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Paul Chinedu Echi
Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Nigeria

Correspondence
Paul Chinedu Echi
Department of Zoology and Environmental Biology, Michael Okpara University of Agriculture, Umudike, Nigeria.

The Overall Differential Morphometric Parts among Clinostomatids (Clinostomatidae) in the Micro-habitats of *Tilapia zillii* and other Cichlids

Paul Chinedu Echi

Abstract
Competition among closely related parasites in a concomitant parasitism within micro-habitats in a host fish determines success and adaptability of one over the other. Consequently, competition for better adaptiveness, access to nutrients, and more population size among clinostomatids resulted in pressures on the parasites' morphometric parts irrespective of the cichlid hosts infected. For instance, *T. zillii* all the morphometric parts of the clinostomatid parasites; *Clinostomum complanatum* and *Euclinostomum heterostomum* (c and b) were significantly different (*P*<0.05) with all the morphometric parts of *Clinostomum tilapiae* (a). However, the result from the overall morphometric information supports genetic success of a closely related species over another as a gradual process in relation to environmental situations.

Keywords: Clinostomatids, *Tilapia zillii*, micro-habitats, adaptiveness, genetic success

Introduction
The most general postulate of the theory of natural selection is that the environment determines the evolution of the anatomy, physiology, and behaviour of organisms as surmised by Darwin. Such pressure must be selective of genetic constituents of organisms. In other words, biological selection is a gradual process and will be reflective of the genes. Recent morphometric studies of three clinostomatids in three different species of cichlids (*Sarotherodon melanotheron, Tilapia guinensis* and *Tilapia zillii)*, were suggestive of fast genetic success [1, 2]. Example in *Tilapia guinensis*, except the Oral sucker *C. complanatum* 2.56± 0.94, *E. heterostomum* 1.62± 0.49, *C. tilapiae* 1.96± 0.84, and Pharynx *C. complanatum* 1.60± 0.46, *E. heterostomum* 1.26± 0.34, *C. tilapiae* 1.58± 0.40 showed significance difference at 95 % confidence interval (*p*< 0.05 %), in the ventral sucker *E. heterostomum* and *C. tilapiae* differed with *C. complanatum* all the other morphometric parts did not showany difference. Similarly, in *Sarotherodon melanotheron*, except the Oral sucker *C. complanatum* 2.35± 1.10, *E. heterostomum* 1.43± 0.50, *C. tilapiae* 1.81± 1.02,and Pharynx *C. complanatum* 1.17± 0.36, *E. heterostomum* 0.89± 0.33, *C. tilapiae* 1.02± 0.38 showed significance difference at 95 % confidence interval (*p*< 0.05 %), in the ventral sucker *E. heterostomum* and *C. tilapiae* differed with *C. complanatum* all the other morphometric parts did not showany difference [1, 2].
In evolutionary biology, 'fitness' is a measure of genetic success, so that 'fitness benefit' refers to the positive effect of a trait on the number of surviving offspring produced by an individual or the number of genes it contributes to the next generation whereas 'fitness cost' refers to the damaging effects of the trait on these measures of individual genetic success [3]. These three clinostomatids that occur together in cichlid hosts demonstrated survival of the fittest in their morphometric parts such as oral sucker, ventral sucker, and distance between the oral and ventral suckers, body length, and pharynx. The anatomy of *Clinostomum* species, especially the length of their body, the diameter of oral sucker, ventral sucker, distance between the oral and ventral suckers and pharynx, reflected selection for firm attachment on host mesenteries for effective use of nutrients [1, 2]. Adaptation is a heritable trait that either spread because of natural selection or has been maintained by selection to the present or currently spreading relative to alternative traits because of natural selection. In all such cases, the trait in question has conferred and continues to confer or is just beginning to confer higher genetic or

Reproductive success on dominant species of the parasites with favourable alternative traits in the various fish species [4]. There is lack in information on the differential morphometric parts among co-infection of clinostomatids recovered from various micro-habitats of *Tilapia zillii* and the overall morphometric parts of these clinostomatids regardless of fish hosts in aquatic ecosystem was needed to verify this perceived fast genetic success.

Materials and Methods

Eye piece and stage micrometers were used to measure the parasite morphometric parts to include the diameters of oral sucker (OS), ventral sucker (VS) and the pharynx (PHA) to the nearest 0.1 micrometers. Other measurements taken were body length (BL) (nm) and the distance between oral and ventral suckers (DOVS) (nm) recovered from the cichlids - *Sarotherodon melanotheron*, *Tilapia guinensis* and *Tilapia zillii* identified based on the details in [5] and the parasites identified [6].

Data analysis

Differences in the various morphometric characters were established using analysis of variance with Duncan's Post Hoc Test. All statistical analysis were done using SPSS version 15 statistical package [7].

Results

On the overall, *Euclinostomum heterostomum*; oral sucker (1.55 ± 0.49 mm), ventral sucker (3.56 ± 1.21 mm), distance between oral and ventral suckers (9.43 ± 2.83 mm), body length (57.0 ± 13.14 mm), body dry weight (0.0075 ± 0.0037 mg), pharynx (1.24 ± 0.46 mm)and *Clinostomum tilapiae*; oral sucker (1.76 ± 0.91 mm), ventral sucker (3.78 ± 1.66mm), distance between oral and ventral suckers (8.08 ± 2.89 mm), body length (54.14 ± 13.21mm), body dry weight (0.0065 ± 0.026mg), pharynx (1.08 ± 0.45 mm). Similarly, in *Clinostomum complanatum*; oral sucker (2.28 ± 0.98 mm), ventral sucker (4.10 ± 1.32 mm), distance between oral and ventral suckers (9.94 ± 2.93 mm), body length (62.00 ± 13.46 mm), body dry weight (0.0088 ± 0.0037 mg), pharynx (1.43 ± 0.49 mm). Duncan's one – way statistical test that was used to determine significant difference among the three parasites morphometric parts irrespective of the host infected, showed that all the parts in *Clinostomum complanatum* and *E. heterostomum* were significantly different (P<0.05) with all the morphometric parts of *Clinostomum tilapiae* (Table:1).

