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Kurze Mitteilung/Short note

Some observations on courtship and mating of *Hemirhamphodon tengah* Anderson & Collette, 1991 (Zenarchopteridae)

Einige Beobachtungen zur Balz und Paarung von *Hemirhamphodon tengah* Anderson & Collette, 1991 (Zenarchopteridae)

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Zusammenfassung: Wir beschreiben erstmals Elemente der Balz und Paarung des offenbar „embryoparen" Halbschnabelhechtes *Hemrhamphodon tengah*. Das geringfügig größere Männchen stellt sich parallel neben das Weibchen, überholt dieses dann, schwimmt vor dem Weibchen zur Seite und dann wieder rückwärts in die Parallelstellung und wiederholt diesen Vorgang einige Male, bis die Bewegungen etwas gleitender werden und die Partner jeweils in dem Moment, in dem sie parallel zueinander stehen, unter Krümmung des hinteren Körperdrittels mit den Genitalregionen mehrere Male hintereinander oder einmal aneinander schlagen. Dann wechselt das Männchen wieder die Seite und wiederholt das Ganze über einen längeren Zeitraum (bis zu 10 min). Dabei ist das Männchen der aktivere Teil. Fotoserien scheinen zu belegen, dass beim Aneinanderschlagen der Genitalbereiche die verlängerte und frei stehende Urogenitalpapille des Männchens in Richtung des Weibchens gekrümmt wird. Die nicht sonderlich vergrößerte Afterflosse des Männchens scheint ebenfalls in Richtung des Weibchen gekrümmt zu werden. Sie ist offensichtlich zu klein, um das Weibchen zu umgreifen. Balz und Paarung unterscheiden sich damit deutlich von entsprechenden Verhaltensweisen der viviparen *Dermogenys*- und *Nomramphus*-Arten. Die Berichte über den mit *H. tengah* näher verwandten viviparen *Hemrhamphodon pogonognathus* sind unvollständig, so dass Gemeinsamkeiten nur vermutet werden können.

Among the Zenarchopteridae (for the reasons to erect this taxon instead of retaining the taxon Hemiramphidae see Lovejoy et al. 2004) the genera *Dermogenys*, *Nomorhamphus*, and *Hemirhamphodon* are viviparous, except *H. tengah*, which has been considered as an "oviparous" species (Anderson & Collette 1991, Kottelat & Lim 1999). However, as documented repeatedly from aquarium observations, *H. tengah* lays fertilized eggs (see Bork & Mayland 1998, Grell 1998). The exact developmental stage of freshly shed eggs is unknown yet. This mode of reproduction undoubtedly represents a kind of "viviparity", but strictly spoken, *H. tengah* is zygo- or most likely embryoparous (for terminology see Greven 2003).

At any case, males have to inseminate females. Internal insemination was suggested to occur also in *Zenarchopterus* spp. due to (1) the presence of testicular spermatozeugmata (Grier & Colette 1987), a character they share with the viviparous species mentioned and *H. tengah* (Downing & Burns 1995), (2) sperm within the ovary (Downing Meisner 2001), and (3) behavioral observations (Kottelat & Lim 1999). Insemination, i.e. mating or copulation, is often preceded by a more or less conspicuous courtship, which appears relatively similar between the *Dermogenys* and *Nomorhamphus* spp. (see Greven & Nehrig 2004; Magyar & Greven 2007), but is insufficiently documented in *Hemirhamphodon* spp. (summarized by Greven 2006, in press). The modified anal fin of the male is suggested to be involved in the insemination process and it was hypothesized that the urogemital papilla may act as intromittent organ (Downing Meisner & Burns 1997). In *Dermogenys* and *Nomorhamphus* spp. shape, size and limited movabil-

ity of the anal fin, which is considerably modified, as well as the organisation of the urogenital papilla and the size of the female urogenital opening appear to exclude an intromittent function of the fin and the papilla. In *Hemirhamphodon pogonognathus*, however, the male urogenital papilla is elongate, freestanding and contains muscles suggesting some movability (GREVEN in press). Further, the large male anal fin was suggested to clasper the female urogenital pore to direct spermatozeugmata (BREMBACH 1978) and to avoid their loss during copulation.

