the river Piraf within the city boundaries. The vegetation is dominated by typical riparian species such as *Erythrina poeppigiana*, *E. dominguezii*, *Tipuana tipu* (Fabaceae), *Triplaris americana* (Polygonaceae), *Gallesia integrifolia* (Phytolaccaceae), *Erythrina poeppigiana*, *E. dominguezii* (Fabaceae), *Ceiba* sp. (Bombacaceae), *Senna spectabilis* (Caesalpineaceae), *Inga adenophylla* (Mimosaceae), *Hura crepitans* (Euphorbiaceae), *Batocarpus amazonicus* (Moraceae) and *Vitex cymosa* (Verbenaceae). The understory mainly comprises species of Solanaceae and Piperaceae, and the palm tree *Bactris major* (Areaceae) dominates in less dense understory. The caecilians were collected on 6 December 2000 (afternoon air temperature 28.5 °C). Heavy rainfall was recorded during the week between 29 November to 5 December before the collection was made including 5 December (rainy season in Santa Cruz usually lasts from November to February). All three individuals were found under rotten logs. Two adult animals immediately burrowed into soil when encountered. One female remained coiled around a clutch of four eggs (Fig. 1A).

The site was revisited several times between 7 and 13 December 2000. When checked, the female was always found coiled around her clutch and never left despite being disturbed. For further observations and measurements in the laboratory, the female and the clutch were taken from the field on

13 December 2000. They were kept in a plastic box (40 × 40 × 60 cm) in humid soil taken from the field site. The diameter of four eggs, including all gelatinous capsules ranged from 7.4 to 8 mm (mean 7.68 ± 0.32 mm), the female had a total length of 302 mm. The guarding female and the clutch were inspected on eleven consecutive days from 14 to 25 December 2000 between 9.00 to 12.00 or 21.00 to 0.00 hrs. Most of the time, the female was coiled around the clutch, occasionally being hidden in the soil. On 22 December 2000, two non-pigmented, pinkish hatchlings were observed in the box (Fig. 1B). The remaining two eggs were not found and might have been ingested by the female or the young. The two hatchlings measured 35 and 36 mm. No external gills or gill slits were observed. The hatchlings were completely helpless and did not burrow in the soil. Both died on 25 December 2000, three days after hatching.

Members of the genus *Siphonops* are thought to be oviparous (WAKE 1992, WILKINSON & NUSSBAUM 1998) with direct development and lacking an aquatic larval stage (NUSSBAUM 1979). In the first record of oviparity in the genus *Siphonops*, GOELDI (1899) reported a clutch of six eggs with embryos in an advanced stage of development of *Siphonops* cf. *annulatus* from Theresopolis (Brazil), found in December. The egg diameter (including all egg capsules) was 8.5 mm × 10 mm, very similar to our measurements from Bolivia. GANS (1961) gave a detailed report on egg-laying in a female *Siphonops paulensis* from Primavera (Alto Paraguay), observed from January 28 to 29. The freshly laid clutch contained six eggs. The total diameter of the eggs ranged from 4.3 to 4.5 mm, a much lower value than in the data discussed above. It is likely that egg size increases during embryonic development as observed in other oviparous caecilians (e. g. *Ichthyophis* cf. *kohtaoensis* TAYLOR, 1960; see KUPFER et al. 2004). JARED et al. (1999) reported on female *S. annulatus* with clutches and newborns. Similar to *Siphonops paulensis*, females of *S. annulatus* were reported as non aggressive when guarding the clutch and after birth; the

mother remains with the young (JARED et al. 1999). Whether female *S. paulensis* from Bolivia have a similar postnatal parental care remains unclear. To the best of our knowledge, the field observation of a mother guarding a clutch of eggs, and later in the laboratory guarding newborn young, is the first for *S. paulensis*. WILKINSON & NUSSBAUM (1998) report on a unique foetal-like dentition in young *Siphonops annulatus* and *S. paulensis* from Brazil, a feature also known from altricial young of the West-African caeciliid *Geotrypetes seraphini* (DUMÉRIL, 1859) (PARKER & DUNN 1964). *Geotrypetes seraphini* are thought to feed their postnatal young with secretions of the skin (O'REILLY et al. 1998). M. WILKINSON, R.A. NUSSBAUM and C. JARED (unpubl. observ., as reported in PENNISI 1999) have similar evidence for juvenile nourishment in *Siphonops annulatus*.

