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Author(s): Zuzana Musilová, Adrian Indermaur, Arnold Roger Bitja Nyom, Robert Tropek, Christopher Martin, and Ulrich K. Schliewen
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Persistence of *Stomatepia mongo*, an Endemic Cichlid Fish of the Barombi Mbo Crater Lake, Southwestern Cameroon, with Notes on Its Life History and Behavior

Zuzana Musilová[1], Adrian Indermaur[1], Arnold Roger Bitja Nyom[2], Robert Tropek[3,4], Christopher Martin[5], and Ulrich K. Schliewen[6]

The extinction of *Stomatepia mongo* Trewavas, 1972, a cichlid species from the Barombi Mbo crater lake, Cameroon, has been repeatedly speculated. Here, we review over 180 presumably unpublished records of this species since its description. Because a majority of them originate from our extensive surveys in the last several years, it is evident that this species still persists. Nevertheless, it is still considered as the rarest species in the lake, but its relative abundance is probably comparable to that in 1972 when the species was originally described. The species also does not seem to live exclusively in deep waters as was previously hypothesized, because we repeatedly collected and/or observed it in the shallow waters as well. We also listed our notes on the species' coloration and behavior. Although we document the persistence of *S. mongo,* it remains threatened by the impact of intensive human activities (fishing and farming) in the area.

ALONG the Cameroon Volcanic Line in western Cameroon, numerous crater lakes were formed (Kling, 1988). The Barombi Mbo lake, 1 km NW from Kumba, southwest Cameroon, is the largest (2.5 km in diameter, over 110 m deep, Cornen et al., 1992). Due to its relatively easy accessibility, the lake ichthyofauna was repeatedly studied (e.g., Trewavas, 1962; Trewavas et al., 1972; Green et al., 1973; Dominey and Snyder, 1988; Bilong Bilong et al., 1991; Schliewen et al., 1994; Schliewen and Klee, 2004; Martin, 2012), which makes it the best known crater lake in the region.

The species flock of the lake comprises 11 morphologically distinct endemic cichlid species, (but see Martin, 2012), which supposedly evolved via sympatric ecological speciation from a single common ancestor, which colonized the lake around one million years ago (Schliewen and Klee, 2004; Friedman et al., 2013). Three species from the Barombi Mbo lake are known since the first half of the 20th century, the others were described later (Trewavas, 1962; Trewavas et al., 1972). All the Barombi Mbo cichlid species represent one monophyletic lineage of oreochromine cichlids closely related to *Sarotherodon galilaeus* distributed in the rivers and streams of the surrounding region (Schliewen et al., 1994). The species flock consists of five genera, four of which are endemic to the lake (i.e., *Konia*, *Myaka*, *Pungu*, *Stomatepia*; Trewavas et al., 1972); the fifth genus *Sarotherodon* is paraphyletic (Dunz and Schliewen, 2013). The genus *Stomatepia* comprises three species, two of which are relatively abundant in the lake: *Stomatepia pindu*, an insect larvae feeder, and *Stomatepia mariae*, a fish predator and insect larvae feeder (Trewavas et al., 1972). *Stomatepia mongo* is by far the rarest species of all the Barombi Mbo cichlids with an almost unknown life history (probably feeding on macroinvertebrates and small fish; our pers. obs.).

Since its discovery, *S. mongo* (Fig. 1) has never been reported as an abundant species. In the two detailed studies carried out in the 1970s (Trewavas et al., 1972; Green et al., 1973), it was represented by a few individuals only (14 and 10, respectively). In the 1980s, all the cichlids from the Barombi Mbo lake received the status of vulnerable species (Moelants, 2010), and *S. mongo* was classified as critically endangered (CR B1ab(iii)+2ab(iii), population trend unknown; Moelants, 2010) later. In 1988, the species was ''not seen in catches for last two years'' and the local fishermen noticed its decline (Reid, 1990). Reid also later speculated that *S. mongo* might be ''the first rare West African cichlid to become extinct'' (Reid, 1991). Similarly, Harrison and Stiassny (1999) also considered the species as possibly extinct with need of a status confirmation. Currently, the species is still listed as potentially extinct with the ''unresolved; insufficient data'' status in the Committee on Recently Extinct Organisms (CREO) Extinction database (CREO, 2010). This status could have consequences in the regional conservation planning, as some local conservationists already considered a potential possibility for the species re-introduction from aquarium populations (Bitja Nyom, 2012), although no successful breeding in captivity has so far been reported. On the other hand, Trewavas et al. (1972) and Lamboj (2004) speculated that the presumed species rarity could be just an artifact of its occurrence in deeper parts of the lake and thus much lower detectability.

