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RHYTHMS OF ACTIVITY OF SOME LAKE TANGANYIKA CICHLIDS

by

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SUMMARY

The rhythm of activity is actographically recorded in *Haplochromis burtoni*, *Simochromis diagramma*, *S. babaulti*, *Tropheus moorii moorii*, *T. brichardi* and *T. duboisi* (Pisces, Cichlidae). The studied species that occur together in the lake (Lake Tanganyika), have different periods with highest activity. The rhythm of activity can be considered as an important feature for the ecological niche.

1. INTRODUCTION

Simochromis and *Tropheus* (Pisces, Cichlidae) are two closely related genera from Lake Tanganyika. Their ethology (colour patterns, aggressive behavior, spawning, sound production ...) has already been studied (Nelissen, 1975 a and b, 1976, 1977 a, b, c, and d). The species of these genera live in the same habitat : they occur together between rocks at a few meter depth. As far as we know, the only ecological difference can be found between *T. duboisi* and the other *Tropheus* and the *Simochromis* species : the former lives in deeper water (about 10 m) than the latter (about 3 m) (see Poll, 1956 and Marlier, 1959).

As the ecological niche is species-specific, some difference must be found in the ecological features of *Simochromis* and *Tropheus*. Such a difference occurs in their rhythms of activity. Indeed, it was noticed that *Tropheus* and *Simochromis* do not perform certain behavior patterns at the same time of the day, e.g. the former spawns more in the early morning, while the latter spawns during the whole light period.

Therefore, the rhythm of activity was recorded for these two genera. As *Haplochromis burtoni* can be considered to be a representative of the ancestral form from which *Simochromis* and *Tropheus* evolved (Fryer and Iles, 1972), this species was studied too. *H. burtoni* does not live among the above mentioned species : it is found in the reed.

If one wants to record an animal's rhythm of activity, two principals must be kept in mind :

1. only a parameter of activity can be measured, as activity itself is no quantifiable concept; so it is necessary to choose a parameter being really representative for activity.

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2. the method used to measure this parameter must not influence the animal's rhythm of activity nor the parameter itself.

To study the rhythm of activity automatically, an actograph in which these conditions are fulfilled was constructed :

1. the number of locomotions was chosen as a parameter of activity; the more a fish is active, the more it will swim around.

2. the number of displacements was counted by an actograph, consisting of a series of photoelectric control systems that could not influence the fishes.

2. MATERIAL AND METHODS

The studied fishes were kept in an aquarium tank measuring 0.80 × 0.30 × 0.40 m. It was devided in two equal parts by an opaque glass. Each part contained one fish. They could not see each other. The bottom was covered by gravel without aquatic vegetation. Two shelters were provided per animal.

At one long side of the tank eight light sources (emitting mostly infrared and a little red light, to which the fishes did not respond) were placed in two rows : four in an upper one and four in a lower one, so, two times two light sources at each side of the glass partition. The lower light beams passed through the glass and water at a height of 5 cm above the gravel, the upper light beams at 10 cm (see fig. 1). At the other long side of the tank eight photoelectric amplifiers were placed just opposite to the light sources to capture the light beams. The amplifiers were connected to an Everett Edgecumbe recorder. An amplifier operates each time the light beam is crossed by a fish.

In this way it was possible to follow activity of the animals without disturbing them.

The animals were sent directly from Lake Tanganyika to the laboratory, where they were studied within one month after arrival. The individuals that were going to be examined actographically were kept apart from the other.

The fishes were fed with living *Tubifex* and frozen Crustacea. By feeding at very irregular moments that were determined ad random, feeding times could not offer timegivers (*Zeitgeber*, definition see Aschoff, 1954 and 1958).

The aquarium was placed in front of a window and was not lit artificially. By offering different kinds of stimuli (e.g. sounds, vibrations, displacements of an object in front of the tank ...) and by continuously observing the animal's reactions to these, it was noticed that they could be disturbed only by visual stimuli and not by sounds or other stimuli from the laboratory. So the tank was isolated with an opaque curtain. The temperature of the water remained at 27° C. In this way we may assume that only natural daylight could be a timegiver for the rhythm of activity of the fishes.

3. RESULTS

Each day (= 24 hours) with registration of activity, was divided in twelve 2-hr periods (0.00 h-2.00 h, 2.00 h-4.00 h and so on). For each period the number of minutes in which at least one locomotion (i.e. one crossing of a light beam) was recorded, is counted (so only locomotions through a light beam could be counted). This value is considered as the measurement of the parameter of activity.

