The Karyotypes of Seven Species of Tilapia
(Teleostei: Cichlidae)

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Tilapia is an ancient and complex genus of cichlid fishes, widely distributed over the African continent. Its economic and scientific importance is comparable with that of Salmo for temperate regions. Karyological studies have much contributed to salmonid systematics (Behnke 1970, Gold 1977). Only two species of Tilapia have been previously karyotyped (Fukuoka and Muramoto 1975, Michele et al. 1977) and a few tentative chromosome counts have been reported (see Michele et al. 1977).

The purpose of this study is to compare the karyotypes of a sample of Tilapia species in order to determine the extent of variation and the usefulness for distinguishing between different taxa.

Materials and methods

Two males and two females from seven species were studied (Table 1). Three species were imported from Zaire: T. sparrmanii (lac Mwadingusha, Shaba), T. congica (Zaire river, Kinshasa) and T. macrochir (Kipopo, Shaba). The other specimens were from the stock of the “Aquarium de l’Université de Liège” and their geographic origin could not be ascertained. The taxonomic identity of the fishes was based on the paper of Thys van den Audenaerde (1968).

Karyotypes were obtained from living specimens. Fin borders were cut off to stimulate mitotic activity. Two to four days later the regenerating fin border was removed, treated for 1 h with distilled water containing 4 γ/ml colchicine and fixed with chilled methanol acetic-acid solution (3/1); further treatment follows Kligerman and Bloom (1977).

Relative chromosome length and centromeric position were used as criteria for chromosome arrangement. “L” designates large double-length chromosomes separated by a size gap from the remaining “F” (fundamental) chromosomes (Chen 1971, Arai and Nagaiwa 1976). Nomenclature for centromeric position, calculated from long arm to short arm ratios (1/s) was adopted from Levan et al. (1964): m (median) for 1/s between 1 and 1.7; sm (submedian) for 1/s between 1.7 and 3; st (subterminal) for 1/s between 3 and 7; t (terminal) for 1/s larger than 7.
Results

The karyotypes of the species under study are given in Figs. 1–7; the results of karyotype analysis are summarised in Table 1.

No difference between male and female karyotypes were noted.

L chromosomes could be paired in all karyotypes; identification of homologues was not possible for F chromosomes.

Five species had 2n=44, one species had 2n=42 and one had 2n=40 (Table 1). This variation could be due to chromosome fusion; indeed, species with 2n=44 had 40 F chromosomes and no large m while *T. sparrmanii* (2n=42) with 36 F chromosomes had one pair large m (L3) and *T. mariae* (2n=40) with 32 F chromosomes had two pairs large m (L3, L4). Hence, one large m corresponds to two F chromosomes.

<table>
<thead>
<tr>
<th>Species</th>
<th>2n</th>
<th>Karyotype formula*</th>
</tr>
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<tbody>
<tr>
<td><em>T. sparrmanii</em> Smith, 1840</td>
<td>42</td>
<td>6L( 4st+2 m)+36F( 6msm+30stt)</td>
</tr>
<tr>
<td><em>T. mariae</em> Bouleguer, 1899</td>
<td>40</td>
<td>8L( 4st+4 m)+32F( 32stt)</td>
</tr>
<tr>
<td><em>T. congica</em> Poll and Thys, 1960</td>
<td>44</td>
<td>4L( 4st )+40F(10msm+30stt)</td>
</tr>
<tr>
<td><em>T. guineensis</em> (Blecker, 1862)</td>
<td>44</td>
<td>4L( 4st )+40F( 8msm+32stt)</td>
</tr>
<tr>
<td><em>T. macrochir</em> Bouleguer, 1912</td>
<td>44</td>
<td>4L(2t+2st )+40F( 6 sm+34stt)</td>
</tr>
<tr>
<td><em>T. andersonii</em> (De Castelnaud, 1866)</td>
<td>44</td>
<td>4L(2t+2st )+40F( 4 sm+36stt)</td>
</tr>
<tr>
<td><em>T. galilaea</em> (Artedi, 1757)</td>
<td>44</td>
<td>4L(2t+2st )+40F( 6 sm+34stt)</td>
</tr>
</tbody>
</table>

*m, sm, st, t indicates respectively median, submedian, subterminal and terminal centromere position. L (large) designates double-length chromosomes and F (fundamental) designates normal sized chromosomes.

L1, the largest pair of the complement, was st and 2.3 to 2.8 times as long as the mean length of the F chromosomes in the karyotypes of *T. sparrmanii*, *T. mariae*, *T. congica* and *T. guineensis*. L1 of *T. macrochir*, *T. andersonii* and *T. galilaea* was t and 3 to 4 times as long as the mean F chromosome. The second pair, L2, was st in all karyotypes and measured 1.5 to 1.8 times the length of the mean F chromosome.

Between F chromosomes differences in length and arm ratio were small and gradual. Separation of sm from st was possible in most karyotypes but in contracted metaphases a slight variation of the number of chromosomes in each group was observed; this was attributed to variation in arm ratio by preparation artefacts or measurement error affecting chromosomes near the borderline between sm and st. Most F chromosomes were stt.

The number of chromosome arms (NF, Matthey 1949) could not be determined objectively as there was no gap between chromosomes with and without “visible” second arms. Several authors consider arbitrarily msm as bi-armed and stt as one-armed; this would give NF=44 for *T. mariae*, NF=48 for *T. macrochir* and *T. andersonii*, NF=50 for *T. sparrmanii* and *T. galilaea*, NF=52 for *T. guineensis* and NF=54 for *T. congica*.

The “New Arm Number”, defined by Arai and Nagaiwa (1976) as the total of
the diploid number and the number of L chromosomes, was 48 for the 7 species studied.

Discussion

The karyotypes of two other species are available for comparison. *T. mossambica*, as reported by Fukuoka and Muramoto (1975) has 2n=44 (18 st + 26 t) and the karyotype shows two large st pairs which correspond to L1 and L2 of the species studied here. In the case of *T. rendalli* Michele et al. (1977) reported 2n=44 (8 sm + 36 acrocentrics) with one acrocentric chromosome pair 3 times larger than the other.

The karyotypes of seven Tilapia species were determined from fin biopsies.
Five species (T. congica, T. guineensis, T. macrochir, T. galiaea and T. andersonii) have 2n=44 comprising two double-length stt pairs and 40 smaller chromosomes, mostly stt. T. mariae has 2n=42 and T. sparrmanii 2n=40 with respectively 1 and 2 double-length in pairs. Differences in arm ratio in the group of smaller chromosomes were also noted between most species.

Acknowledgements

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References


Note added in proof

Kornfield et al. (1979) studied the chromosomes of T. zillii, T. gallilaea and T. aurea, all with 2n=44, with the C-band technique and found C-band positive heterochromatin on the long arms of L1 and on the short arms of some small sm pairs; thus addition or loss of heterochromatin could possibly explain the length variation of L1 as well as part of the differences in arm ratio between the smaller chromosome of the different species.