In brief, information on courtship and mating of inseminating halfbeaks is meagre and anecdotal at best. Thus, in the present note we report some observations on courtship and mating of *Hemirhamphodon tengah*, which differ from courtship and mating known from other hemirhamphids (see literature cited above).

In 2007, Aquarium Glaser, Rodgau (Germany) imported *Hemirhamphodon tengah,* probably collected near the terra typica (F. SCHÄFER, personal communication). Males are slightly larger than females and possess an anal fin, not notably enlarged, and a freestanding genital papilla (figs. 1 a, b). Two males and three females with a total length of approximately 55 mm were held in an aquarium (40 x 25 x 25 cm) at approximately 26 °C with a light period set at 12:12 h. The aquarium was fitted with some plants (*Anubias barteri*) and a cushion of *Vesicularia* sp. near the water surface. The water was regularly replaced by water filtrated with peat; the pH-value ranged from 5.6 to 6.4. Total hardness of water was approximately 2 °dGH. Fish were fed twice daily with living white midge larvae and springtails.

Under these conditions the dominant male, which swam most of the time in the free water near the water surface, displayed and mated regularly. Subdominant males mostly stayed alone taking shelter under plants and were chased away, when they approached the dominant male or the courting pair. Females laid eggs and the hatching offspring, which could be raised in some cases until maturity, showed courtship and mating in the same way as the specimens from the wild.

Courtship and mating was documented with a Mini-DV Camcorder (JVC GR-D760E). Photographs were made with a CANON EOS 300 D using a 50 mm Macro lens, a teleconverter and a flash (CANON Speedlight 420 EX): The male and a female stay under the water surface more or less parallel, but distantly to each other. Then the male swims alongside the female, overtakes her, slightly moves laterally to come to the other side of the female, swims backwards and when alongside her, he starts again repeating this action several times, i.e. the male describes an incomplete rectangle around the female with the open side at her tail region. In this phase movements of the male appear jerky and as drawn with a ruler (fig. 2). During this "mating dance" the female is largely stationary, unless she is reluctant and escapes (rarely seen). After some seconds, movements of the male became more smooth; the male stops for a short time alongside the stationary female, slightly tilts his body upward and toward the female and mates once or several times beat their genital regions against each other, before the male changes the side again (figs. 1 c-h, 3). This must be the moment spermatozeugmata become transferred. Flicking behavior and changeover takes a relatively long time (we observed up to 10 min). After this mates break away from each other. The actual physical contact of the mates appears very short. However, on some photographs we saw an inclination of the male urogenital papilla toward the female either caused actively by muscles of the papilla and/or by

Figs. 1 a-h: Sex dimorphic genital region (a, b) and mating (c-h, except d female in front) of *Hemirhamphodon tengah*. **a** Anal fin of the male and freestanding genital papilla (arrow); **b** anal fin of the female; **c** the male swims alongside the female; **d** male (left side) alongside the female with approaching genital regions; genital papilla (arrow); **e** male alongside the female; genital papilla (arrow); **f** ditto**; g** male behind the female; note putative discharge of spermatozeugmata (arrow); **h** position as in g**;** note the slightly bent genital papilla of the male (arrow).

