ZOOLOGICAL SCIENCE **15**: 405–408 (1998)

Asymmetry of Mouth-Opening of a Small Herbivorous Cichlid Fish *Telmatochromis temporalis* in Lake Tanganyika

Sima Keita Mboko[1], Masanori Kohda[2]* and Michio Hori[3]

[1]*Centre du Recherche en Hydrobiologie/ Uvira, P.O. Box 254, Bujumbura, Burundi*
[2]*Laboratory of Animal Sociology, Faculty of Science, Osaka City University, Sumiyoshi-ku, Osaka 558, Japan*
[3]*Animal Ecology, Faculty of Science, Kyoto University, Sakyo-ku, Kyoto 606, Japan*

ABSTRACT—Direction of mouth-opening of a small herbivorous Tanganyikan cichlid, *Telmatochromis temporalis*, was studied. Each sample fish opened its mouth either rightward or leftward in some degree. The directions of mouth-opening were independent of the body curve directions, and the asymmetry will be due to asymmetric mouth morph individually specific. The degree of the mouth asymmetry was not related to body size, suggesting the asymmetry being not acquired characters. No fish opened the mouth in lateral symmetry, indicating that the asymmetry is different from "fluctuating asymmetry". This fish took algae on rock surface usually using right or left side of its mouth. However, strong relations between directions of mouth-openings and frequencies of mouth side used in foraging were not found, and the biological role of the asymmetry, if any, is not clear now.

INTRODUCTION

Many zoologists studying fish morphology may regard fish bodies as being laterally symmetric. Recently, however, asymmetry of mouth morph has been documented in scale-eating cichlids in Lake Tanganyika (Liem and Stewart, 1976; Hori, 1991, 1993). In these fish, an individual's mouth opens either rightward or leftward as a result of an asymmetrical joint of the jaw to the suspensorium (Liem and Stewart, 1976). *Perissodus microlepis* is one of such scale-eaters. This fish dashes and tears off fish scales from behind the prey; fish opening the mouth rightward (dextral) always attack left-side flank of prey and those opening leftward (sinistral) do right-side of prey (Hori, 1993). The asymmetry of deviated opening of mouth is related to the specific foraging techniques.

Lake Tanganyika harbors more than 170 cichlid fishes of various food habits (Poll, 1986; Hori, 1987). *Telmatochromis temporalis* is a small herbivorous cichlid dwelling rocky substrates (Brichard, 1989; Mboko and Kohda, 1995). This fish takes algae on the surface of rocks. While examining samples of this fish, surprisingly we noticed that directions of opened mouth of each sample deviated either rightward or leftward. In field observations, we found that this fish usually used either left or right side of the mouth in a feeding bite. Here, we report the asymmetry in direction of mouth-opening of *T. temporalis* and the relationship of the mouth morph asymmetry and their foraging behaviours.

* Corresponding author: Tel. +81-6605-2584;
FAX. +81-6605-3172.

MATERIALS AND METHODS

We observed foraging behaviours of *Telmatochromis temporalis* at Kasenga Point at the southern end of Lake Tanganyika from October to December 1994, using SCUBA. This point is in a rocky shore which continues for several kilometers. Individuals were easily identified by individual-specific colour patterns and tears on body. Foraging behaviours of a total of 48 individuals were observed, each more than 20 min (mean ± SD: 31.4 min ± 6.7, n = 48). Mouth sides (right, left or frontal side) used in a feeding bite at rock surface were recorded. Of the 48 fish, 4 showed foragings less than 20 times, and were omitted from examination of relations between mouth asymmetry and foraging behaviours. The mean number of observed foraging of the examined 44 fish were 45.0 ± 32.1 SD (range 33 – 163). Body size of the 44 fish ranged 41.3 – 79.2 mm SL.