MATERIALS AND METHODS

We reviewed all the available published studies of the cichlid group (Trewavas et al., 1972; Green et al., 1973; Dominey and Snyder, 1988; Schliewen et al., 1994; Schliewen and Klee, 2004; Martin, 2012) looking for any records of *S. mongo*. We also collected all records from our own visits of the Barombi Mbo lake in 2001–2013 (summarized in

[1] Zoological Institute, University of Basel, Vesalgasse 1, 4151 Basel, Switzerland; E-mail: (ZM) zuzmus@gmail.com; and (AI) a.indermaur@unibas.ch. Send reprint requests to ZM.
[2] Faculty of Science, University of Ngaoundéré, PO Box 454, Cameroon; E-mail: arnold.bitja@univ-ndere.cm.
[3] Institute of Entomology, Biology Centre, Czech Academy of Sciences, Branisovska 31, CZ-37005 Ceske Budejovice, Czech Republic; E-mail: robert.tropek@gmail.com.
[4] Department of Environmental Science (Biogeography), University of Basel, St. Johanns-Vorstadt 10, CH-4056 Basel, Switzerland.
[5] Department of Environmental Science, Policy & Management, University of California, Berkeley, California 94720; E-mail: chmartin@berkeley.edu.
[6] Bavarian State Collection of Zoology, Münchhausenstr. 21, 81247 München, Germany; E-mail: schliewen@zsm.mwn.de.
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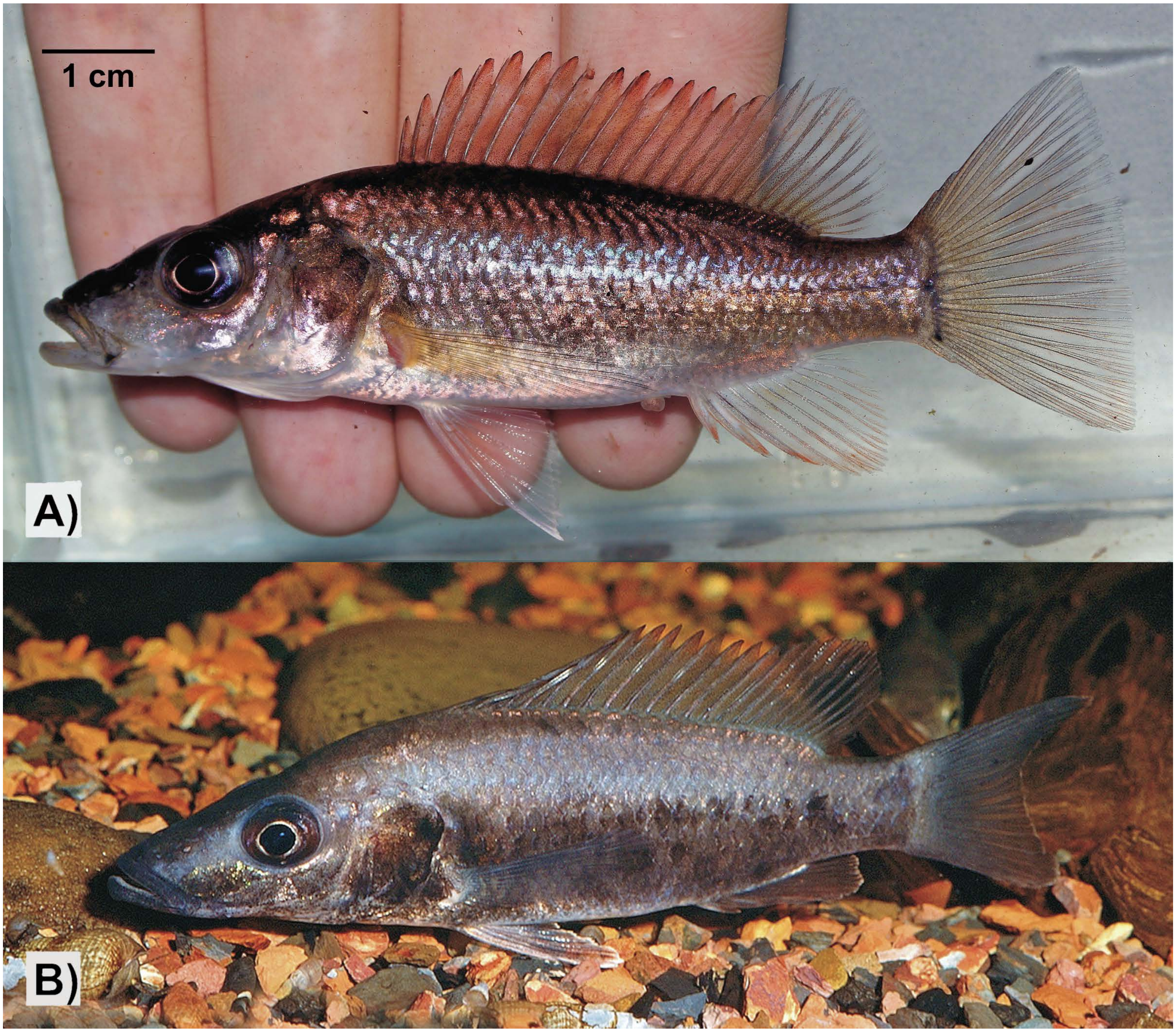

