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On Aberrant Sagittas of Teleostean Fishes

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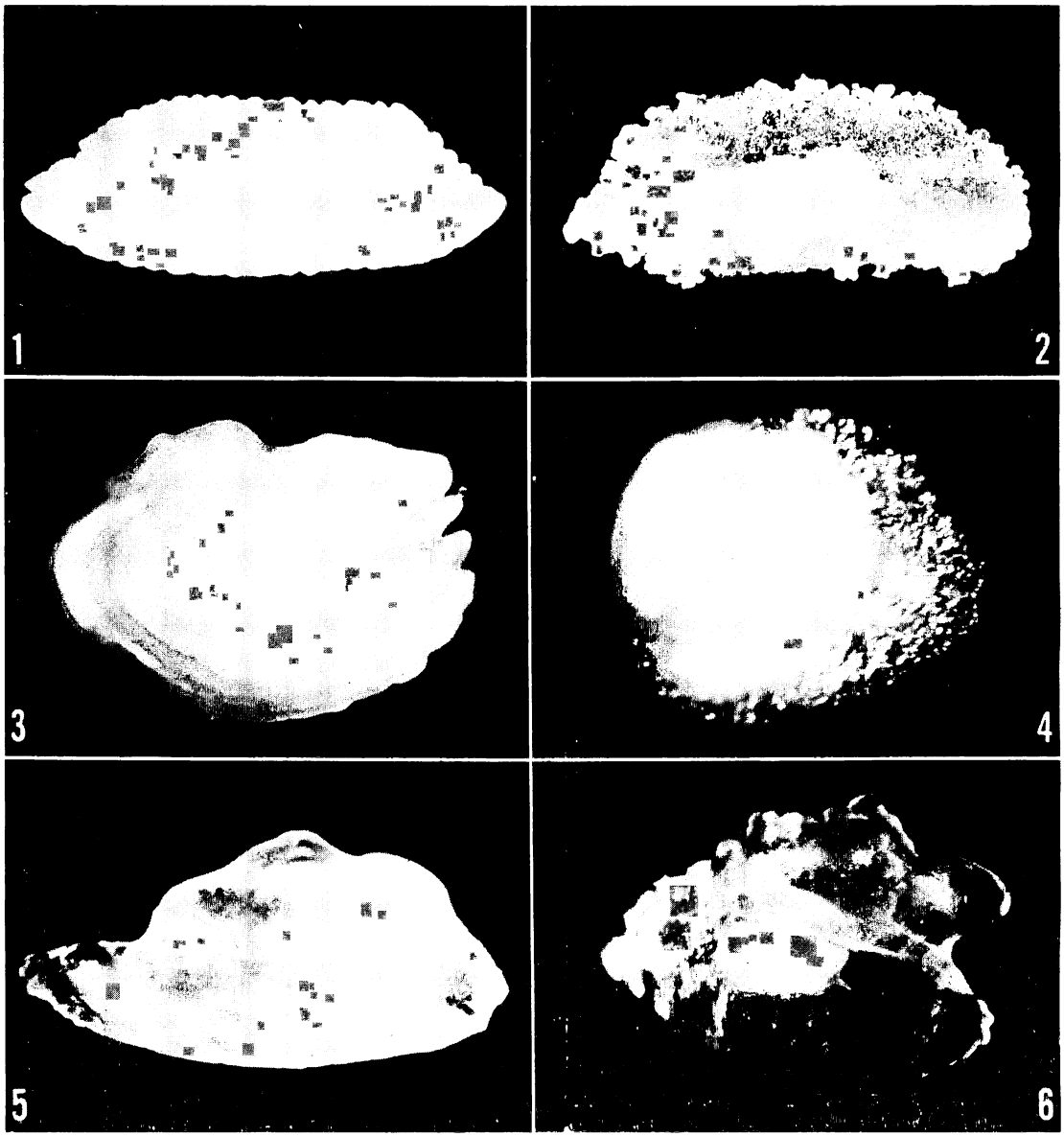
Abstract Aberrant sagittas of *Theragra chalcogramma*, *Cleisthenes pinetorum herzensteini*, and *Salmo gairdnerii irideus* are described. They are made up of abnormal portion where crystalline blocks of various sizes are piled up irregularly. The aberrant sagittas were found in either of the left or right sacculi, and in most cases those of the other side were normal.