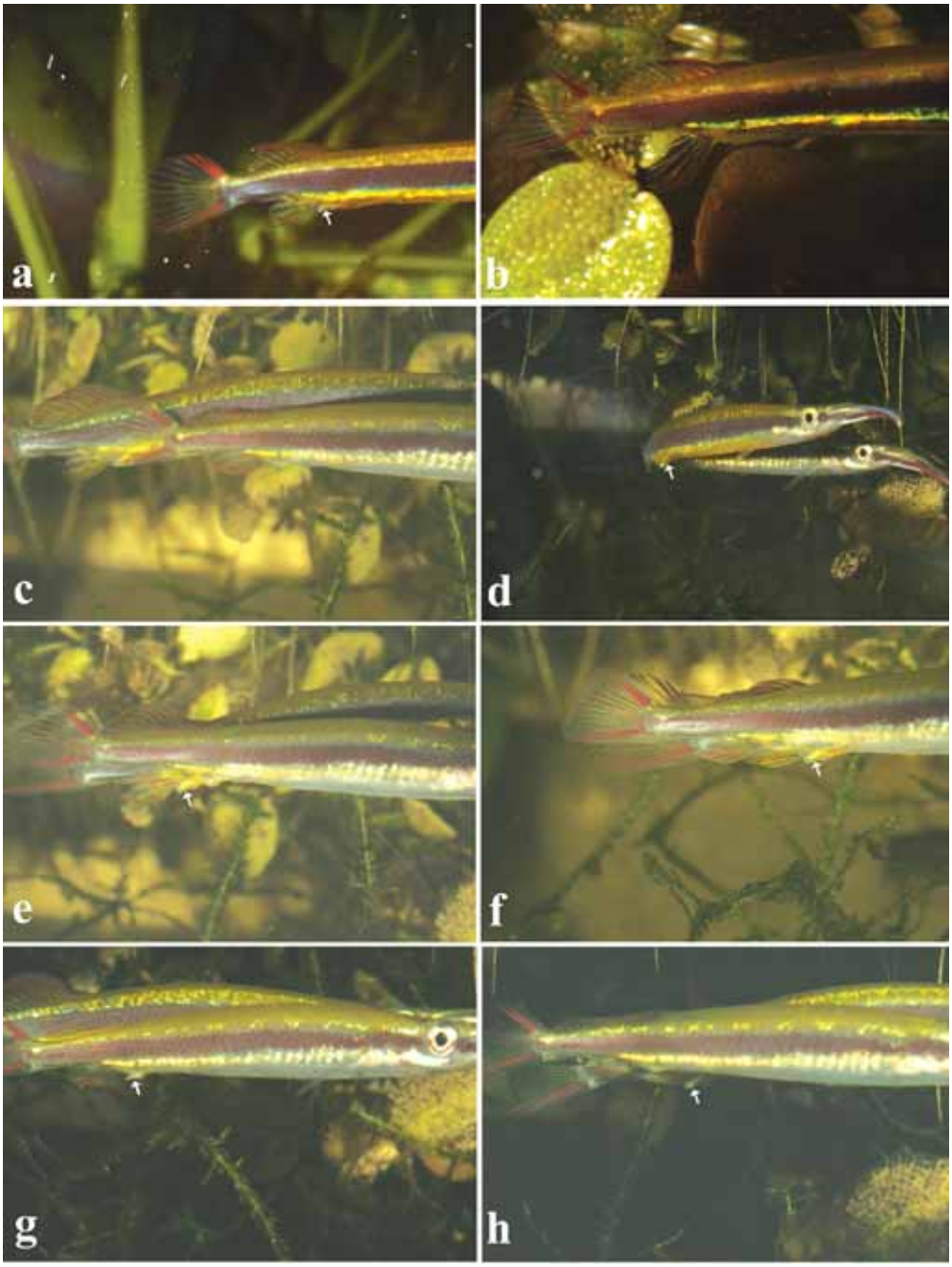

Abb. 1 a-h: Geschlechtsdimorphe Genitalregion (a, b; Weibchen vorn außer in d) und Paarung von *Hemirhamphodon tengah*. **a** Afterflosse des Männchens und freistehende Genitalpapille (Pfeil); **b** Analflosse des Weibchens; **c** Männchen schwimmt an die Seite des Weibchens; **d** Männchen (links) längs des Weibchens: die Genitalregionen sind einander genähert; Genitalpapille (Pfeil); **e** Männchen an der Längsseite des Weibchens; Genitalpapille (Pfeil); **f** dito; **g** Männchen hinter dem Weibchen; man beachte die Genitalpapille, wahrscheinlich mit einer Spermatozeugme an der Spitze (Pfeil); **h** Position wie in g; man beachte die wahrscheinlich leicht zum Weibchen hin gebogene Genitalpapille (Pfeil).

