The larval electric organ of the weakly electric fish *Pollimyrus (Marcusenius) isidori* (Mormyridae, Teleostei)

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Summary

The larval electric organ of *Pollimyrus isidori* consists of four longitudinal tubes, a dorsal and a ventral pair, which begin behind the skull, end at the beginning of the caudal peduncle and show myotomic segmentation. The elementary units are, apparently, transformed muscle fibres called electrocytes. They are shorter and thicker than muscle fibres, with long stalks and are found in the medial part of the deep lateral muscle. Electron microscopy reveals a clear difference between the anterior and posterior face of the electrocyte. Anteriorly, deep linear invaginations of the surface membrane together with many small vesicles of about 100 nm diameter can be seen. Posteriorly, many plasma membrane invaginations and vacuoles are found together with numerous cytoplasmic organelles — pleiomorphic nuclei, Golgi apparatus, oblong mitochondria and multivesicular bodies. The stalk originates at the posterior face and the nerve terminals are situated at the distal end of the stalk. In the electrocyte, myofibrils, similar to those found in muscle fibres, can be detected with clearly visible Z lines but with only a suggestion of H zones. Two bundles of myofibrils can be seen arranged orthogonally in the electrocyte. Strong acetylcholinesterase activity was found on the anterior face and on the innervated stalk. Under the given recording conditions the overall discharge amplitude of the larval electric organ reaches a maximum of about 100 mV peak to peak. The pulse duration is 1 millisecond and the main phase is head-positive.

Introduction

Myofibrils have been found in the electrocytes of adult mormyrids: this observation has led several authors (Ogneff, 1898; Schlichter, 1906; Dahlgren, 1910) to the conclusion that these cells develop from muscle tissue. Szabo (1957b) found parts of the deep lateral muscle, rostral to the adult organ of *Gnathonemus*, replaced by

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connective tissue and concluded that the electric organ had developed from this part of the lateral muscle. Ontogenetic information about the origin of the electric organ of mormyrids is incomplete because of the difficulty of obtaining larvae from the field. Preliminary results based on sparse material (Szabo, 1960, 1961a) indicate that the electrocytes develop from the transformation of muscle fibres.

The recent identification of the environmental factors leading to gonad maturation and spawning in these fish (Kirschbaum, 1975) made a developmental study of Pollimyrus isidori possible. Both the ontogeny of the electric organ and the development of the electric organ discharge (EOD) were followed in detail. The development of the EOD has shown that in young larvae a characteristic larval EOD first appears (Kirschbaum and Westby, 1975; Westby and Kirschbaum, 1977a) which is followed later by the adult discharge of opposite polarity. Spinal cord sections, electric field measurements, and micro-injections of curare (Westby and Kirschbaum, 1977b) together with an ontogenetic study of the adult electric organ (Kirschbaum, in preparation) have shown definitely that the larval discharge arises from a larval electric organ situated in the deep lateral muscle. This organ could be identified histologically as consisting of transformed muscle fibres (Kirschbaum, 1977). The larval electric organ and the adult electric organ—the well-known electric organ of mormyrids—are apparently homologous structures, of which the larval organ is the more primitive one. This is the first example of two distinct evolutionary steps in the development of electric organs existing simultaneously in the same species. In skates different evolutionary steps could also be found (Ewart, 1892; Engelmann, 1894) but they exist in different but related species. In this paper we describe the anatomy of the larval electric organ of Pollimyrus isidori and the cytology of the larval electrocytes. This should constitute a basis for the comparison of the ultrastructure of the larval electrocyte of Pollimyrus and that of the electrocytes of other electric fish already described (Luft, 1956, 1957, 1958; Mathewson et al., 1958, 1961; Wachtel et al., 1961; Bruns, 1971; Waxman et al., 1972; Schwartz et al., 1975; Machado et al., 1976). These investigations together with ontogenetic studies concerning both the larval and the adult electric organ of Pollimyrus (Kirschbaum, in preparation) will, we hope, enable us to understand how the highly specialized electrocytes of mormyrids have evolved from the more primitive electrocytes of the larval electric organ.

Material and methods

The larvae of the mormyrid fish Pollimyrus isidori, formerly Marcusenius isidori (Taverne, 1971) we used in this study came from different spawnings which had taken place over a period of more than 2 years in our laboratory (Kirschbaum, in preparation). These larvae were raised and some of them reached maturity after about 1 year.

The histological investigations were done with Bouin-fixed and paraffin-embedded material. The whole fishes were serially sectioned, 7 μm thick, either transversely or sagittally, and then stained with Azan stain (Heidenhain). Paramedian cryostat sections (16 μm) of fresh larvae were used in order to study acetylcholinesterase (AChE) activity. AChE activity of the sections was