On The Organization of the Telencephalon in Elasmobranchs

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I. Introduction

The interest in brain organization of elasmobranchs relates to the evolutionary history of the group. The best paleontological information suggests an origin in the early Devonian period, some 400 million years ago, or 250 million years before the African and American continents separated. The sharks evolved rapidly in Devonian times and continued their expansion through the Carboniferous and Permian periods. The available data suggest that the group was successful early and that relatively few selective pressures for structural modification have taken place since those early days.

Contrary to common belief only 10 years ago, recent studies have shown that brain organization in sharks is much more “advanced” in terms of connections than hitherto believed, that the brain size–body weight ratio in some sharks exceeds those of other anamniotes, and that some sharks are capable of learning complex visual discriminations rapidly (see Chapter 2 in this volume). These and other findings have revealed our ignorance about brain organizations of elasmobranchs and have provided new insights into brain evolution. Perhaps the most important recent revision of thought relates to the organization and functional role of the forebrain. Whereas the telencephalon has traditionally been considered an “olfactory lobe,” recent experiments indicate an organization comparable to that of other vertebrates, including mammals.

This is a brief overview of telencephalic organization as we see it 12 years after the new neuroanatomical methods of Nauta (1957) were first applied to shark
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brains (Ebbesson, 1967; for an excellent review of brain organization as it was understood in 1963, see Aronson, 1963). These techniques allowed the first accurate tracing of neuronal pathways and involve the selective silver impregnation of degenerating axons and their terminals (Ebbesson, 1970).

II. Organization of Elasmobranchs

The cartilaginous fishes (class Chondrichthyes) are composed of two major groups, the Holocephali and the Elasmobranchii. The latter group is by far the larger and comprises the sharks, rays, and skates. Table I indicates the organization of the class and shows which groups have been studied in terms of their brain structure (from Northcutt, 1977).

III. Brain Weight–Body Weight Ratio

Brains of elasmobranchs are, on the whole, relatively large compared to brains of other nonmammalian forms. Brain weight–body weight ratios are in some cases comparable to those of birds and mammals (Ebbesson and Northcutt, 1976; Northcutt, 1977). The relatively large telencephalon in elasmobranchs is also noteworthy. The mammalian and the osteichthyan data presented in Fig. 1 have been taken from Jerison (1973), and the stippled polygon encloses the elasmobranch brain–body data reported by Ebbesson and Northcutt (1976) and Northcutt (1977), as

Figure 1. Brain and body weights for four vertebrate classes expressed as minimum convex polygons after Jerison (1973). Stippled polygon encloses elasmobranch brain–body ratios and overlaps polygons for bony fishes, birds, and mammals. From Ebbesson and Northcutt (1976), Northcutt (1977), and data recently collected by the author.