Incidence of Gill Asymmetry in *Oreochromis niloticus* (L.) and *Clarias gariepinus* (Burchell, 1822) from Asejire Reservoir, Southwest Nigeria

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Abstract

Gill rakers and filaments were analyzed for asymmetry in a small sample of *Oreochromis niloticus* (n = 33) and *Clarias gariepinus* (n = 37) from Asejire reservoir, Southwest Nigeria. *O. niloticus* (9%) recorded a higher incidence of asymmetry in gill filaments whilst *C. gariepinus* (6%) in gill rakers. In both species, the gill rakers exhibited higher fluctuating asymmetry (FA) and are, therefore, more sensitive for environmental health evaluations compared with filaments.

Introduction

Fish are sensitive to trace levels of contaminants in aquatic media because gills, representing 60-75% of total surface in contact with water, are the first critical organ systems to encounter the impact (Powers, 1989; Lauren, 1991; Jobling, 1995; Tuossaint *et al.*, 2001). Gill perturbations and asymmetry have proved a simple, inexpensive and rapid assessment tool of previous and current aquatic conditions and has been used extensively in laboratory assessments of contaminant effects. The contrary has been the case with field or *in situ* evaluations of natural populations (Bengtsson *et al.*, 985; Lauren, 1991; Poleksic & Mitrovic- Tunlundzic, 1994). Van Valen (1962), Palmer & Strobeck (1986) and Graham *et al.* (1993) described the principles and the bilateral traits used in evaluating asymmetry. This study attempts to provide information on field evaluation of gill asymmetry in a small sample of the Nile tilapia, *Oreochromis niloticus* (L.) and the African catfish, *Clarias gariepinus* (Burchell, 1822) as indicators of environmental health of Asejire reservoir, a man-made tropical lake. The Nile tilapia and African catfish have been used extensively in both laboratory and field studies and their cosmopolitan nature makes for ease of universal data comparison.

Asejire reservoir (04° 05'E and 07° 21'N), a man-made lake on River Oshun, has an impounded area of 2342 ha and located about 30 km east of Ibadan, Southwest Nigeria (Egborge, 1972; Ekpo, 1993). The highest temperature recorded in the area was 33.9 °C (Department of Geography, University of Ibadan, 1990). Both the reservoir and the parent river have not been reported as polluted.

Materials and methods

Seventy fish specimens comprising 33 *O. niloticus* (mean SL = 11.74±2.59; mean BW = 57.91±70.94) and 37 *C. gariepinus* (mean SL = 21.67±4.53; mean BW = 92.22±63.97) were purchased from fishermen at Asejire fishing jetty between

December 1999 and March 2000. The gills from both sides of the head were extracted (Lucky, 1977) and examined for asymmetry. The gill rakers and filaments were counted for each of the four gill arches extracted from both sides of the head. Filaments were counted with the aid of a magnifying lens. On the basis of filament numbers, members of each species were characterized as having (i) complete symmetry, where all gill arches had the same number of filaments on both sides, (ii) partial symmetry, where some gill arches recorded different numbers of filaments, and (iii) asymmetry, where arches from both sides recorded different numbers of filaments. Shrinkages were minimized by analyzing extracted gills the same day. Fluctuating asymmetry (FA) given as $A_i = | R_i - L_i |$, the difference between the values of traits on the right and left sides, was used as an index of asymmetry (Van Valen, 1962; Palmer & Strobeck, 1986; Graham *et al.*, 1993), and the relationship between gill rakers and filaments from both sides were determined using students' t-test and F- test (Sokal & Rohlf, 1987).

Results and discussion

The summary of the gill meristics and their relationships in *O. niloticus* and *C. gariepinus* is presented in Table 1. *O. niloticus* recorded a lower mean number of gill rakers and filaments from both sides compared with *C. gariepinus*. Bilateral differences were not significant in *O. niloticus* (t = -1.00; F = 0.002) and *C. gariepinus* (t = 1.43; F = 0.001) for gill rakers and filaments, respectively (Table 1). Asymmetry was observed in 9% and 11% of gill filaments from *O. niloticus* and *C. gariepinus*, respectively, the remaining recorded partial or complete symmetry (Fig. 1). Lower incidence of asymmetry (6% and 3%, respectively) was, however, observed in the corresponding gill rakers. Table 2 (summarizes FA in both species with *C. gariepinus* recording higher mean FA in gill filaments compared with gill rakers in *O. niloticus*. FA was not significantly

TABLE 1

Summary of gill meristics in O. niloticus *and* C. gariepinus

O. niloticus					C. gariepinus				
		Mean	*t*	*F*			*Mean*	*t*	*F*
Gill rakers	L	59.55±t13.08	-1.00		Gill rakers	L	72.92±2T86	1.43	
	R	59.58+13.06				R	72.76±23.84		
Gill filaments	lL	149.00±4.73			Gill filaments	1 L	152.95±9.26		
	R	149.00±4.73				R	152.97±9.28		
	2L	148.88±4.73				2L	153.03±9.18		
	R	148.94±4.80				R	152.86±9.27		
	3L	148.91±4.77		0.002		3L	152.81±9.24		0.001
	R	148.84±4.77				R	15292±9.30		
	4L	148.94±4.77				4L	152.92±9.30		
	R	148.94±4.77				R	152.92±9.30		