Table 1: Overall Morphometric parts of *Clinostomum* spp. From the three cichlid hosts

Morphometric parts(Micro-meter)	***C. complanatum* (Mean ± SD)**	***E. heterostomum* (Mean ± SD)**	***C. tilapiae* (Mean ± SD)**
OS (mm)	2.28 ± 0.98^{c}	1.55 ± 0.49^{b}	1.76 ± 0.91^{a}
VS (mm)	4.10 ± 1.22^{c}	3.56 ± 1.21^{b}	3.78 ± 1.66^{a}
D.O/V (mm)	9.94 ± 2.93^{c}	9.43 ± 2.83^{b}	8.08 ± 2.89^{a}
BL (mm)	62.00 ± 13.46^{c}	57.32 ± 13.14^{b}	54.14 ± 13.21^{a}
BW (mg)	0.0088 ± 0.0037^{c}	0.0075 ± 0.0034^{b}	0.0065 ± 0.026^{a}
Pha (mm)	1.43 ± 0.49^{c}	1.24 ± 0.46^{b}	1.08 ± 0.45^{a}

Letters a, b, and c show significance difference at 95 % confidence interval (P<0.05 %), the figures with similar letters indicate no significance difference, while those with different letters show significance difference.

In *Serathomeron melanotheron*, except for the body weight and distance between the oral sucker and ventral sucker, the parasites differed significantly in all other morphometric parts (P<0.05) [2]. In *Tilapia guinensis*, the parasites differed significantly only in their pharynx, oral sucker, and body weight (P<0.05) [1]. However, in *Tilapia zillii*, except for the oral sucker, *Clinostomum complanatum* and *E. heterostomum* differed in all other parts significantly with *Clinostomum tilapiae* (P<0.05) (Table:2).

Table 2: Morphometric parts of *Clinostomum* spp. from *Tilapia zillii*

Morphometric parts(Micro-meter)	***C. complanatum* (Mean ± SD)**	***E. heterostomum* (Mean ± SD)**	***C. tilapiae* (Mean ± SD)**
OS (mm)	1.65 ± 0.67^{b}	1.54 ± 0.49^{ab}	1.47 ± 0.51^{a}
VS (mm)	3.58 ± 1.14^{a}	3.30 ± 1.17^{a}	3.43 ± 0.89^{a}
D.O/S (mm)	9.28 ± 3.08^{b}	9.85 ± 3.35^{b}	6.99 ± 1.92^{a}
BL (mm)	55.51 ± 12.45^{b}	54.57 ± 13.58^{b}	44.83 ± 7.23^{a}
BW (mm)	0.0071 ± 0.0023^{b}	0.0067 ± 0.0023^{b}	0.0050 ± 0.0015^{a}
Pha (mm)	1.24 ± 0.51^{b}	1.35 ± 0.53^{b}	0.76 ± 0.23^{a}

Letters a, b, and c show significance difference at 95 % confidence interval (P<0.05 %), the figures with similar letters indicate no significance difference, while those with different letters show significance difference.

Discussion

The clinostomatid species are phylogenetically different, and despite the pressure to ensure better adaptiveness due to competition their individual genetic constituents were distinctly selective which was reflected in their innate morphometric parts. Over the years as their aquatic habitat fallowed due to reduced anthropogenic disturbance to its site these three clinostomatids had differential parasitic implications due to selection for relatively better adaptiveness to hosts' microhabitats, more population size, better host location, larger body size in these three cichlids. Although, this resulted in a trade-off between larger morphometric parts and acquisition of nutrients and larger population size among these parasites, however the overall statistical analyses showed that the pressure was gradual.

The attribute of nutrition that appears to be most significant is the larger surface area per unit volume of *Clinostomum tilapiae* in *S. melanotheron*, *Euclinostomum heterostomum* in *Tilapia guinensis* and *Clinostomum complanatum* in *Tilapia* *zillii*. Spatial adaptation of theses clinostomatids in the various microhabitats of *T. zillii* indicate selection for relatively better adaptiveness, and host location. This relative larger surface area of the body length and the diameter of other parts in the parasite populations resulted in a trade – off between selections for maximum nutrient absorption and reproductive success / population [8].

Adaptation is a heritable trait that either spread because of natural selection or has been maintained by selection to the present or currently spreading relative to alternative traits because of natural selection. In all such cases, the trait in question has conferred and continues to confer or is just beginning to confer higher genetic or reproductive success on *C. complanatum* with highest population than the other two species of the parasites [7, 8]. Even with more encysted forms, adsorption of nutrients such as free proteins, amino acids and transaminases was readily very successful [4]. In evolutionary biology, 'fitness' is a measure of an individual's reproductive or genetic success, so that 'fitness benefit' refers to the positive effect of a trait on the number of surviving offspring produced by an individual or the number of genes it contributes to the next generation whereas 'fitness cost' refers to the damaging effects of the trait on these measures of individual genetic success [3].

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