Fig. 1. *Stomatepia mongo*. (A) A freshly caught male (SL = 80 mm) with the silvery coloration mode in a photo tank (photo by Zuzana Musilová); (B) an adult male (exact SL is unknown) kept in aquarium with the darker coloration of its lower body part (photo by Mark Smith). The scale differs between the two pictures.

Table 1). The most extensive fish surveys were performed in October 2001 and February 2002 by U.K.S. (mainly point abundance counts and gill netting). The most recent visit was in June–July 2013 by Z.M. and A.I. (mainly gill netting and snorkeling). All the other reported visits were short-term with rather accidental surveys by cast netting or seine netting close to the lake banks and exploration of the local fish market. We supplemented the published data and fieldwork observations by direct reports of the local ornamental-fish exporters Ngando Ephesians Jiku and Cyrille Dening, who both made specific efforts to catch *S. mongo* between 2006 and 2011.

RESULTS AND DISCUSSION

Our field surveys together with the available data yielded 182 individuals of *S. mongo* recorded in the past four decades (see Table 1 for details). Several other specimens were also exported for aquarium trade in Europe and North America (N. Ephesians Jiku and C. Dening, pers. comm.); however, to the best of our knowledge, there is no evidence of any successful breeding in captivity. Our recent surveys in particular directly proved that *S. mongo* still occurs in the Barombi Mbo lake. Apparently, it is the most sparsely recorded species, as we usually recorded maximally a few specimens per day of fieldwork. This is comparable to 1970 when Trewevas et al. (1972) gained 14 specimens in three weeks, and also to all other mentioned studies where any quantification is available. The only published species-unbiased transect observations in 2 m depth (Dominey et al., 1988) reported only three individuals of *S. mongo* out of 13373 total observed fish specimens, and it thus confirmed the extraordinary rareness of the species, at least in shallow water. Based on our records and the local fishermen's experiences, it seems that the species is more abundant in deeper parts of the lake (i.e., below 3 m) but scarcely occurs in shallow parts around the entire lake shore.

Table 1. A summary of all known records of *Stomatepia mongo* from the Barombi Mbo lake. 0: no caught/observed specimens despite some catching/observation effort; –: no catching/observation effort in particular depths.

Date	Duration of fieldwork	Number of recorded specimens: In total (with sex if known)	In shallow water (<3 m)	In 3–10 m of depth	In deep water (>10 m)	Recording methods	Reference
March/April 1970	~3 weeks	14 (min 1 female = holotype)	?	14? ("deeper water of several metres of depth")		minnow-trapping by local fishermen	Trewavas et al., 1972
March/April 1972	~1 month	10	?	?	?	?	Green et al., 1973
December 1984–May 1985	?	3	3	–	–	transect observation by snorkeling	Dominey and Snyder, 1988
September–October 2001	16 days	45	13	32	–	gill netting (captured specimens released)	Ulrich Schliewen, unpubl.
February 2002	12 days	16	2	1	13	gill netting (captured specimens released)	Ulrich Schliewen, unpubl.
October 2001	21 days	45	10	35	–	point abundance observation by snorkeling	Ulrich Schliewen, unpubl.
February 2002	11 days	36	2	3	31	point abundance observation by snorkeling	Ulrich Schliewen, unpubl.
December 2006	1 day	1	1	–	–	gill netting	Cyrille Dening, unpubl.
January 2007	1 day	4	4	–	–	gill netting	Cyrille Dening, unpubl.
March 2010	1 day	2	2	–	–	gill netting	Cyrille Dening, unpubl.
December 2009–January 2010	6 days	0	0	0	–	seine netting, gill netting, snorkeling	Chris Martin and Cyrille Dening, unpubl.
March 2011	1 day	10	10	–	–	night seine netting	Ngando Ephesians Jiku, pers. comm.
December 2011	1 day	1	1	–	–	snorkeling with a gill net	Musilova and Tropek, unpubl.
June–July 2013	8 days	9 (3 females, 2 males, 4 unrecogn.)	3	0	6	snorkeling with a gill net, deepwater gill netting	Musilova and Indermaur, unpubl.