During the course of studies on the otolith formation in fishes, the author happened to find sagittas of an unusual type in the walleye pollock *Theragra chalcogramma* (Pallas), a flatfish *Cleisthenes pinetorum herzensteini* (Schmidt), and the rainbow trout *Salmo gairdnerii irideus* Gibbons. Generally, otoliths of this unusual type are externally characterized by rugged surfaces in a hyaline appearance as described below in detail. The elaborate investigation of the otoliths is expected to afford suggestive information on elucidating the mechanism whereby normal ones are formed. So far as the author knows, however, there has been no record on the finding of such a kind of sagittas in fishes, though the hereditary absence of otoliths is the case with pallid mice (Lyon, 1951). This short report deals with a description of external features of those aberrant otoliths. Chemical and crystallographic aspects of the otoliths will be published elsewhere.

Theragra chalcogramma (Figs. 1 and 2): Two otoliths presented here were obtained from both sacculi of one individual caught off Kushiro, Hokkaido. One of them is a normal otolith, and the other is an aberrant one found in the left sacculus. Compared with the former, the latter shows a very rugged surface on both inner and outer sides: crystalline blocks of various sizes are piled up irregularly. Each block is hyaline and easily breakable from the otolith. When decalcified with 0.3 M disodium ethylenediaminetetraacetate (pH 7.4) or weak acids, the block disappeared leaving a diminished volume of the organic matrix or, on rare occasions, leaving no matrix appreciable behind, though a normal otolith treated identically as a control retained its original size and form in the matrix. No alternate pattern of translucent and opaque zones is recognizable on the rugged surface. Even in the aberrant otolith, there is a milky patch of normal development on its central area, which was undoubtedly formed in the early life of the fish. The contour of the patch, however, does not so closely follow that of the otolith itself. Besides the otolith presented here, four other otoliths belonging to the unusual type have been found among numerous pollock otoliths examined. All of them show much the same appearance as the specimen mentioned above, but the rugged crystalline portion is limited to anterodorsal and anteroventral margins of the otoliths. Of them, two specimens were obtained from both sacculi of one individual and the others were obtained from left sacculi of two individuals.

Cleisthenes pinetorum herzensteini (Figs. 3 and 4): Otoliths in these figures were obtained from the left (blind side) and the right (eyed side) sacculi, respectively, of one individual caught at Hakodate Bay. The otolith in question shows much the same abnormality in appearance as in the case of the pollock: the pile of hyaline crystalline blocks and the subsequent formation of the rugged surface

portion, which is limited to anterodorsal and anteroventral margins of the otolith. Translucent and opaque zones are clearly seen on the outer surface of both otoliths, but the rugged portion shows no such zones even in the ground preparation. The ratio of the anteroposterior to dorsoventral diameter is smaller in the deformed otolith than in the normal one. Thus the rounder shape is regarded as another feature of the aberrant



Figs. 1 and 2. Lateral view of otoliths obtained from a specimen of *Theragra chalcogramma*. 1. A normal otolith contained in the right sacculus. 2. An aberrant otolith in the left sacculus.
Figs. 3 and 4. Lateral view of otoliths obtained from a specimen of *Cleisthenes pinetorum herzensteini*. 3. A normal otolith in the left sacculus. 4. An aberrant otolith in the right sacculus.
Figs. 5 and 6. Otoliths obtained from a specimen of *Salmo gairdnerii irideus*. 5. Lateral view of a normal otolith in the left sacculus. 6. Median view of an aberrant otolith in the right sacculus.

otolith in the flatfish.