L=left side; R =right side

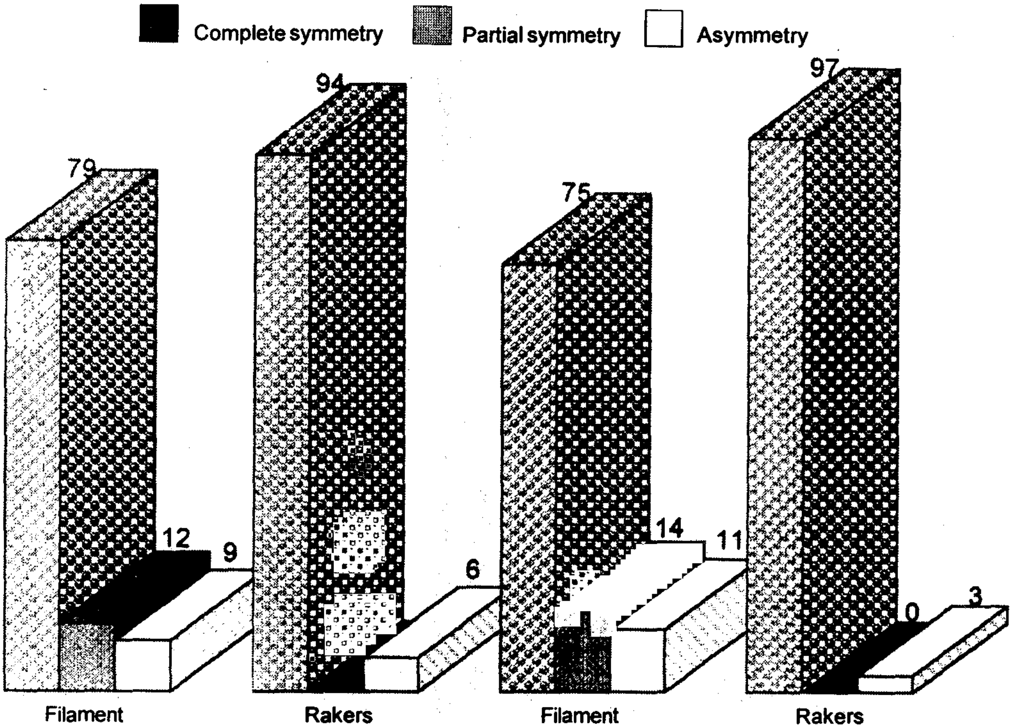

Fig. 1. Percentages of different symmetry observed in gills

TABLE 2

Fluctuating asymmetry in the dills of O. niloticus *and* C. gariepinus

		O. niloticus				C. gariepinus	
		Mean	*F*			*Mean*	*F*
Gill rakers		0.03±0.17		Gill rakers		-0.16±0.68	
Gill filaments	1	0.00		Gill filaments	1	0.02±0.16	
	2	0.06±0.24			2	-0.16±0.72	
	3	0.03±0.18	1.37		3	0.01±0.51	2.31
	4	0.00			4	0.00	

different in gill filaments across the four arches from both species. Levels of FA in gill rakers and gill filaments are presented in Fig. 2, with both organisms recording higher FA frequency of gill rakers.

The minor departures from perfect symmetry observed in gill rakers and filaments of *O. niloticus* and *C. gariepinus* in this study (Fig. 1 and 2) provided evidence of disturbance within internal regulatory mechanism caused by degeneration in environmental health. Fluctuating asymmetry (FA) occurs when one side of a bilaterally symmetrical structure is enhanced over the