Some days can show a higher level of activity than others, without changing the rhythm, so without a change of the occurence of peaks. But, days with a higher level of activity carry more weight when the average rhythm is calculated, which is undesirable if such a day accidentally shows an « abnormal » rhythm (e.g. because of one or other disturbance). Therefore, for all days the graphs are normalized to the same level. This is done by expressing the values of one day as percentages of

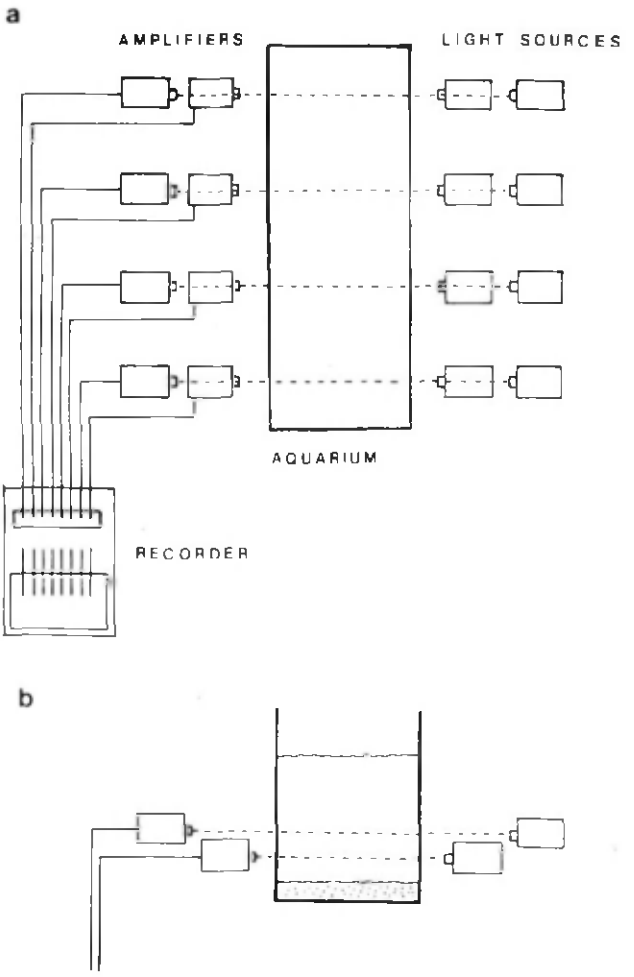

Fig. 1. — Scheme of the actograph, used for automatic registration of the rhythm of activity of cichlid fishes. a. Seen from above. b. Seen in front.

the total sum of values of that day. The average rhythm of activity is drawn per species as an actogram in fig. 2.

To be sure that the rhythms of activity of different individuals in one species did not differ significantly one from another, the concordance of these rhythms is determined. For every individual, the average rhythm was calculated. In these rhythms, the twelve periods of two hours were ranked according to the obtained values of the parameter of activity. These ranks (one rank per individual) were compared one to another for each species with Kendall's coefficient of concordance (Siegel, 1956). This coefficient is given below for all studied species.

The activities were found to peak at one or more times during the day. This is checked with the Friedman two-way analysis of variance (Siegel, 1956). With this test it can be shown that the twelve 2-hr periods do not all have the same values of

the parameter of activity, that means that there is at least one period with a higher or lower value than the other periods. This proves the periodicity of the activity. The χ_r^2 of this test is given below.

In table I the results of the actographical recordings and of the significance tests are summarized. The columns give the following information :

1. (n) Number of individuals that were used for the actographical recordings.
2. (days) Total number of days in which usefull recordings were made. If e.g. on one day the actograph failed to work, this day was not considered. All individuals of each species were studied for about the same time.
3. (rec. period) The period(s) in which recordings were performed, throughout the study.
4. (W) Kendall's coefficient of concordance, calculated for the rankings of the twelve 2-hr periods of the n individuals in each species.
5. (χ^2) The chi-square value that is calculated to interpret W.
6. (level W) The level of significance of W (or χ^2) to reject the null hypothesis (that the individuals in one species do not have the same rhythm of activity). There are always $12 - 1 = 11$ degrees of freedom (as twelve periods of two hours have been ranked).
7. (χ_r^2) Friedman's chi-square to test wether there is a peak in the rhythm, calculated per examined individual.
8. (level χ_r^2) The level of significance of χ_r^2 to reject the null hypothesis (that all 2-hr periods have the same value). There are $12 - 1 = 11$ degrees of freedom.
9. (act. peak) The period with maximal registrated activity.

The rhythms of activity are schematized as actograms on fig. 2.

As there was only one actograph available in which only two fishes at a time could be studied, different species had to be examined successively. So, the species were studied at different times of the year (different conditions of sunrise and sunset). Moreover, for some species the recording period had to be divided in two periods on different times of the year. However, these different conditions in which the rhythm of activity was determined, did not influence the results. When the invariability of the rhythm of activity at different seasons within the species is shown, it is also proved that differences among species are not caused by the different light conditions.

