Preliminary results on morphometric differentiation between natural populations of the Nile tilapia *Oreochromis niloticus* (Perciformes, Cichlidae)

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Introduction

The Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is one of the most important cultured freshwater fishes in the World. It naturally occurs in West Africa, the Nile and East Africa. TREWAVAS (1983) and TREWAVAS and TEUGELS (1991) listed seven subspecies: *O. n. niloticus* known from the Senegal, Gambia, Niger, Volta and Chad basins in West Africa, the Jebel Marra between Lake Chad and the Nile, the Nile from below the Albert Nile to the delta and the Yarkon River near Jaffa (Israel); *O. n. eduardianus* (Boulenger, 1912) known from the Lakes Edward and George basins, Lake Kivu, the Ruzizi River and Lakes Tanganyika and Albert; *O. n. baringoensis* Trewavas, 1983 only known from Lake Baringo (Kenya); *O. n. sugutae* Trewavas, 1983 only known from the Suguta River and its tributary the Kapedo

River and its warm alkaline springs; *O. n. vulcani* (Trewavas, 1933) known from Lake Turkana (Kenya) and its affluent streams and the crater lakes on its central island; *O. n. cancellatus* (Nichols, 1923), known from Lake Tsana and other lakes and rivers of Ethiopia, excluding the Blue Nile, Lake Turkana and certain hot springs in the Awash system; *O. n. filoa* Trewavas, 1982, only known from hot alkaline springs in the Awash National Park, Shoa, near Addis Ababa (Ethiopia).

SEYOUM and KORNFIELD (1992) described an additional subspecies, *Oreochromis niloticus tana*, only known from Lake Tana. The same authors reassigned *O. n. cancellatus* and *O. n. filoa* to *O. cancellatus* as *O.c. cancellatus* and *O. c. filoa* respectively. Their results, however, have been seriously questioned by AGNESE *et al.* (1997).

As part of a multidisciplinary programme on the characterization of species and strains used in aquaculture in Africa, an important collection of Nile tilapias was made originating from nearly allover its distribution range. In this paper, we study the morphometric variation between these different populations.

Material and methods

Two hundred and ninety two specimens of *Oreochromis niloticus* were studied morphometrically. Subspecific identifications follow TREWAVAS (1983). Representatives of all subspecies were examined except for *O. n. filoa*. Table 1 gives details on their origin, number of specimens examined and their size. All the material is deposited in the Musée royal de l'Afrique centrale, Tervuren, Belgium. Twenty five measurements and eigth meristic counts were taken on each specimen using dial calipers. Measurements and counts follow VREVEN *et al.* (in press). Only those specimens for which a complete data set was available, have been used for further analysis.

Origin	n	standard length (mm)
O. n. niloticus		
Dagana (Senegal)	18	77.4-252.6
Selingue (Mali)	24	95.0-138.5
Bamako (Mali)	17	73.5-219.4
Battor (Ghana)	7	180.0-252.4
Lake Chad (Chad)	20	140.6-279.3
Ndjamena (Chad)	17	97.7-156.9
Lake Manzalla (Egypt)	16	122.1-178.0
Cairo (Egypt)	17	136.9-246.7
O. n. eduardianus		
Lake Edward(Uganda)	28	152.9-223.9
O. n. baringoensis		
Lake Baringo (Kenya)	24	149.8-185.0
O. n. sugutae		
Kapedo, Suguta River (Kenya)	11	69.9-163.2
O. n. vulcani		
Lake Turkana (Kenya)	28	132.6-187.6
O. n. cancellatus		
Lake Awasa (Ethiopia)	15	99.6-162.1
Lake Langano (Ethiopia)	6	87.2-118.0
Lake Ziway (Ethiopia)	21	99.9-122.1
Lake Koka (Ethiopia)	13	105.9-159.2
Sodore, Debra Zet (Ethiopia)	10	95.0-138.5

Table 1
Population origin, number of specimens examined and minimum and maximum standard lengths for the different subspecies of *Oreochromis niloticus.*

Data obtained were submitted to factor analysis using a principal component analysis (PCA) (STATISTICA, statsoft, versions 3.1 and 5.0). Measurements were log-transformed before the PCA was run on the covariance matrix. An independent PCA was run on the correlation matrix from the untransformed count data.