Each fish was captured after observations, and was kept in 10%-formalin solution. Hori (1991) used the sub-orbital width difference between right and left ones as an index of the mouth morph asymmetry in scale-eaters. Sub-orbital widths of *T. temporalis* were small, and were difficult to be measured without some errors. In the scale-eaters, the degree of the mouth morph asymmetry is related to the degree of the deviated mouth-opening (Hori, pers. obs.). To examine the asymmetry of mouth in *T. temporalis*, we measured the angles between a body-axis (sagittal plane) and a line between the both ends of opened mouth of the samples (Fig. 1). For the measurements, two 0.15 mm fishing lines were stretched; one along the body-axis (between both the center of throat and of pelvic fin base) and the other between the both ends of the opened mouth under a magnifying glass (x4). After the stretching, the angle of the two lines was measured to the nearest 0.5° by a protractor 24 cm in diameter. For exact mea-

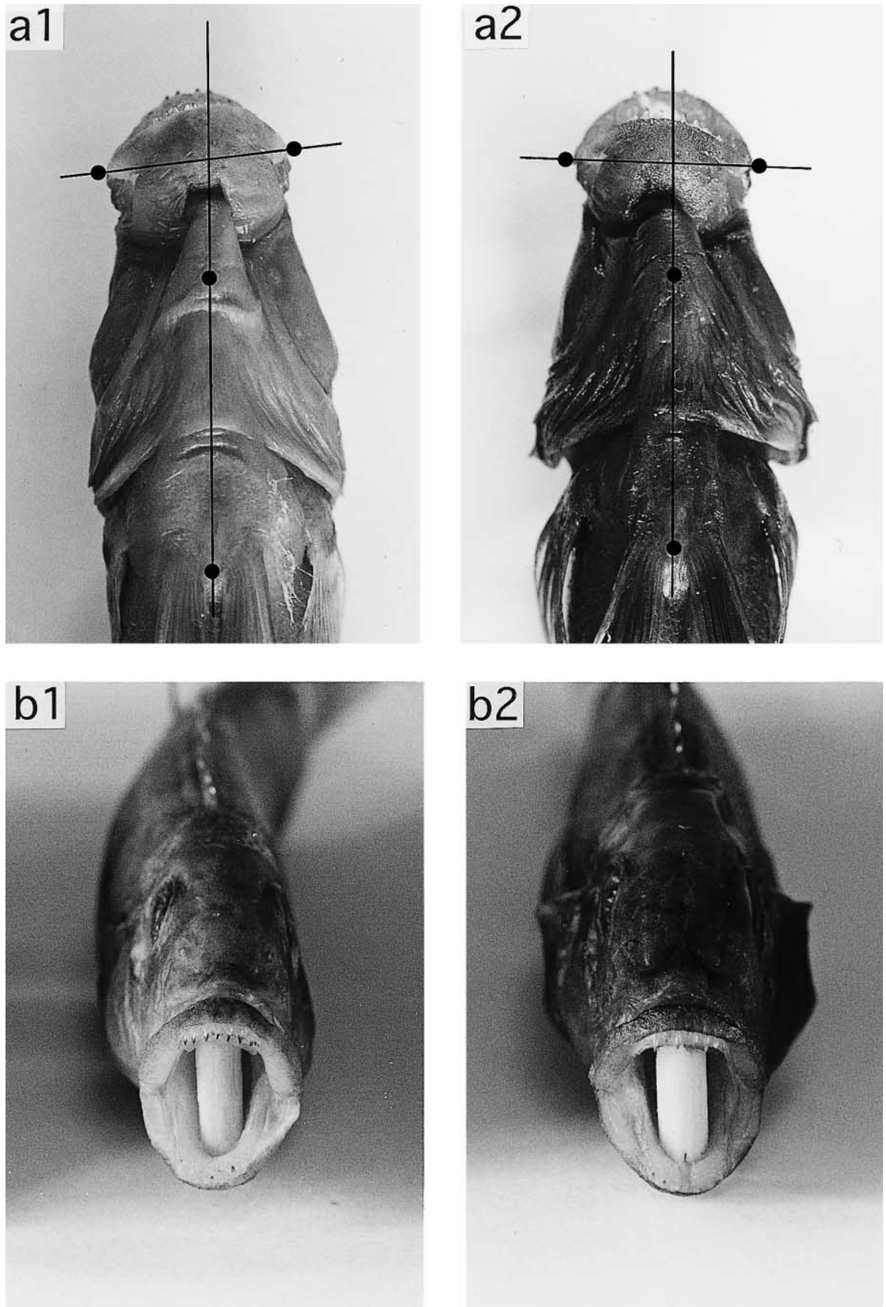

Fig. 1. Photographs of a sinistral and a dextral *Telmatochromis temporalis* individual with opened mouth. (**a**) Ventral view and (**b**) frontal view. (**1**) Sinistral fish and (**2**) dextral fish. Two lines are given between both of the center of throat and of pelvic fin base, and between both ends of the mouth. Photo by N. Miyata.

surement, the angle of each mouth was measured three times, each in different days, and the average value was used for analysis. Additional 20 samples obtained at the same site in December 1994 were also measured. The error of measurements was small (mean absolute angle ± SD = 6.9° ± 3.0, n = 64; mean SD of each sample ± SE = 1.02 ± 0.62, n = 64). Body size of the 64 fish ranged 35.8 – 79.2 mm SL. Each fish was sexed by gonad examination.

