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FIELD OBSERVATION OF EGG BROODING IN THE CAECILIAN *CAUDACAECILIA ASPLENIA* FROM SABAH, MALAYSIA (AMPHIBIA: GYMNOPHIONA: ICHTHYOPHIIDAE)

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ABSTRACT. **–** We provide the first report of egg brooding in the caecilian amphibian *Caudacaecilia asplenia* in Borneo. This is also the first observation of eggs and brooding for the genus. Brooding habits of this species are basically similar to those of species of the other ichthyophiid genus, *Ichthyophis*. Eggs (n = 16) were laid and guarded by a female under a decaying log on a stream bank. These eggs seemed to have been laid recently following rainy nights. The breeding ecology of *Caudacaecilia* is briefly discussed.

KEY WORDS. **–** Sabah, caecilian, *Caudacaecilia asplenia*, egg brooding.

INTRODUCTION

Gymnophiona (the caecilians) is one of three orders of extant amphibians and is distributed in tropical and subtropical regions. Caecilians have no limbs and live mainly underground. Because of their secretive habits, their life history has not been well understood. However, it is known that their reproductive modes are highly variable (e.g. Wake, 1977; Wilkinson & Nussbaum, 1998). Most caecilians are viviparous or develop directly from eggs to metamorphs, while the probably ancestral mode of laying and brooding eggs that develop into aquatic larvae is retained in some lineages (Taylor, 1968; Wake, 1977; Wilkinson & Nussbaum, 1998; San Mauro et al., 2004).

From Borneo, six caecilian species have been recorded and these belong to two genera, *Ichthyophis* and *Caudacaecilia*, of the family Ichthyophiidae (Taylor, 1968; AmphibiaWeb, 2005). This family is thought to be one of the ancestral lineages (San Mauro et al., 2004) and, as far as is known, its members retain the ancestral caecilian breeding habits as mentioned above. The first detailed account of caecilian reproduction was made in this family (*I. glutinosus*: Sarasin & Sarasin, 1887–1890), but study of breeding biology in this

family has been scarce since then (e.g. Seshachar et al., 1982; Kupfer et al., 2004, 2005). Here we report our field observation of egg brooding of an ichthyophiid caecilian from a field site in Sabah, Malaysian Borneo. This is the first report of eggs and brooding of Bornean caecilians.

MATERIALS AND METHODS

Between 17 and 18 August 2005, we searched for caecilians along Sungai [= River] Kilampun in Crocker Range National Park, 12 km north of Tenom, Sabah, Malaysia (5°13'N 115°57'E, ca. 390 m).

Around 1990, one of the authors, PY, had collected a caecilian there. Later, between 1998 and 1999, the forest was burned by natural fire that left most parts severely damaged. Currently, the forest is recovering through natural regeneration of vegetation and the area along Sungai Kilampun is mostly covered by secondary growth.

We searched for caecilians in the daytime by digging in soil, looking under dead leaves, and turning over and cutting open rotting logs along the stream. We also dug in the streambed and turned over stones in the stream in order to find aquatic larvae. We measured air and water temperatures, as well as soil temperature of the caecilian nest.

The voucher specimen, after being fixed by 10% formalin and transferred to 70% ethanol, was sexed by direct observation of the gonad, identified by measuring and counting morphological characters, and stored at the Institute for Tropical Biology and Conservation, University Malaysia Sabah (BORNEENSIS 23435). Eggs were also fixed and preserved in 10% formalin, and stored at the Graduate School of Human and Environmental Studies, Kyoto University (KUHE, no number).

We measured the following characters: total length (TL), tail length (TAL), head width at jaw angle (HW), body width at middle (BWM), interorbital distance (IOD), internarial distance (IND), eye-nostril distance (END), eye-tentacle distance (ETD), and tentacle-nostril distance (TND). We also counted the following characters: total annuli (TA), premaxillary-maxillary teeth (PMM), vomeropalatine teeth (VP), dentary teeth (DE), splenial teeth (SP), and vertebrae (VER). These measurements and counts were made based on Nussbaum & Gans (1980) and Kupfer & Müller (2004) and Matsui et al. (2006). Measurements were taken to the nearest 0.1 mm with a dial caliper. The number of vertebrae was counted from soft x-ray photographs using Fuji® Medical X-Ray Film. We measured the egg diameters by a vernier caliper and weighted the clutch mass by a digital balance. We follow Sarasin & Sarasin (1887–1890) for determining the developmental stage of embryos.