Tropheus moorii moorii was actographically examined at the most dissimilar light conditions (February and July). The rhythms of activity in these two periods are compared one to the other with the aid of the Spearman rank correlation coefficient r_s (Siegel, 1956) : the 2-hr periods are ranked according to their values in the first and in the second period. The coefficient is $r_s = 0.68$ which corresponds with a Student's t-value $t = 296$. This means that with $12 - 2 = 10$ degrees of freedom, there is a chance of $p = 0.001$ that the rhythms do differ in February and July. Also the other species showed no significant differences at different times of the year.

The actograms of fig. 2 make it clear that the rhythms of activity show differences among the studied species. This can also be tested statistically. For each species, the two hour periods are ranked according to the obtained values of the parameter of activity. The concordance of these ranks can be calculated with Kendall's coefficient : $W = 0.09$ which means that there hardly is a concordance.

$\chi^2 = 5.81$, so with 11 degrees of freedom, there is a chance of only 0.10 that the rhythms are concordant, which means that the difference among the species is shown.

4. DISCUSSION

Fig. 3 is a summary of the actograms of fig. 2. The arrows indicate the periods of highest activity of the studied species. It can be seen that these peaks do not

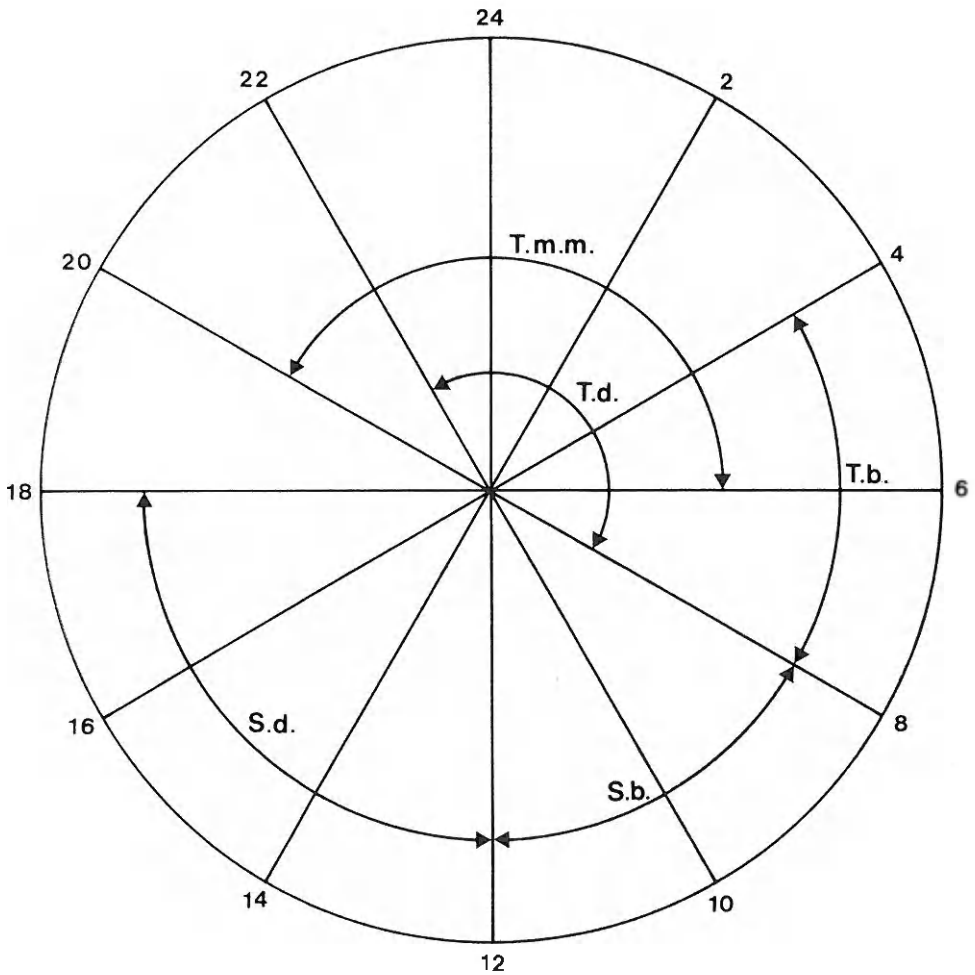

Fig. 3. — Summary of the actograms. The arrows indicate the periods with highest activity for *Simochromis diagramma* (S.d.), *S. babaulti* (S.b.), *Tropheus moorii moorii* (T.m.m.), *T. brichardi* (T.b.) and *T. duboisi* (T.d.).

overlap with the studied species that occur together in the lake. *Haplochromis burtoni* is not mentioned in this scheme as it lives in a very different habitat. *T. m. moorri* and *T. duboisi* do have about the same rhythm of activity, but as mentioned above (1. Introduction), these animals do not occur together in the lake.

As far as we know, both *Simochromis* and *Tropheus* have the same ecological features. For instance, they both feed themselves with the « Aufwuchs » (algae ...) covering the rocks. However competition might be reduced by the different rhythms of activity. In other words, the rhythm of activity seems to be an important element of the ecological niche in the cichlid fishes of Lake Tanganyika.

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