moulting type III, the outer dendritic segments break off below the old hair base, although the dendrites possess a dendritic sheath[15].

Altner and Thies[9] require transitional types between the moulting cycles I and II. For Larink[15] moulting type III mediates between the forms I and II. The sensilla described here may be considered as another transitional type. The elongated outer segments of the dendrites cross the exuvial space freely (that means, without a dendritic sheath) into the old hair shaft. From the electron micrographs it appears that the dendrites are in a functional state. These findings indicate that the sensitivity of the old receptor is maintained during the moulting cycle. Then a protective mechanism against the enzymes of the exuvial fluid must exist. Such a protection can be provided by the surface coat which covers the outer dendritic segments. Thus both requirements for maintaining the sensitivity of the old sensillum are complied with.

On ecdysis, when the old cuticle is shed, the newly formed hair shaft of the sensillum is everted like the invaginated finger of a glove. The outer dendritic segments break off on or in the new shaft. The formation of the short dendritic sheath, which serves here to anchor the outer dendritic segments to wall of the hair shaft, takes place after ecdysis.

1 A. Anderson, Zool. Scr. *4,* 151 (1975).
2 N. Rieder, Zool. Anz. *202,* 317 (1979).
3 G.-W. Guse, Protoplasma, in press (1981).
4 W. Gnatzy, Cell Tissue Res. *187,* 1 (1978).
5 D.J. Harris, Zoomorphologie *88,* 37 (1977).
6 J. Haupt and Y. Coineau, Cell Tissue Res. *186,* 63 (1978).
7 Y. Crouau, C.r. Acad. Sci. Paris *287,* 1215 (1978).
8 G.-W. Guse, Protoplasma *95,* 145 (1978).
9 H. Altner and G. Thies, Z. Zellforsch. *129,* 196 (1972).
10 W.M. Blaney, R.F. Chapman and A.G. Cook, Z. Zellforsch. *121,* 48 (1971).
11 K. Schmidt and W. Gnatzy, Z. Zellforsch. *122,* 210 (1971).
12 W. Gnatzy and K. Schmidt, Z. Zellforsch. *126,* 223 (1972).
13 W. Gnatzy and K. Schmidt, J. Microsc. *14,* 75 (1972).
14 W. Gnatzy and J. Tautz, Physiol. Ent. *2,* 279 (1977).
15 O. Larink, Zool. Jb. Anat. *95,* 252 (1976).

# Influence of chemical signals on the topographic orientation of the cave fish *Caecobarbus geertsi* Boulenger (Pisces, Cyprinidae)[1]

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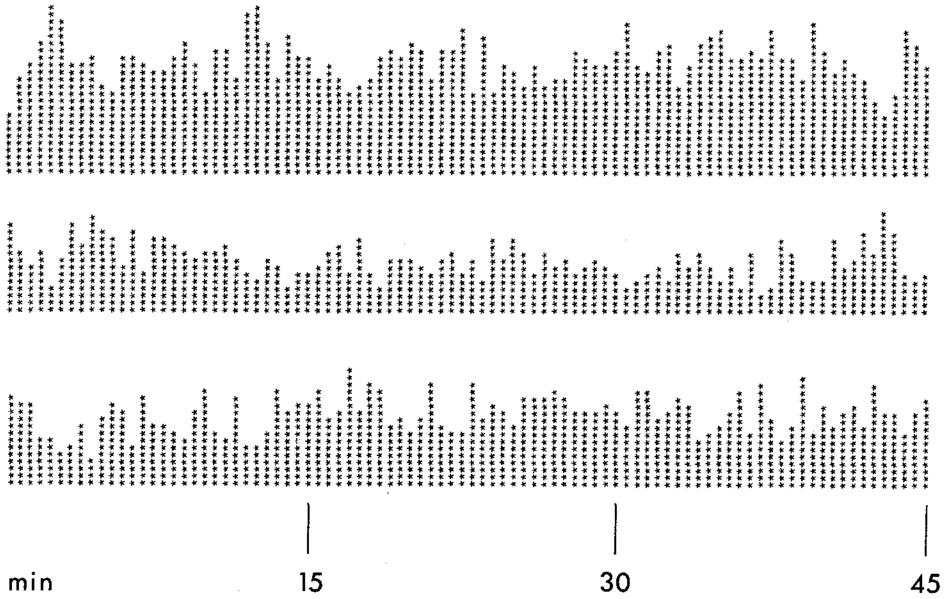
*Summary.* Adult individuals of the cave cyprinid *Caecobarbus geertsi* Boulenger, when placed in a choice-apparatus, show a significant tendency to orient towards the zone in which water from a tank occupied by known conspecifics is introduced. The phenomenon is briefly discussed in relation to the physical features of the subterranean biotopes.