RESULTS AND DISCUSSION

On 17 August, we intensively searched for caecilians along main streams of Sungai Kilampun but before we found any, it began to rain heavily so we retreated. On 18 August, we again searched and finally found a caecilian at 1330 hours in its nest under a rotting log (130 cm in length and 12 cm in diameter) on the bank of a small tributary (width 80 cm and depth 1–3 cm, Fig. 1A) of Sungai Kepipio, a branch of Sungai Kilampun. Air and water temperatures at the time of the finding were 32.5°C and 23.5°C, respectively. Soil temperature of the nest wall was 22.4 °C. The nest was an ellipsoid mud chamber 60 mm in width and 35 mm in height (Fig. 1B). The nest was about 60 cm away from the stream but was connected to it by a small tunnel (diameter 10 mm and length ca. 120 cm, Fig. 1C). The tunnel seemed to have been constructed by the animal, but we could not confirm this. No larvae were found in the stream.

The caecilian was found guarding 16 eggs in the nest by coiling around them. Fourteen eggs were connected like a ball by a string-like structure (Fig. 1D) but the remaining two were isolated from the ball. The diameter of the eggs, including their gelatinous capsules, ranged from 5.8 to 7.1 mm (mean ± SD = 6.5 ± 0.4, n = 16) mm and the total mass of the eggs was 1.7 g. The eggs were in the beginning of the blastula stage of development (around St. 10 after Sarasin & Sarasin, 1887–1890, but see also Wilkinson et al., 2002). If the eggs were developed to the cleavage stage in the oviduct same as the reported cases of some ichthyophiids (Sarasin & Sarasin, 1887–1890; Kupfer et al., 2004), the blastula stage is the earliest one after oviposition (but see Kupfer et al., 2006 for variation in the stage at oviposition). Thus, the eggs seemed to have been laid during the rainy night of 17 August.

When we disturbed the adult (later proved to be female by dissection) by breaking into its chamber, it uncoiled and attempted to escape from the nest. After collection, we kept the caecilian and its eggs alive in a plastic box for one night. The next morning, we found the caecilian again brooding its eggs, but it soon deserted them after we disturbed it. Kupfer et al. (2006) reported that *I.* cf. *kohtaoensis* laid a mean of 13 eggs (n = 7) in one day and continued to lay eggs up to a mean of 41 eggs in total (n = 7), but no more eggs were laid overnight in our case of *Caudacaecilia*. We also confirmed no ripe eggs left in the ovaries by dissection.

The voucher specimen was measured and counted (TL: 230.0; TAL: 3.0; HW: 6.4; BWM: 8.1; IOD: 4.2; IND: 2.3; END: 2.7; ETD: 0.8; TND: 1.8; TA: 271; PMM: 24/23; VP: 20/20; DE: 20/18; SP: 0/0; VER: 106), and temporally identified as *Caudacaecilia asplenia* following Taylor's (1968) description, and recent work on ichthyophiids from western Sabah (Matsui et al., 2006, which suggests invalidity of the genus *Caudacaecilia*). The individual is a female. In Ichthyophiidae, breeding habits have been reported thus far only in several species of *Ichthyophis* (see Kupfer et al., 2004), but not in the another genus *Caudacaecilia*. Thus, this is the first report of a brooding female and egg of the genus, and this finding is also the first one for Bornean caecilians as a whole.

The breeding features of *C. asplenia* are basically similar to

those of *Ichthyophis* species (*I. glutinosus*: Sarasin & Sarasin, 1887–1890; *I.* cf. *kohtaoensis*: Dünker et al., 2000 and Kupfer et al., 2004 [both reports on same population]; *I. malabarensis*: Seshachar et al., 1982), in which the female lays and guards eggs. It is supposed that the female of the genus *Caudacaecilia* lays eggs after rain as in at least some *Ichthyophis* (e.g., Sarasin & Sarasin, 1887–1890; Seshachar et al., 1982; Kupfer et al., 2004). This habit is also typical of oviparious and viviparious species of other families (Caeciliidae: Montero et al., 2005; Typhlonectidae: Wake, 1980; Exbrayat & Delsol, 1985; Measey & Di-Bernardo, 2003). According to Kupfer et al. (2004), larvae of *Ichthyophis* in Thailand hatch about 12 weeks after eggs are laid (mean temperatures were 26°C for first four weeks in the field and 27°C after four weeks until hatching in the laboratory). In the study site, the rainy season normally starts in late August. Thus the larvae may hatch and migrate to streams in the subsequent months of the rainy season.

The caecilian was found in forest that was once destroyed by fire. However, because the animals dwell underground near water bodies and can burrow deeply in the soil, they would have been able to survive such a calamity. In contrast, the forest's anuran fauna was reportedly devastated by the fire (Sudin, 2004).