Results

Populations of West Africa and the Nile (Egypt)

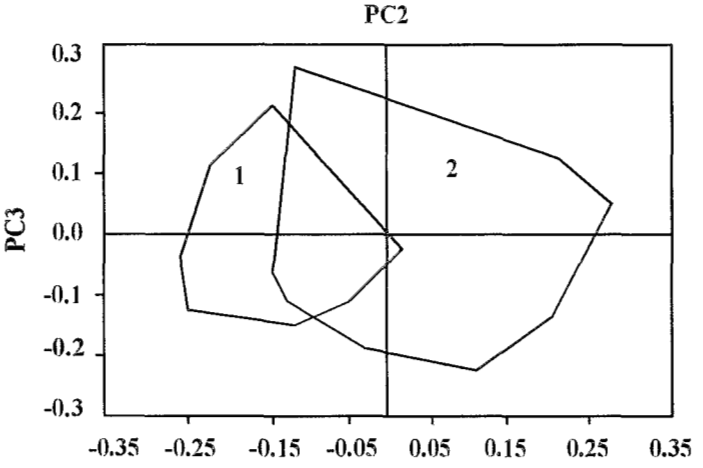

Figure 1
Plot of a principal component analysis using 25 log-tranformed metric variables on specimens examined of the natural populations of *Oreochromis niloticus niloticus sensu* TREWAVAS (1983) from Egypt (1) and from West Africa (2).

VREVEN *et al.* (in press) recently studied the morphometric and genetic variation in natural populations and cultured strains of *Oreochromis niloticus niloticus*, using part of the material examined in this study. We refer to that paper for details on morphometric variation in the natural populations of *Oreochromis niloticus niloticus sensu* TREWAVAS (1983). A summary is given in figure 1: the plot of a PCA on 25 log-transformed metric variables shows that the majority of West African specimens are located on the positive sector of the second component, while the specimens from Egypt are situated on the negative sector. The second component is merely defined by the caudal peduncle length (generally longer in specimens from Egypt) and the toothed

pharyngeal bone width (smaller in specimens from Egypt). A comparison of meristic counts between the different populations did not reveal differences between them.

Populations from West Africa, the Nile (Egypt) and Lake Edward

The results of a PCA on 25 log-transformed metric variables for populations of *Oreochromis niloticus* from West Africa, the Nile and Lake Edward are illustrated in figure 2. Interestingly, all specimens from the Nile and Lake Edward, except one, are located on the negative sector of the second component, while the majority of specimens from West Africa are located on the positive sector. The same variables as above define the second component. It should be noted that, following TREWAVAS (1983), the Nile specimens (Lake Manzalla and Cairo) are identified as *O. n. niloticus* while those from Lake Edward belong to *O. n. eduardianus*.

Populations from East Africa

The plot of a PCA on 25 log-transformed metric variables for the subspecies of *Oreochromis niloticus* from East Africa, is given in figure 3. The population from Lake Turkana (= *O. n. vulcani*) can easily be distinguished from the populations from Lake Baringo (= *O. n. baringoensis*), Suguta (= *O. n. sugutae*). A small overlap between the Lake Turkana (= *O. n. vulcani*) and the Lake Edward (= *O. n. eduardianus*) populations is noted.

The Lake Turkana population is entirely situated on the positive sector of the second component and the negative sector of the third component.

The second component is mainly defined by the anal spine and the dorsal spine lengths (generally longer in the Lake Turkana population) and in a lesser extent the lower jaw length. The third component is merely defined by the pelvic fin length and the anal fin length.