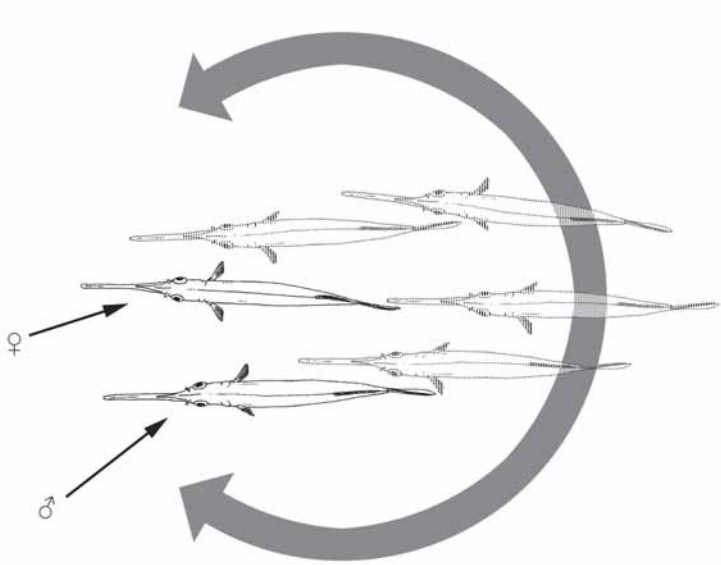

Fig. 2: "Mating dance" of *Hemirhamphodon tengah*. Drawing: S. DASHDAMIROV. For further explanation see text.
Abb. 2: „Balztanz" von *Hemirhamphodon tengah*. Zeichnung: S. DASHDAMIROV. Weitere Erklärungen siehe Text.

the upward tilt of the male. Also his anal fin appears to point in this direction (fig. 1 g, h). A schematic diagram of the entire action is given in figure 2.

Within two days the volume of the females increased conspicuously and eggs were found after this time, preferably in the cushions of *Vesicularia* sp. However, direct release of eggs was never observed. Therefore their exact developmental stage at this moment could not be determined.

The immediate act of mating amazingly resembles the mating behaviour of *Zenarchopterus buffonis*, a species with slightly modified dorsal and anal fin rays. Here, mating behaviour was suggested as being a plesiomorphic character state in this genus (KOTTELAT & LIM 1999). Differences between the reasonably well described courtship and mating of *Dermogenys* and *Nomorhamphus* spp. and the herein described behavior of *H. tengah* are obvious, but also the very sketchy report of courtship and mating in other *Hemirhampodon* species – actually only *H. pogonognatus* (BREMBACH 1978) – may differ in some respect. We want to point the following topics to be substantiated in further studies:

1) In *H. tengah* males defend a territory. In the aquarium the dominant male occupies most of the space. Subdominant males do not have a territory or occupy only a small one. In *H. pogonognathus*, in which males are on average larger than females (ANDERSON & COLLETTE 1991), a dominant male chases away other males and guard a harem (GROß 1993), whereas in *Dermogenys* and *Nomorhamphus* spp., in which females are on average larger than males, females appear most dominant in a group (GREVEN 2006, in press).

2) *H. tengah* shows an obviously very short, but conspicuous courtship and the precise "mating dance" shown by the males may be quantified in future studies more easily than for instance the courtship of *Dermogenys* and *Nomorhamphus* spp. (GREVEN, in press). Courtship probably resembles that of *H. pogonognathus*, in which species it was described vaguely as swimming around the female in a semicircle (BREMBACH 1978).