Southeast Asia is a home of Ichtyophiidae, the second largest family of Gymnophiona. In order to fully understand caecilian biodiversity in this part of the world, studies on taxonomy, ecology, and life history of ichthyophiids are indispensable. It is hoped that even such a brief observation as this will contribute to that goal.

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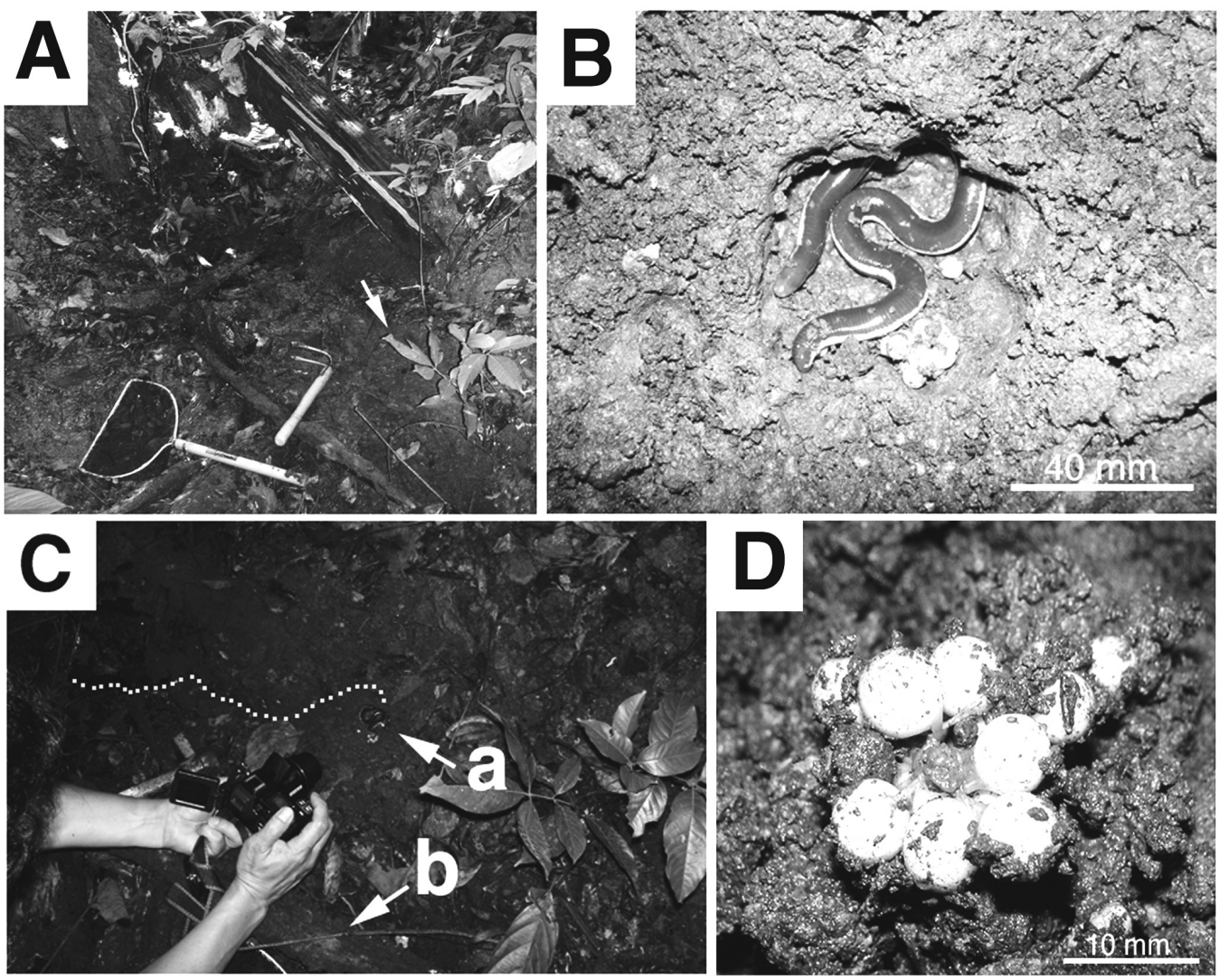

Fig. 1. A, A small tributary of Sungai Kepipio where an egg-brooding caecilian was found. The arrow shows the location of the nest; B, The female with its eggs in a mud chamber. The chamber was widened to show the animal; C, The mud chamber: a, a small tunnel (shown by white dots) found under a rotting log (b, turned off in this figure); D, The eggs connected by a string-like structure.

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