*Siphonops paulensis* inhabits and breeds in anthropogenic habitats close to the city of Santa Cruz (see also MONTERO 2003). Additional specimens were collected at the University campus (NKA 152, Natural History Museum Noel Kempff Mercado, Santa Cruz) and within various private properties (reference specimen NKA 4556). Furthermore, MUÑOZ (2000) reported on *Siphonops paulensis* from the city centre of Santa Cruz (Calle Ballivian, near the plaza central). This demonstrates the tolerance of this species to anthropogenic pressures as has been reported for some other caecilians (OOMMEN et al. 2000, MEASEY 2004, GOWER & WILKINSON 2005).

The remarkable diversity of reproductive modes, including various levels of parental care that are extensive relative to the other major amphibian groups, makes caecilians ideally suited for evolutionary reproductive studies. We hope our observations are useful in building up an evolutionary comparative framework.

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#### References

- DE LA RIVA, I., J. KÖHLER, S. LÖTTERS & S. REICHLER (2000): Ten years of research on Bolivian amphibians: updated checklist, comprehensive literature, taxonomic problems, and iconography. – *Rev. Esp. Herp.*, **14**: 19-164.
- DUNN, E.R. (1942): The American caecilians. – *Bull. Mus. Comp. Zool. Harvard*, **91**: 439-540.
- EXBRAYAT, J.M. & M. DELSOL (1985): Reproduction and growth of *Typhlonectes compressicaudus* – a viviparous gymnophione. – *Copeia*, **1985**: 950-955.
- FUNK, W.C., G. FLETCHER-LAZO, F. NOGALES-SORNOSA & D. ALMEIDA-REINOSO (2004): First description of a clutch and nest site for the genus *Caecilia* (Gymnophiona: Caeciliidae). – *Herpetol. Rev.*, **35**: 128-130.
- GANS, C. (1961): The first record of egg laying in the caecilian *Siphonops paulensis* BOETTGER. – *Copeia*, **1961**: 490-491.
- GOELDI, E.A. (1899): Ueber die Entwicklung von *Siphonops annulatus*. – *Zool. Jb. Syst.*, **12**: 170-173.
- GOWER, D.J. & M. WILKINSON (2005): Conservation biology of caecilian amphibians: a review. – *Conserv. Biol.*, **19**: 45-55.
- HIMSTEDT, W. (1991): Zur Biologie und Larvenentwicklung der thailändischen Blindwühle *Ichthyophis kohtaoensis*. – *Veröff. Naturh. Mus. Schloss Bertholdsburg*, **6**: 16-24.
- HIMSTEDT, W. (1996): Die Blindwühlen. – *Neue Brehm Bücherei*, Bd. **630** Magdeburg, (Westarp), 159 pp.
- JARED, C., C.A. NAVAS & R.C. TOLEDO (1999): An appreciation of the physiology and morphology of the Caecilians (Amphibia: Gymnophiona). – *Comp. Biochem. Physiol.*, **123**: 313-328.
- KUPFER, A., J. NABHITABHATA & W. HIMSTEDT (2004): Reproductive ecology of female caecilian amphibians (genus *Ichthyophis*): a baseline study. – *Biol. J. Linn. Soc.*, **87**: 207-217.

