Genetic Characterization of West African Populations of Sarotherodon melanotheron (Teleostei, Cichlidae)

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Since 1993, studies have been conducted on the genetic characterization of species and populations of West African tilapiines used in aquaculture, as part of two collaborative projects funded by the German Agency for Technical Cooperation. In this paper, we summarize the results of a recent population genetic study on one of the most abundant and most polymorphic tilapiine species in lagoons and estuaries of West Africa (Senegal-Congo), the black-chinned tilapia *Sarotherodon melanotheron* (Rtippell, 1852). Based on morphological characteristics, Trewavas (1983) recognized five subspecies: (1) *S.m. paludinosus,* only known from certain regions near Dakar (Senegal); (2) *S.m. heudelotii,* ranging from Senegal to Guinea; (3) *S.m. leonensis,* ranging from Sierra Leone to Liberia; (4) *S.m. melanotheron,* ranging from Cote d'Ivoire to southern Cameroon; and (5) *S.m. nigripinnis,* known from Equatorial Guinea to the mouth of Congo River.

In this study, material from 18 localities all over the distribution range of the species (Trewavas and Teugels 1991) was examined. Allozyme, hemoglobin and globin chain variations were analyzed comparatively. Data were subjected to phenetic and cladistic analyses. Morphometric variations were studied at the Musee Royale de I' Afrique Centrale, Belgium.

Results obtained question the current sub-specific classification and distribution of sub-species proposed by Trewavas (1983), in particular for the western range of West Africa. So far, three of the five presently known sub-species could be distinguished by cladistic analysis of allozyme data and globin chain characteristics (Fig. 1): (1) *S.m. heudelotii,* ranging from Senegal to Sierra Leone; (2) *S.m. melanotheron,* ranging from Cote d'Ivoire to southern Cameroon; and (3) *S.m. nigripinnis,* ranging from Equatorial Guinea to the mouth of the Congo River.

With respect to the validity of *S.m. paludinosus* (Senegal), however, we suspected that the morphological characteristics used to distinguish this subspecies from *S.m. heudelotii* reflect ecophenotypical variation. For the same reason, we also doubt the

validity'of *S.m. leonensis.* Based on phenetic and cladistic analyses of allozyme data and globin chain characteristics, all samples studied from Senegal and Sierra Leone are considered representatives of the same taxon. Genetic distance estimates (N ei 1978) inferred from allozyme studies gave concordant re- stilts. We therefore propose to introduce a synonymy between both subspecies described in Senegal, *S.m. heudelotii* being a senior synonym of *S.m. paludinosus.* Moreover, a further synonymy between *S.m. heudelotii* and *S.m. leonensis* is assumed. However, the remaining three subspecies are genetically clearly distinguished as separate taxa, a finding also supported by previous studies (Tetigels and Hanssens 1995; Adepo-Gourene et al. 1998).

Phylogenetically, our data suggest a sister group relationship between *S.m. nigripinnis* and all other populations investigated (outgroup: *Tilapia guineensis).* The consensus tree presented in this paper (Fig. 1) has been rooted accordingly (outgroup: *S.m. nigripinnis).* Moreover, a close relationship is indicated between *S.m. nigripinnis* and *S.m. melanotheron,* whereas populations from Senegal and Sierra Leone appear to share a high number of more derived character states. Consequently, we assume a Congolese origin for S. *melanotheron.* From this area, populations would have been able to colonize the northern West African coastal basins up to