Due to the permanent darkness of subterranean biotopes and the phyletic degeneration of the eye, blind cave animals can only rely on 2 types of sensory cues, viz. mechanical and chemical ones. However, as previous studies indicate, chemical cues seem to play a more important role in the behaviour of cave vertebrates than mechanical ones do. Thus, comparative studies on the cave fishes *Astyanax (=Anoptichthys) jordani* Hubbs & Innes and *Caecobarbus geertsi* Boulenger showed that in both forms chemical stimulation is determinant in eliciting the feeding behaviour pattern characterized by a sudden diving response towards the bottom of the aquarium, followed by a continuous active exploration of the substrate[2]. Mechanical stimulation, on the contrary, seems to play only a secondary role: juvenile individuals of *Astyanax jordani* are unable to seize moving prey *(Cyclops)* except when they happen to collide with it while swimming[3]. Moreover, the topographical orientation of the cave urodele *Proteus anguinus* Laurenti is determined by chemical markings on the substrate[4]. More recently, it has been shown that chemical information from conspecifics is effective in orienting the locomotor responses of the blind cave cyprinid *Phreatichthys andruzzii* Vinciguerra. If pure water or water from tanks containing 13–14 known or unknown individuals of this species is introduced randomly into either of the end chambers of a choice apparatus, the water volume introduced being 500 ml in all cases, the test individuals orient significantly towards the treated chamber[5]. The aim of the present study was to investigate whether similar responses to conspecific odour could be shown in the blind cave cyprinid *Caecobarbus geertsi.*

*Material and method.* 9 adult individuals of *Caecobarbus geertsi* were collected in the lower Congo cave system in July 1976. During the 60 days prior to the experiments and during the experiments themselves (March 1979), they were placed together in a tank as a single group. Using the same method as in the previous experiments on *Phreatichthys,* the presence of the test-fishes in one of the 3 chambers of a choice-apparatus trough: 180 × 20 × 8 cm; water level: 8 cm was noted individually every 30 sec for 45 min. Each test-fish was transferred from the group-tank and placed in the

Statistical analysis of results obtained in choice-experiments on *Caecobarbus geertsi* (35 experiments)

| Intervals of analysis (min) | Experiments Positive | Neutral | Negative | $\chi^2$ | Significance |
|---|---|---|---|---|---|
| 0′–45 | 27 | 0 | 8 | 10.31 | $0.001 < p < 0.01$ |
| 0′–15′ | 28 | 2 | 5 | 16.03 | $p < 0.001$ |
| 15′–30′ | 24 | 1 | 10 | 5.76 | $0.01 < p < 0.02$ |
| 30′–45′ | 23 | 1 | 11 | 4.23 | $0.02 < p < 0.05$ |
| 0′– 3′ | 20 | 5 | 10 | 3.33 | $0.05 < p$ (n.s.) |
| 3′– 6′ | 18 | 11 | 6 | 6.00 | $0.01 < p < 0.02$ |
| 6′– 9′ | 20 | 7 | 8 | 5.14 | $0.02 < p < 0.05$ |
| 9′–12′ | 20 | 6 | 9 | 4.17 | $0.02 < p < 0.05$ |
| 12′–15′ | 21 | 4 | 10 | 3.90 | $0.02 < p < 0.05$ |