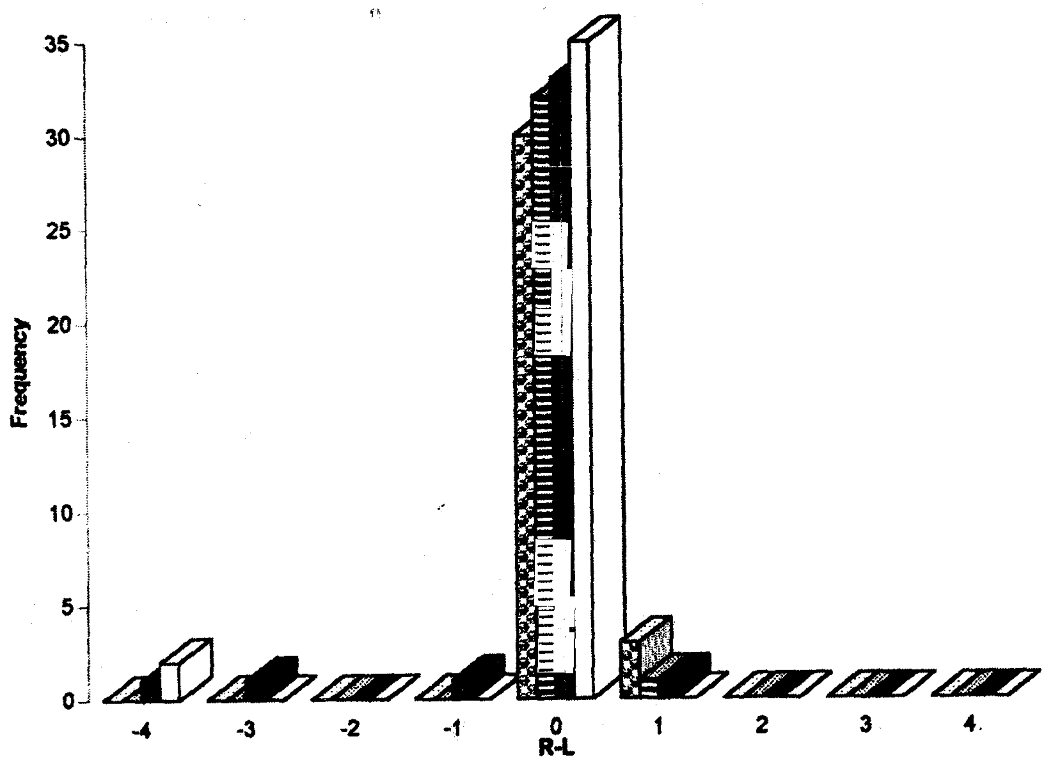

Fig. 2. Level of fluctuating asymmetry in *O. niloticus* and *C. geriepinus*

other in an individual, and it has been acknowledged to act as indicator of population under exogenous and endogenous stress (Van Valen, 1962; Palmer & Strobeck, 1986; Graham *et al.*, 1993. Generally, *O. niloticus* exhibited higher FA compared with *C. gariepinus* (Table 2), showing that homeostatic integration of pollutants differs for species, corroborating the conclusion that gill susceptibility to damage is species dependent (Poleksic & Mitrovic-Tuntundzic, 1994), although the notion of a higher stress threshold of *C. gariepinus* may have a role to play (Haylor, 1993). Gill rakers were more sensitive to homeostatic flux compared with gill filaments, though different parts of gills are under similar genetic control (Zacharov & Yablokov, 1990; Jobling, 1995). The different susceptibilities arose from developmental and morphological variability (Suzuki *et al.*, 2000), as the gill precursor-pharyngeal arches develop at different rates into separate gill regions. Thus, the sequence and duration of exposure to pollutants or perturbations probably dictate the degree of disturbance.

The study was conducted to evaluate the state of health of water body based solely on a biological tool, with an attribute of integrating not just the contemporary conditions but previous circumstances. This is, therefore, a better approach than chemical evaluations which reveal only the prevailing contemporary conditions. The conditions in Asejire reservoir were such that it has not been reported as polluted, even though pollutants were likely to be present at submorbidity or microconcentration levels, usually the desirable level for pollutant detection in the aquatic environment (Bengtsson *et al.*, 1985). Asymmetry of biological structures permits low-level pollution detection before irreparable damage manifests.

Fluctuating asymmetry within filaments has not been extensively used for the purpose of evaluating environmental health compared with gill rakers. However, its extensive utilization for determination of gill dimension in different fish species (Hughes, 1984), made it attractive for measuring asymmetry. Information on the use of gill filaments for this purpose was not readily available, but based on the conclusions of Zacharov and Yablokov (1990) and Suzuki *el al.* (2000) that development of different morphological characteristics on the same bilateral structure proceeds from the same genotype, similar conditions were assumed to apply to both gill rakers and filaments. Asymmetry in gill filaments because of the number of arches and filaments involved was classified as asymmetry, partial symmetry or complete symmetry. This was based on the number of gill arches with similar number of filaments on either side. *O. niloticus* exhibited lower filament FA and partial symmetry compared with *C. gariepinus* in comparison with gill rakers.

Earlier studies compared gill rakers with other structures especially paired fins, lateral line scale number, premaxillary teeth (Bengtsson *et al.*,1985; Felley, 1980; Vrijenhoek & Lerman, 1982) but none reported the use of gill filaments. The ultrasensitivity of bilateral structures to environmental perturbations informed recommendation for their use in environmental monitoring (GESAMP, 1980). Gills have always been primary target organ of unfavourable conditions with different morphological responses. However, the acknowledged dearth of information (Bengtsson *et al.*, 1985; Lauren, 1991; Poleksic & Mitrovic-Tuntundzic, 1994) is more acute for the African continent. The little available information was obtained largely from laboratory investigation without provisions for field observation where conditions and responses are different. It is hoped that increased evaluation holds part of the solutions to environmental assessment without problem of resource restriction.

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