# Morpho-anatomy of the otic region in Carapidae – Eco-morphological study of their otoliths

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## Introduction

The major roles associated with the otoliths of the inner ear in teleosts are sound transduction and participation in maintaining static and dynamic equilibrium. These inner ear functions result in otolith shapes known to be species-specific. However, the litterature reports examples of convergence in otolith shape among unrelated teleost families sharing similar ecological niches during their life span. Two aims : ➤**1** A set of structures (Fig.1) are associated with sound production. The carapid inner ears might be expected to show special features. ➤ **2** Four habitats and lifestyles can be distinguished among Carapidae species. *Pyramodon* and *Snyderidia* species are pelagic, *Echiodon* species are benthic. *Carapus* and *Encheliophis* can penetrate inside various invertebrates. *Carapus* is commensal, which necessarily implies moving outside the host to obtain food. *Encheliophis* is parasitic and sojourn longer inside its host. Life in these different habitats could require different sound perception, equilibration, and swimming capacities. An ecomorphological approach might show that the shape of the otoliths is not merely a compromise between the different functions in which they participate, but also a reflection of the influence of environmental factors.

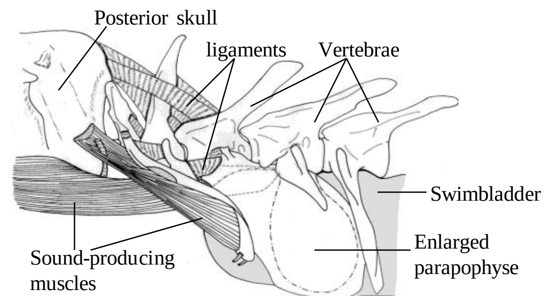


**Fig. 1** - Lateral view of the otophysic structures in *Carapus boraborensis*

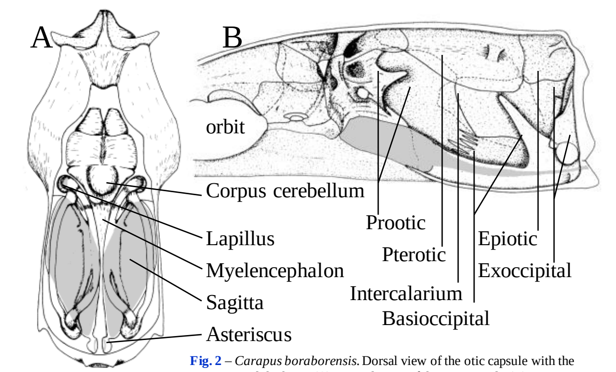


**Fig. 2** – *Carapus boraborensis.* Dorsal view of the otic capsule with the inner ear and the brain (A). Lateral view of the otic capsule (B)

## Results and Discussion

➤**Part 1.** The otic capsule is very wide and completely occupied by the membranous labyrinths (Fig.2). Only the myelencephalon crosses the otic cavity. The left and right sacculi and lagenae touch each other posteriorly. In most non-otophysine teleosts, the two membranous labyrinths are clearly separated by the metencephalon and myelencephalon. The very voluminous sagitta of Carapidae species might be linked to a special aptitude to perceive sound. This aptitude may have developed in these fish in parallel with the otophysical structures assumed to produce sounds (Fig. 1). *Encheliophis* and *Carapus*, which possess the thickest otoliths, are also the species in which the third rib pair is the most developed.

| Species | n | otolith length/ otolith thickness | n | Otolith lenght/ otolith width |
|---|---|---|---|---|
| *Encheliophis gracilis* | 4 | 34 (±1,7)% | 3 | 51 (±0,5%) |
| *Carapus boraborensis* | 10 | 25,4 (± 2)% | 8 | 44 (±3,8)% |
| *Echiodon drummondi* | 2 | 22,5% | 2 | 43,2 % |
| *Pyramodon punctatus* | 1 | 16% | 1 | 43,2% |
| *Snyderidia canina* | 1 | 16% | 1 | 42% |

**Table1.** - Relative thickness and width of the sagittae in different Carapidae.

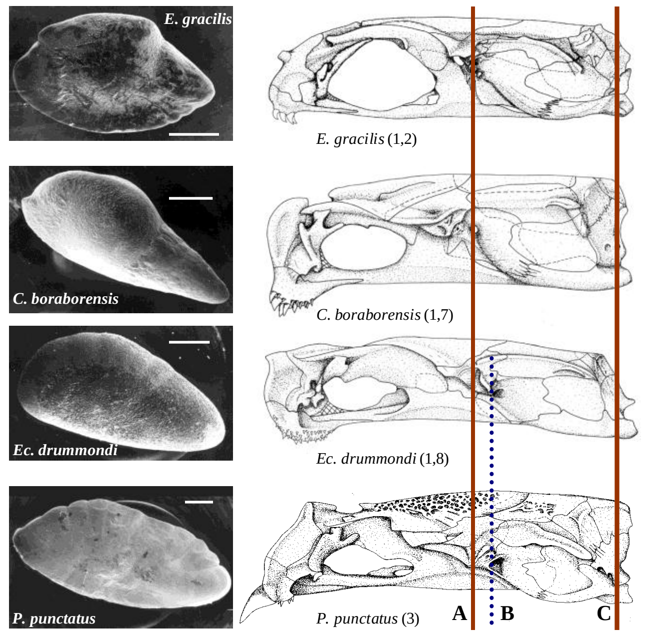


**Fig. 3** - Distal view of the sagitta and laterla view of the neurocranium of different Carapidae. (#) = real lenght of the neurocranium (cm), scale bar of the otolith = 1mm.

➤**Part 2.** In Carapidae, the variations observed concern the relative sizes of the components. The adjustment of the various species neurocrania adjusted proportionately to a same length enables evaluation of the relative sizes of the otic capsules Lines A and B limit the otic cavity in front. Line C provides a posterior limit of the cavity (Fig.3). Table 1 gives the ratio of the thickness of the sagitta (Fig.3) to its length measured along the antero-posterior axis. A combinaison of these date clearly shows that the largest otic cavities with the thickest otolith are found in the parasitic and commensal species, both with lesser mobility. *S. canina* and *P. punctatus* have the thinnest otoliths in the shortest otic cavities and live in open water. *Echiodon* possess an intermediate situation.

Like all functional structures in an organism, the otic capsule and stato-acoustic system must have a shape and organisation that represent a compromise between different needs and functions (swimming, hearing, equilibration, etc.) On the other hand, there is the influence of ecological niches in the construction of an organism. Several factors may explain this relationship between the inner ear and the ecological niche: (1) the shape of the sagitta in pelagic species could be an element contributing to making the neurocranium lighter, thus reducing energy expenditure during swimming.

(2) The inertia of commensal and parasitic Carapidae sagittae should be greater, with respect to the movements of the cranium. This difference in inertia might lead to more efficient perception for the commensal and parasitic species than for the pelagic and benthic species. These various adaptations could prove useful to species that must perceive sounds through the body of a host. The benthic species *Ec. drummondi* with an intermediate situation might be capable of hiding in crevices or burying itself in the substrate like as it is the case for other Ophidiiforms

## Conclusion

Although no sound recording has been done with the Carapidae, there appears in these fish a relationship between the auditory structures and some of those believed to produce sounds. The largest otic cavity, the widest sacculus and sagitta surrounded by the thinnest bones, are found in the species with the most developed parapophyses. These structures, both auditory and otophysical, are most developed in species that are not completely free-swimming, i.e., with a commensal or especially a parasitic lifestyle.