RESULTS

The direction of mouth-opening of *Telmatochromis temporalis* was deviated to either leftward (sinistral) (5.92° ± 2.99 SD, n = 31) or rightward (dextral) (7.83° ± 2.77 SD, n = 33; Figs. 1 and 2), and there were no fish that opened mouth in lateral symmetry against the body axis. The asymmetry was found from both sexes (20 sinistral and 28 dextral in male, 8 and 8 in females; $\chi^2 = 0.34$, $P = 0.56$).

Bodies of many samples curved either left- or rightward

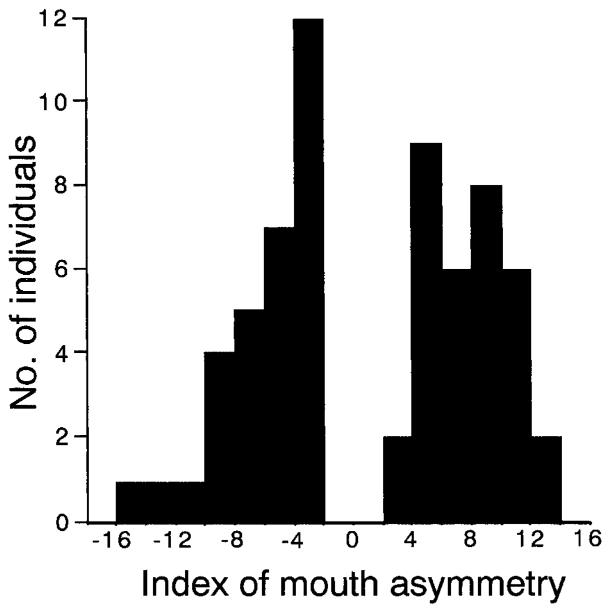

Fig. 2. Individual frequency in degree of the mouth-opening in *Telmatochromis temporalis*. Index of mouth asymmetry is angle between a body line and a line between the both ends of opened mouth. Minus values show angles of leftward opening mouths.

in some degree. However, the direction of mouth-opening was not related to the direction of body curve (7 sinistral and 10 dextral in leftward curved body fish, 14 and 17 in rightward curved body; $\chi^2 = 0.71$, $P = 0.79$).

The degree of the deviated mouth-opening was not correlated with fish body sizes in either sinistral or dextral opening mouth types ($r = 0.32$, $n = 31$, $P = 0.08$, size range 36.1 – 79.2 mm SL in sinistral; $r = 0.14$, $n = 33$, $P = 0.43$, size range 35.8 – 77.8 mm in dextral). This suggests that the degree of the mouth-opening does not increase with fish growth.

Fish of this population used either side of the mouth in a foraging bite: the average foraging frequency by using frontal side of mouth was 5.2% (SD = 4.4, n = 44). Each individual used both sides of mouth in foraging epilithic algae in various ratio. There was significant difference between mouth-opening direction and mouth sides that were used more frequently than the opposite (Table 1, $\chi^2 = 4.13$, $P = 0.042$). Many dextral fish used the left side of the mouth more frequently than the right side. However, there were no significant correlations between the degree of mouth-opening directions of dextral fish and their feeding ratios by left side mouth (no. of left side feeding/left and right side feeding x 100) ($r = 0.24$, $n = 24$, $P = 0.25$), and also between the degree in sinistral fish and their feeding ratios by left side mouth ($r = 0.33$, $n = 19$, $P = 0.16$).

Table 1. Relations between directions of mouth-opening and foraging mouth sides in *Telmatochromis temporalis*. Fish numbers are shown.

Direction of mouth-opening	Mouth side used in foraging	
	Right side more	Left side more
Sinistral	10	10
Dextral	5	19

DISCUSSION

We found that each individual of *T. temporalis* had mouth-opening either leftward or rightward. The direction of asymmetry and its degree may not be due to measuring errors, and were individually specific. The deviation will be difficult to be ascribed to some artificial factors, such as the process of formalin fixation or the method of opening mouth. Body curvedness was not related to the mouth asymmetry, indicating that the mouth asymmetry does not result from the body curve. This asymmetry may be caused by mouth morph asymmetry, as has been suggested in the scale eaters of the genus *Perissodus* (Liem and Stewart, 1976; Hori, 1991), although the degree of the deviation is less than that of them.