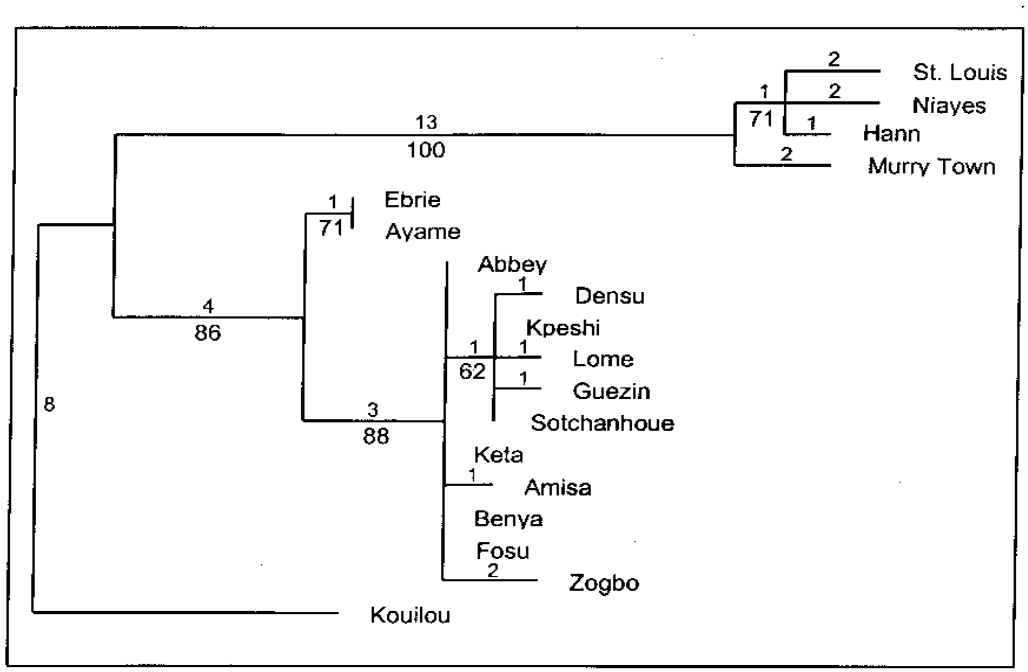

Fig. 1. *Genetic relationships among* 18 *populations of* S. melanotheron *based on a/1ozyme data* (25 *characters) and globin chain characteristics* (22 *characters): Bootstrap* 50% *majority rule consensus tree rooted by the population from the Lower Kouilou (Congo). Numbers below branches indicate the percentages obtained using bootstrapping* (1 000 *replicates). Above branches are the number of character changes along branches. Tree length:* 44 *steps. Consistency index:* 0.864. *Populations examined:* (1) *St. Louis (Senegal);* (2) *Hann (Senegal);* (3) *Niayes (Senegal);* (4) *Murry Town (Sierra Leone);* (5) *Ebrie Lagoon (Cote d'Ivoire);* (6) *Lake Ayame (Cote d'Ivoire);* (7) *Abbey Lagoon (Ghana);* (8) *Benya Lagoon (Ghana);* (9) *Fosu Lagoon (Ghana); (10)Amisa Lagoon (Ghana);* (11) *Densu River (Ghana);* (12) *Kpeshi Lagoon (Ghana);* (13) *Keta Lagoon (Ghana);* (14) *Lome Lagoon (Togo);* (15) *Guezin at LakeAheme (Benin);* (16) *Zogbo at Lake Nokoue (Benin);* (17) *Sotchanhoue at Lake Nokoue (Benin); and* (18) *Kouilou (Congo).*

the mouth of the Senegal River. Migration northwards could possibly have been enabled and facilitated through former connections between river basins and coastal lagoons during high flood periods.

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Discussion

Dr. Agnese: What is the minimum distance acceptable to separate two subspecies? The distance between *S.m. heudelotii* and *S.m. nigripinnis* was quite high. What is the level of significance?

Dr: Falk: Of course, this is dependent on the species and populations being studied. Using Nei's genetic distance estimates, we found three genetically well-defined groups within the material we analyzed, and we obtained concordant results by cladistic studies with significant bootstrap support. These results constitute what we can say is a significant genetic difference. Again, the level of significance concerning species, subspecies and populations depends on the species, subspecies and populations under study. There is no general scheme.

Mr. Kwarfo: In your opinion, which of the three subspecies would you recommend as the best for brackishwater culture based on temperature, oxygen, etc.?

Dr. Falk: I am not the best person to answer this, but from studies made in Cote d'lvoire by the team of Dr. Agnese, it seems the subspecies from Senegal might be the best under the conditions used. This question could be better answered by Dr. Agnese.

Dr. Da Costa: The question of what species is the "best" among the others as a culture commodity should be handled carefully, because environmental effects can influence performance. Maybe Dr. Agnese can tell us some of the experience with breeding in Cote d'lvoire.

Dr. Agnese: Results show that fish from the populations from Senegal can grow as fast as 2.5 $g.day^{-1}$ from a weight of about 200 g. This means that within six months you can have a fish weighing about 400 g. As to whether this has a genetic basis, I cannot say.

Mr. Attipoe: For the Senegal strain that you are talking about, what was the stocking density for the fish that attained 2.5 $g.day^{-1}$ growth?

Dr. Agnese: Thirty-one fish per m^3. They use high density to avoid reproduction.

Dr. Teugels: This question is for Dr. Agnese. I would like to know your opinion about the cladistic results. When you look at them, can you conclude that the *heudelotii* population is the more derived and that the Kouilou population from the mouth of the Kouilou is the more primitive one?

Dr. Agnese: Probably the more ancestral population should be in Senegal because this population possesses the most important polymorphisms more than all the other populations. We can consider that when populations move from one point to another, they lose some alleles. There is the hypothesis that the farther a population is away from the center of origin, the less alleles this population will have".

For this species, there seems more polymorphism in the populations in Senegal and Guinea than in the Ivorian populations, but I have not yet read the results thoroughly so perhaps I could change my mind.

Dr. Falk: I am not very happy with this kind of interpretation using heterozygosity because, from my point of view, the proposed hypothesis is not very useful for inferring phylogenies. Anyway, from our study, the most important polymorphisms were found in Ghanaian populations far away from Senegal and Guinea. However, we used a very different approach to trace organismal genealogies within this particular species: a cladistic approach using globin chain characteristics and allozyme data, looking at the distribution of important phylogenetic signals within the material that we analyzed. By rooting our tree with *Tilapia guineensis,* a more ancestral but related tilapiine species, we found a clear sister group relationship between the population from Congo and all other populations investigated: a good indication that the most ancestral population is a Congolese one.

Dr. Pullin: Based on what is known now about the genetic diversity and culture performance of S. *melanotheron,* which genetic resources from that range of diversity need to be kept for the future use of the species? Would everyone not want to grow the S. *m. heudelotii* from Senegal, which might then result in one homogenous farmed strain, escaping and interbreeding with the other populations? These are fundamental questions for conservation and use of genetic resources.

Dr. Abban: The problem of which species or subspecies is the best depends on many issues-where it is grown, the management practices, etc. We don't know how long this high performance of *S.m. heudelotii* in Cote d'Ivoire will last-it may be a fluke. So in the final analysis one has to be very cautious in deciding which species is the best.

Dr. Brummett: I want to support what Dr. Abban said about the "suitability" of a species for aquaculture being dependent on the culture conditions-as culture conditions vary over space or time, different species or subspecies may be found to be the "best".