

Influence of temperature on fertility, growth rates, and reproductive success on selected species of *Apistogramma* (Teleostei, Cichlidae)

Einfluß der Temperatur auf Fertilität, Wachstum und Fortpflanzungserfolg ausgewählter *Apistogramma*-Arten (Teleostei, Cichlidae)

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Abstract: The temperature of the environment has significant influence on growth and reproduction in the species of *Apistogramma*. High temperatures cause reduced survival of the offspring, reduction of growth (size and weight), number of eggs and clutches, and size of eggs, a possible reason being a temperature-induced deficiency of energy. Six month old *A. cacatuoides* shows optimal growth (females up to 46 mm TL, males up to 76 mm TL) and gain of weight at 26°C. Temperatures lower than 25°C have a weak negative effect, those in excess of 28°C a substantial negative effect on growth. Female *A. cacatuoides* matures at an age between 140 and 350 days. This is not directly linked to temperature, but indirectly via the temperature-influenced reaching of a length of 30 to 34 mm TL, at which females spawn for the first time. The number of eggs per clutch and the number of clutches per female depend on temperature. Both low (20 to 22°C) and high (29 to 30°C) temperatures results in reduced numbers in comparison to intermediate temperatures (25 to 28°C). Eggs produced at low temperatures (< 25°C) are about one fifth larger than those produced at high temperatures (> 28°C). The reproductive success in the field seems not to be significantly influenced by temperature, but from predation and the female's capacity for sheltering the offspring in its mouth.

Keywords: biometry, environment, fecundity, maturation, temperature-dependent sex determination

Zusammenfassung: Die Umgebungstemperatur hat signifikanten Einfluß auf Wachstum und Reproduktion von Arten der Gattung *Apistogramma*. Hohe Temperaturen führen zur Reduktion der Überlebensrate der Nachkommen, zu einer Verringerung des Wachstums (Körperlänge und -gewicht), der Ei- und Gelegezahl sowie der Eigröße, was möglicherweise auf temperaturbedingte Energiedefizite zurückzuführen ist. Sechs Monate alte *A. cacatuoides* zeigen bei 26 °C optimales Wachstum (Männchen bis 76 mm TL, Weibchen bis 46 mm TL) und die beste Gewichtsentwicklung. Temperaturen unter 25 °C haben einen leicht negativen, solche über 28 °C einen deutlich negativen Effekt auf das Wachstum. Weibliche *A. cacatuoides* erreichen die Geschlechtsreife mit 140 bis 350 Lebenstagen. Der Eintritt der Geschlechtsreife ist nicht direkt mit der Temperatur gekoppelt, aber indirekt über das temperaturabhängige Erreichen einer Körperlänge von 30 bis 34 mm TL, bei der die Weibchen erstmals laichen, damit verknüpft. Die Zahl der Eier pro Gelege und die Zahl der Gelege ist von der Temperatur abhängig. Sowohl tiefe (20 bis 22 °C) als auch hohe (29 bis 28 °C) Temperaturen führen im Vergleich mit mittleren Wassertemperaturen (25 bis 28 °C) zu deren Verringerung. Eier, die bei niedrigen Wassertemperaturen (< 25 °C) abgelegt werden, sind etwa ein Fünftel größer als solche, die bei hohen Temperaturen

(> 28 °C) gezeitigt werden. Der Bruterfolg im Freiland wird anscheinend weniger von der Temperatur als vom Feinddruck und der maximal vom Weibchen im Maul transportierbaren Nachkommen beeinflusst.

Schlüsselwörter: Biometrie, Umwelt, Fruchtbarkeit, Geschlechtsreife, temperaturabhängige Geschlechtsbestimmung

1. Introduction

In many groups of animals the physical development has an influence on the probability of survival and reproduction. This is particularly true for small fishes that live in habitats where they are exposed to fierce inter- and intraspecific competition, predation, or extremely variable environmental conditions. It is known of marine *Menidia menidia* that temperature plays a key role in the development of the body, the reproductive system, and regarding the probability of survival of females (Conover 1984; Conover and Heins 1987a, b). Size and mass are furthermore often the determining factors in the choice of partners (Andersson 1994). Unfortunately, no such data are hitherto available for the group of dwarf-cichlids of the neotropical genus *Apistogramma*.

The cichlid-genus *Apistogramma* at present contains 53 valid taxa and about the same number of species still awaiting description (Römer 1998b). Apart from numerous taxonomical studies (e.g. Regan 1906; Kullander 1980, 1986; Koslowski 1985; Staack 1991; Römer 1994b etc.) only a few aspects apart from maintenance and breeding are known about the biology of this usually highly sexual dimorphic and dichromatic dwarf species-group.

In earlier papers Römer and Beisenherz (1995, 1996) presented results of research on environmental sex determination of *Apistogramma* species, within which group temperature-dependent sex determination (TSD) was found as a common mechanism (general overview in Barroiller

et al. 1999). Preliminary field studies have also shown that temperature plays a dominant role in the environment of this group of neotropical cichlids, which influences distribution of species as well as different classes of specimens (Römer 1998a, b). The area investigated in the Rio Negro system in the north-western Brazilian federal state Amazonas has been extensively described by Römer (1992a, b, 1994, 1998b). The region in large parts has retained intact and untouched ecosystems in primary rainforest. It has nevertheless to be mentioned that intense commercial collecting of ornamental fish takes place at certain hot-spots and may possibly have a negative influence on local populations. Such effects were, however, not discernible at my sampling sites. Accordingly, the water-bodies still hold many areas that are largely uninfluenced anthropologically and therefore perfectly suited for the study of small fishes. Data on ecology, behaviour, population densities, and reproduction were gathered during times of low as well as high water-levels (Römer 1992a, b, c, 1993a, b, 1994a, b, 1998a, b).

In addition to these studies the object of this paper is to present laboratory data on the influence of modificatory environmental parameters on the physical development of this freshwater fishes, especially the temperature-influenced development of the individuals and some parameters of productivity. To create a basis for the estimation how far these factors influence fitness, it was first investigated to what extent the temperature influences their growth and mass increase.