Absolute frequencies of presence of test-fishes in the 3 chambers of the experimental trough. Upper row: end chamber containing chemical information from conspecifics. Central row: central chamber. Lower row: end chamber devoid of chemical information from conspecifics. Abscissa: total observation time (45 min: 90 counts). Each point in ordinate corresponds to a single count (total per column: 35 points).

central chamber of the apparatus where it could adapt for 4 h before the observations started. 500 ml of tank water were then introduced into one of the end chambers, the other one receiving an equivalent volume of pure water from a reserve. The walls between the 3 chambers were then removed so that the test-fish could move from the central chamber towards either of the extreme ones. The number of fishes available being small, the 9 individuals had to be tested four times each in a total of 35 experiments. In four successive experiments on the same individual, the experiments were separated by a time-interval of 4 to 12 days, in order to reduce as much as possible the effects of one test on the next. The group aquarium, the water reserve and the choice-apparatus were all kept in a single room in which a constant temperature of 28 °C was maintained. The room was dimly illuminated by red bulbs placed centrally above the troughs in order to ensure the same illumination in both of the end chambers. The fishes were fed at intervals of 1 to 5 days, not however during the 24 h prior to the experiments. The complete consumption of food was checked in all cases.

*Results and discussion.* The overall results are given in the figure in terms of absolute frequencies of presence of the test-fishes in the three chambers of the choice-apparatus respectively. The observed frequencies for the chamber containing water from the group-tank (upper row) are higher than those observed for the two other chambers throughout the whole series of experiments and testify to a definite preference of the fishes for the zone of the apparatus in which the odour of conspecifics was present as against the zone where pure water from the reserve was introduced (lower row). The central row expresses the observed frequencies of presence of the fishes in the central chamber, i.e. either nonoriented locomotion or passages from one end chamber to the other. The latter data cannot be compared to those obtained for the end chambers, first because this chamber not being limited longitudinally was geometrically different from the two other ones and secondly, because, being the adaptation area of the test-fishes, it was better known to them than the end ones when they had to make their choice. For these reasons, the data collected in the central chamber were left out of the statistical analysis.

Each individual experiment was rated positive, neutral or negative according to whether, in its total duration (45 min, 90 counts), the number of counts for the end chamber containing chemical information from conspecifics was 'higher than', 'equal to' or 'lower than' the number of counts for the opposite end chamber. The $\chi^2$ 1-sample test[6] was applied to evaluate the difference between the positive and the negative value. The evolution of the response in time has been analyzed in the same fashion over 3 periods of 15 min, the 1st period being itself divided into 5 sub-periods of 3 min each. Results are given in the table.

Considering the total 45 min observation period, the fishes show an evident locomotor polarisation towards the chamber containing chemical information, the difference between the positive and the negative value being highly significant. The analysis of the evolution of the locomotor orientation in time shows that this difference is maximal during the 1st 15 min and gradually decreases during the 2 following sub-periods, though still remaining significant. This decrease may be ascribed either to a habituation to the stimuli or to a progressively more intensive exploratory behaviour in various directions. A similar decrease is observed within the 1st 15 min period, from the 2nd to the 5th sub-period of 3 min. The fact that the difference between the positive and the negative value is not significant during the 1st 3 min indicates, at first sight, that the locomotor responses towards the treated zone are properly oriented only after a certain latency time, however small.

These results suggest the existence in *Caecobarbus geertsi* of a topographical orientation mechanism governed, at least in part, by chemical information from the zones of the biotope normally occupied by conspecifics. The biological significance of such an attraction effect by the chemical stimuli present in our experimental setup remains unexplained. However, since a comparable effect is found in the cave cyprinid *Phreatichthys andruzzii*, it must have some definite specific function within the subterranean ecological system.

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[2] G. Thinès and N. Wissocq, Int. J. Speleol. *4,* 139 (1972).

[3] K.H. Lüling, Zool. Jb. *65,* 9 (1954).

[4] J. Parzefall, Z. Tierpsychol. *42,* 29 (1976).

[5] R. Berti, G. Thinès and B. Lefèvre, Int. J. Speleol., in press (1981).

[6] S. Siegel, Kogakusha Co. Ltd., Tokyo 1956.