All of the mentioned reports of rarity of *S. mongo* could be caused by the species life history, such as its preference for deeper waters (Trewavas et al., 1972; Lamboj, 2004) or its extraordinary vigilance. Many of our field records were, however, caught or observed in relatively shallow water, not deeper than 2 m, which proves that the species does not occur in lower depths exclusively. In contrast to a deep-water specialist, *Konia dikume*, *S. mongo* has no known morphological or physiological specializations to deep waters (Green et al., 1973). Compared to *K. dikume*, of which we usually received more than ten specimens per day from local fishermen, *S. mongo* does not seem to be abundant in the deep waters either. No sophisticated depth-dependent abundance data are, however, available so far. It is worth mentioning the hypothesis that the species could be nocturnal, as one highly effective night of fishing by N. Ephesians Jiku (pers. comm.) in March 2011 yielded ten specimens. It is also possible that *S. mongo* could move to shallow waters close to the shore to be safer from large nocturnal predators (*Clarias* spp.), or it could simply lessen its vigilance at night. On the other hand, this success has never been repeated, and the same collector reported that he "very often did not catch any *S. mongo* during the whole week of fishing" (N. Ephesians Jiku, pers. comm.). Nevertheless, no comprehensive data exist so far.

Our records (especially those of U.K.S.) allow us also to comment on the species' so far rather unknown habitat and behavior. Usually, we observed *S. mongo* close to the bottom substrate, most often foraging in sand or debris to find potential prey. The body position for this is with a slight angle so that the head is turned downward. It seems to use its sensory pits to detect small animals in the detritus or sand. Several times U.K.S. observed small groups of foraging animals without any signs of intraspecific aggression, suggesting that cooperative hunting may be a strategy in *S. mongo*. Once, a group of six adult specimens was observed resting collectively at the bottom.

There are three modes of coloration of *S. mongo* known from our direct observations in the lake as well as from the individuals kept in aquaria: 1) the whole body is silvery with rose hues (Fig. 1A); 2) the lower half of the body is black (Fig. 1B) or has dark blotches in the entire ventral region, similar to *Neolamprologus nigriventris* from lake Tanganyika; and 3) the whole body is completely velvety black. In several non-black individuals, we observed light orange margins in dorsal, ventral, and anal-fin rays. U.K.S. observed mature individuals on several occasions in all three coloration modes, and functions of the individual coloration modes are not clear enough. A completely black pair of *S. mongo* was observed in shallow water in a narrow flat zone under the stone. Similarly, from a second pair captured close to a stone, only a male was also black. Further, a group of fish were observed at a rocky terrace with a dominant territorial black fish and several large non-black adult fish swimming close. The black coloration could be thus linked to territoriality and/or sexual behavior. The other two coloration modes were observed in standard (i.e., not related to aggressive or sexual behavior) situations: the silvery coloration mostly over a sandy bottom, whereas the halftone coloration seemed to be related to the rocky sites. Aggression was always very low among the non-black animals.

Although *S. mongo* is not extinct, it remains, together with all the fish species of the Barombi Mbo lake, endangered for being endemic to just a small lake (~7 km^2) that is situated very close to the relatively large and rapidly developing town of Kumba. Human activities directly influencing the lake's environment include fishing (although seemingly not too intensive so far, as it is performed by the Barombi villagers exclusively), agriculture accompanied by deforestation and erosion of the slopes along the shoreline, and damming the outflow for the water level stabilization (Reid, 1991). Following these threats we suggest treating *S. mongo* as critically endangered according to the valid IUCN criteria (IUCN, 2012). On the other hand, for the final evaluation, a more detailed study is necessary because all those activities were reported already in the 1990s (Reid, 1990, 1991) and so far no decline in fish abundance has been evidenced, although any sophisticated analysis is still absent. Nevertheless, such a small water body is fragile and extremely susceptible to any potential threats. In addition, spontaneous disturbance of the water column either due to gas leaks from the volcanic bedrock or due to sudden upwelling of anoxic deep water after regional seismic activity have been observed in 2007 and 2009 (C. Dening and local fishermen, pers. comm.), but these observations need to be confirmed. The observers reported increased water turbidity and an emergence of dead fish on surface including the deepwater *K. dikume*. Gas releases in Cameroonian crater lakes have been previously documented by Kusakabe et al. (1989) based on the dissolved gas concentrations evident in lakes Nyos, Monoun, and Wum and the high mortality of the fishes (and also for terrestrial life including humans) caused by these natural gaseous releases was previously reported from Lake Monoun-Njindoun and Lake Nyos, NW Cameroon (Moelants, 2010).

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