One of prevailing explanations on body asymmetry within an animal population may be “fluctuating asymmetry” (Van Valen, 1962; Palmer and Strobeck, 1986; Leary and Allendorf, 1989). This asymmetry is caused by genetic homogeneity under some conditions such as small-sized population, and is not adaptive. The asymmetry caused by this mechanism will have a normal distribution in the frequency with a peak at point 0 (Leary and Allendorf, 1989). The frequency of mouth asymmetry of *T. temporalis* clearly indicates that the asymmetry of this fish is different from fluctuating asymmetry.

The mouth asymmetry of the scale eater *P. microlepis* was strictly related to their foraging behaviours (Hori, 1993), and can be explained as an adaptive morph for its specific foraging technique. In *T. temporalis*, such strong relations were not detected. We have no data to explain the significance (if any) of the asymmetry of mouth-opening of this herbivore at all now.

Telmatochromis temporalis forage on small filamentous algae, and their foraging behaviours are ordinary in herbivorous cichlids (Yamaoka, 1983, 1991). Our preliminary examinations on mouth-opening direction of the other herbivorous cichlids suggest that most of the herbivores have the asymmetry, as was observed in *T. temporalis*.

Mouth asymmetry of the scale-eater, *P. microlepis* is suggested to be genetically determined by simple Mendelian system (Hori, 1993). The degree of mouth asymmetry of *T. temporalis* is not related to body size, suggesting the asymmetry being not acquired characters. The dimorphism of *P. microlepis* is maintained by frequency dependent selection (Hori, 1993). How are the dimorphisms of *T. temporalis* and the other herbivorous cichlids maintained, and are there significance of the dimorphisms? We are only at the starting point of studies on this interesting phenomena.

ACKNOWLEDGMENTS

We are grateful to the staff of Lake Tanganyika Research Unit of the Department of Fisheries, Zambia for their helpful supports. This work was supported by the Grants-in-Aid for Overseas Scientific Research (Nos. 04041781, 04044088, 07041147) from the Japanese

Ministry of Education, Science, Sports and Culture.

REFERENCES

Brichard P (1989) Cichlids and All the Other Fishes of Lake Tanganyika. TFH Publications, Neptune City

Hori M (1987) Mutualism and commensalism in the fish community of Lake Tanganyika. In “Evolution and Coadaptation in Biotic Communities” Ed by S Kawano, JH Connell, T Hidaka, University of Tokyo Press, Tokyo, pp 219–239

Hori M (1991) Feeding relationships among cichlid fishes in Lake Tanganyika: effects of intra- and interspecific variations of feeding behavior on their coexistence. INTECOL Bull 19: 89–102

Hori M (1993) Frequency-dependent natural selection in the handedness of scale-eating cichlid fish. Science 260: 216–219

Leary RF, Allendorf FW (1989) Fluctuating asymmetry as an indicator of stress: implications for conservation biology. Trends Ecol Evolv 4: 214–217

Liem KF, Stewart DJ (1976) Evolution of the scaleeating cichlid fishes of Lake Tanganyika: a generic revision with a description of a new species. Bull Mus Compr Zool 147: 319–350

Mboko SK, Kohda M (1995) Pale and dark dichromatism related to microhabitats in a herbivorous Tanganyikan cichlid fish, *Telmatochromis temporalis*. J Ethol 13: 77–83

Palmer AR, Strobeck C (1986) Fluctuating asymmetry: measurement, analysis, pattern. Ann Rev Ecol Syst 17: 391–421

Poll M (1986) Classification des cichlidae du lac Tanganyika: tribus, generes et especes. Mem Acad R Belgique (Science) 45: 1–163

Van Valen L (1962) A study of fluctuating asymmetry. Evolution 16: 125–142

Yamaoka K (1983) Feeding behaviour and dental morphology of algae scraping cichlids (Pisces: Teleostei) in Lake Tanganyika. Afr Stud Monogr Kyoto Univ 4: 77–89

Yamaoka K (1991) Feeding relationships. In “Cichlid Fishes” Ed by MHA Keenlyside, Chapman & Hall, London, pp 151–172

(Received November 18, 1997 / Accepted February 4, 1998)