3) In *H. tengah* mating does not appear so forceful as in *Dermogenys* and *Nomorhamphus* (see GREVEN 2006, in press, MAGYAR & GREVEN 2007) and is repeated several times by flicking the genital regions against each other. Our observations suggest an involvement of the uro-

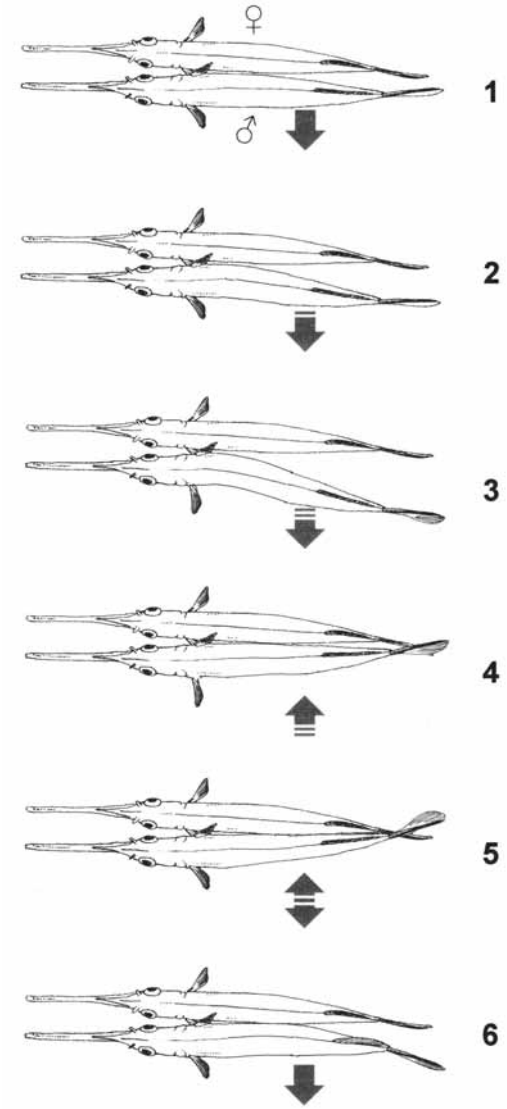

Fig. 3: Copulation of *Hemirhamphodon tengah*. Drawing: S. DASHDAMIROV. For further explanation see text.
Fig. 3: Kopulation von *Hemirhamphodon tengah*. Zeichnung: S. DASHDAMIROV. Weitere Erklärungen siehe Text.

genital papilla. Also here some similarities with mating of *H. pogonognathus* may exist. However, BREMBACHS (1978) report is not comprehensible in all details and needs reexamination. He described that the male first huddles against the female clasping her anal region (sic!) with the flag-like anterior part of his anal fin that forms a groove. This action is accompanied by heavy shivering of the male. In a second phase mates rhythmically beat their anal regions (sic!) together. Then sperm threads (i.e. spermatozeugmata) are discharged from the urogenital papilla, slip through the groove the anal fin has formed and are stuffed into the female genital pore with the help of the smaller posterior part of the male anal fin, which action is supported by the rhythmic beating (BREMBACH 1978).

4) Females of *H. tengah* appear peacefully and appear cooperative, as they remain stationary during copulation and even may slightly tilt their body to the male (rarely seen, if any). Again this is in strong contrast to *Dermogenys* and *Nomorhamphus* spp., but may be the case also in *H. pogonognathus*.

5) Apparently fertilization (=karyogamy), whether it occurs in the follicle or in the ovarian cavity, does not immediately follow insemination. In *H. tengah* final vitellogenesis seems to take place after insemination, as the female's body volume begins to increase thereafter. Thus, spermatozoa might be stored for a certain time in the oviduct and/or the ovary as known from the viviparous forms (see GREVEN 2006, in press).

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