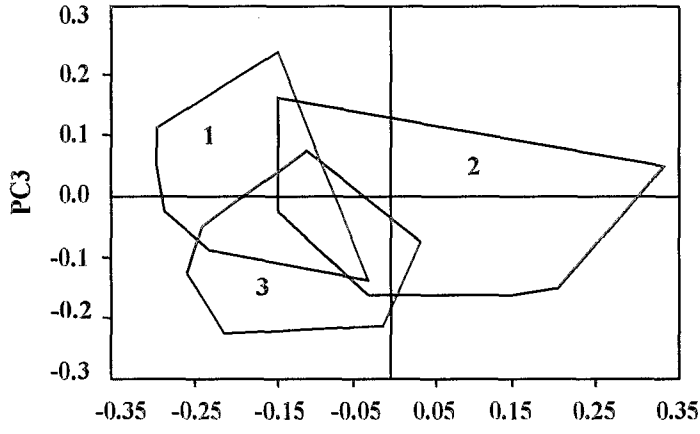

Figure 2
Plot of a principal component analysis using 25 log-transformed metric variables for populations of *Oreochromis niloticus* from Lake Edward (1), West Africa (2) and Egypt. (3)

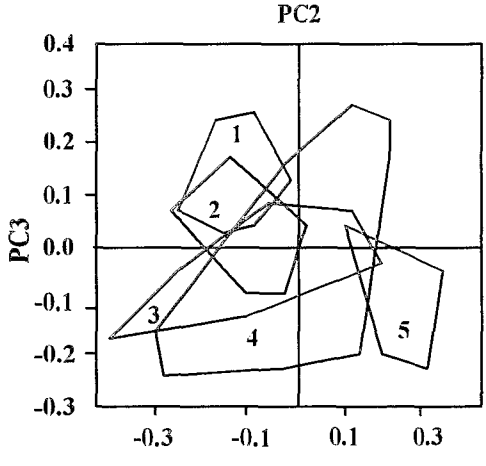

Figure 3
Plot of a PCA on 25 log-transformed metric variables for the subspecies of *Oreochromis niloticus* from East Africa:
(1) *O. n. baringoensis*, (2) *O. n. sugutae*, (3) *O. n. eduardianus*, (4) *O. n. cancellatus*, (5) *O. n. vulcani* .

Most important differences resulting from the analysis of meristic counts were the higher number of gill rakers in the Lake Edward (= *O. n. eduardianus*) and the Lake Turkana (= *O. n. vulcani*) populations.

All populations examined of Oreochromis niloticus

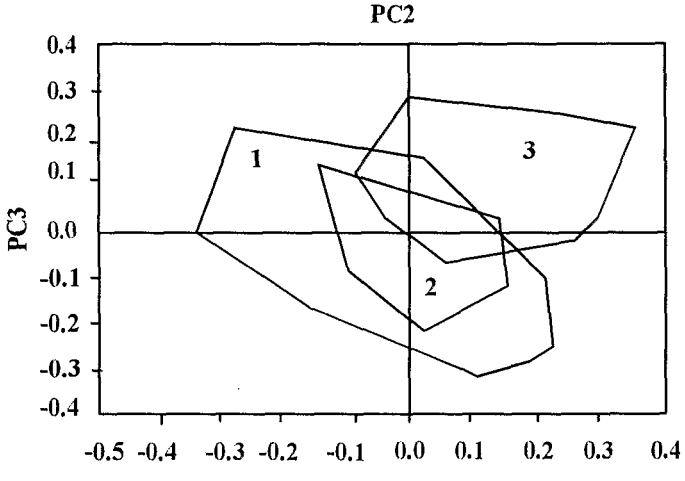

Figure 4
Plot of a PCA on 25 log-transformed metric variables for all the populations examined of *Oreochromis niloticus*, indicating separately the specimens from East Africa (1), the Nile (Egypt) (2) and West Africa (3).