- KUPFER, A., J. NABHITABHATA & W. HIMSTEDT (2005): Life history of amphibians in the seasonal tropics: habitat, community and population ecology of a caecilian (genus *Ichthyophis*). – *J. Zool. (Lond.)*.
- LOADER, S.P., M. WILKINSON, D.J. GOWER & C.A. MSUYA. (2003): A remarkable young *Scolecormorphus vittatus* (Amphibia: Gymnophiona: Scolecormorphidae) from the North Pare Mountains, Tanzania. – *J. Zool. (Lond.)*, **259**: 93-101.
- MEASEY, G.J. (2004): Are caecilians rare? An East African perspective. – *J. East Afric. Nat. Hist.*, **93**: 97-117.
- MEASEY, G.J. & M. DI BERNARDO (2003): Estimating juvenile recruitment to a population of the semi-aquatic caecilian, *Chthonerpeton indistinctum* (Gymnophiona; Typhlonectidae), in southern Brazil. – *J. Herpetol.*, **47**: 371-373.
- MEASEY, G.J., D.J. GOWER, O.V. OOMMEN & M. WILKINSON (2003): A pilot mark-recapture study of the caecilian amphibian *Gegeneophis ramaswamii* (Amphibia: Gymnophiona: Caeciliidae) in southern India. – *J. Zool. (Lond.)*, **261**: 129-133.
- MONTERO, I. (2003): Zu den Amphibien in Santa Cruz de la Sierra, einer Grossstadt in Bolivien. – *Amphibia*, **2**: 3-6.
- MOODIE, G.E.E. (1978): Observations on the life history of the caecilian *Typhlonectes compressicaudus* (DUMÉRIL & BIBRON) in the Amazon basin. – *Can. J. Zool.*, **56**: 1005-1008.
- MUÑOZ, I. (2000): Sobre las cecilias. – pp. 17-19 in MUÑOZ, I., (ed.): *Naturaleza, ecología urbana y turismo. Artículos periodísticos*. – Santa Cruz (Prefectura del Departamento de Santa Cruz).
- NUSSBAUM, R.A. (1979): The taxonomic status of the caecilian genus *Uraeotyphlus* PETERS. – *Occ. Pap. Mus. Zool. Univ. Michigan*, **687**: 1-20.
- NUSSBAUM, R.A. & M.E. PFRENDER (1998): Revision of the African caecilian genus *Schistometopum* PARKER (Amphibia: Gymnophiona: Caeciliidae). – *Misc. Pub. Mus. Zool. Univ. Michigan*, **187**: 1-32.
- OOMMEN, O.V., J.G. MEASEY, D.J. GOWER & M. WILKINSON (2000): Distribution of *Gegeneophis ramaswamii* (Amphibia: Gymnophiona) in southern Kerala. – *Curr. Sci.*, **79**: 1386-1389.
- O'REILLY, J.C., D. FENOLIO, L.C. RANIA & M. WILKINSON (1998): Altriciality and extended parental care in the West African caecilian *Geotrypetes seraphini* (Gymnophiona: Caeciliidae). – *Am. Zool.*, **38**: 187A.
- PARKER, H.W. & E.R. DUNN (1964): Dentitional metamorphosis in the Amphibia. – *Copeia*, **1964**: 75-86.
- PENNISI, E. (1999): Society for integrative and comparative biology: meeting spotlights creatures great and small. – *Science*, **283**: 623-625.
- SANDERSON, I.T. (1937): *Animal treasure*. – New York (The Viking Press), 325 pp.
- SARASIN, P. & F. SARASIN (1887-1890): *Ergebnisse naturwissenschaftlicher Forschungen auf Ceylon in den Jahren 1884-1886. Band II: Zur Entwicklungsgeschichte und Anatomie der Ceylonesischen Blindwühle *Ichthyophis glutinosus**. – Wiesbaden (C.W. Kreidels Press), 343 pp.
- SESHACHAR, B.R., T.A. BALAKRISHNA, K. SHAKUNTALA & K.R. GUNDAPPA (1982): Some unique features of egg laying and reproduction in *Ichthyophis malabarensis* (TAYLOR) (Apoda; Amphibia). – *Curr. Sci.*, **51**: 32-34.
- TAYLOR, E.H. (1968): The caecilians of the world: a taxonomic review. – Lawrence (University of Kansas Press), 845 pp.
- WAKE, M.H. (1977): The reproductive biology of caecilians: an evolutionary perspective. – pp. 73-101 in TAYLOR, D.H. & S.I. GUTTMAN (eds.): *The reproductive biology of amphibians*. – New York (Plenum Press).
- WAKE, M.H. (1980): Reproduction, growth and population structure of the Central American caecilian *Dermophis mexicanus*. – *Herpetologica*, **36**: 244-256.
- WAKE, M.H. (1992): Reproduction in caecilians. – pp. 112-120 in HAMLETT, W.C. (ed.): *Reproductive biology of South American vertebrates*. – New York & Berlin (Springer Press).
- WILKINSON, M. & R.A. NUSSBAUM (1998): Caecilian viviparity and amniote origins. – *J. Nat. Hist.*, **32**: 1403-1409.

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