A PCA on 25 log-transformed metric variables for all the populations examined and identified following TREWAVAS (1983) is given in figure 4. Most important result from this analysis is once again the almost complete overlap between the Nile specimens and the East African populations.

The plot of a PCA on 5 meristic counts for all the populations examined and identified following TREWAVAS (1983) is given in figure 5. *Oreochromis niloticus niloticus*, *O. n. vulcani* and

O. n. eduardianus are mainly situated on the negative sector of the first component, while the other subspecies are mainly located on the positive sector. The first component in this analysis is merely defined by the number of gill rakers on the cerato- and hypobranchials of the first gill arch.

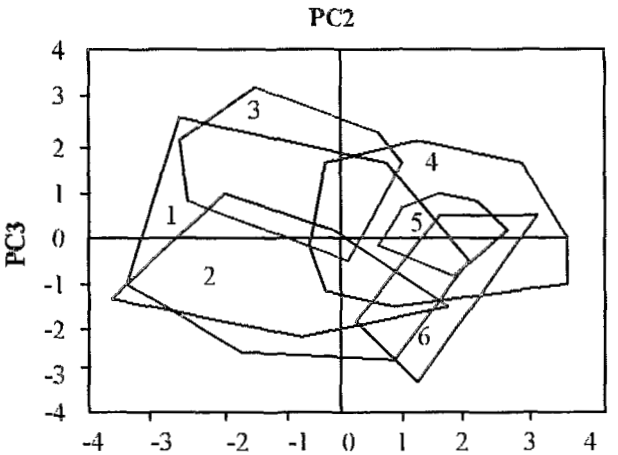

Figure 5
Plot of a PCA on 5 meristic counts for all the populations examined of *Oreochromis niloticus*, identified following TREWAVAS (1983), *O. n. niloticus* (1), *O. n. vulcani* (2), *O. n. eduardianus* (3), *O. n. cancellatus* (4), *O. n. baringoensis* (5), *O. n. sugutae* (6).

Discussion

The most important result of this preliminary study is undoubtedly the fact that morphometrically the populations from the Nile (Lake Manzalla and Cairo) seem closer to the East African populations than to the West African populations of *Oreochromis niloticus*. ROGNON *et al.* (1996) studying allozyme variation in West African and Nile populations of this species, reached the same conclusion

because their Nile population (also from Lake Manzalla) clusters exclusively with a population from Lake Turkana. Allozyme data based on tissue-electrophoresis of the same material as studied in this paper, confirmed this (VREVEN *et al.*, in press). TREWAVAS (1983) considered both, the West African and the Nile populations as belonging to *O. n. niloticus*. Therefore their arrangement in the same subspecies can be questioned.

From our results on the study of the East African populations, it is clear that the Lake Turkana specimens, identified as *Oreochromis niloticus vulcani* clearly differ from all the other subspecies. From the same results it is also clear that the *O. n. cancellatus* complex shows a high degree of morphometric polymorphism. Remarkably the different geographic populations are almost all distinctly marked in the *O. n. cancellatus* polygone (not illustrated), with the more northern populations (Sodore and Lake Koka) and the more southern populations (Lakes Ziway, Awasa and Langano) located close to each other. This pattern probably indicates a clinal variation which is an argument in favour of considering these populations as belonging to the same subspecies. From our morphometric analysis we did not find sufficient evidence to support the conclusion of SEYOUM and KORNFIELD (1992) that *O. n. cancellatus* is a separate species that contains two subspecies.

The results presented in this study indicate that the subspecific classification of *Oreochromis niloticus* as given by TREWAVAS (1983) can be questioned. The results however are still preliminary: not all subspecies have been examined (*e.g. O. n. filoa* and *O. n. tana*) and for some subspecies only few specimens have been examined. This is the subject of forthcoming research.

Acknowledgements
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