Salmo gairdnerii irideus (Figs. 5 and 6): In the case of the rainbow trout, otoliths of the unusual type were occasionally found in both sacculi or only in one of them. Two otoliths presented here were obtained from one individual purchased from a commercial dealer of Nanae, Hakodate. The aberrant otolith found in the right sacculus was milky or opaque only in the area near the center of its outer surface, but this portion somewhat differs in nature from the opaque central area of otoliths of the similar kind in the pollock and the flatfish: in the rainbow trout the central area has a globular protuberance, which is easily distinguished by its size from the so-called nucleus on the outer surface of a normal otolith. The nucleus is too small in size to be noticed unless carefully observed, and is often embedded within the otolith. The presence of such a protuberance on the outer surface is one of the external features in the aberrant otolith of the trout. Next, the otolith is rugged on both inner and outer surfaces, but is so hyaline as a whole that the protuberance is clearly visible from the inner surface. Another characteristic of the otolith is, as in the case of the flatfish, that its dorsoventral diameter is somewhat larger than that of the normal otolith obtained from the left sacculus of the same individual. All these characteristics are more or less present in other aberrant otoliths of the rainbow trout, though no photograph is presented here.

Although the sagitta of fishes is held morphologically over the cell region of the acoustic sensory macula by a tendinous attachment to the inner wall of a sacculus, we have as yet little available information as to what is involved in the mechanism of otolith formation. Concerning the cause of occurrence of otoliths in question, therefore, the author is unable to discuss in detail here. Since the otoliths found in the present three species, however, showed almost similar characteristics of abnormality, the mechanism whereby the hyaline rugged part develops seems not to be so different among these species.

In the process of otolith formation, two stages are discriminated, though these may almost simultaneously occur as a matter of fact: (1) an initial phase characterized by the formation of the organic matrix, otolin (Degens et al., 1969); (2) a phase of mineralization characterized by the deposition of calcium as carbonate on the matrix, which presumably plays an essential role in the initiation and orientation of the growth of crystals. The normal development of an otolith is under the controlled balance between the two phases. If the balance is disturbed by still unknown factors at a certain time of life, thereafter the otolith will irreversibly continue to grow in an unusual fashion, resulting in the occurrence of an abnormal otolith. An impediment in the matrix formation at a cellular or a successive extracellular level may damage an intimate structural interrelationship between the organic and inorganic phases, and thereby crystals may grow with less controlled orientation to the irregular pile of the hyaline blocks. This view does not conflict with the result of the aforementioned observation on decalcification of the crystalline blocks. If so, the author is unable to say here what is the causative agency for such an impediment.

Mineralogically, teleostean otoliths have been proved to be consisted of calcium carbonate in an aragonite form (Carlström, 1963). X-ray diffractograms of aberrant otoliths collected from the rainbow trout, however, revealed that three polymorphs of the carbonate are encountered: a mixture of aragonite and vaterite in the central protuberant area and predominating vaterite with a trace of calcite in the rest, though a unique pattern of aragonite-vaterite mixture also was unexpectedly recorded in the control otolith of a normal type, at least, in the trout (unpublished data). Thus aberrant otoliths of fishes have an interesting bearing on researches for the polymorphic formation of calcium carbonate.

Literature cited

Carlström, D. 1963. A crystallographic study of vertebrate otoliths. Biol. Bull., 125: 441–463.

Degens, E. T., W. G. Deuser, and R. L. Haedrich. 1969. Molecular structure and composition of fish otoliths. Mar. Biol., 2: 105–113.

Lyon, M. F. 1951. Hereditary absence of otoliths in the house mouse. J. Physiol., 114: 410–418.

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真骨魚類の異常耳石について　　**麦谷 泰雄**

スケトウダラ，ソウハチおよびニジマスの小嚢より得られた異常な耳石について，おもにその外観的特徴を記載した．これらの耳石はいずれも透明な結晶塊の不規則な集積よりなる異常部分を有する点で共通し，このような部分では輪紋構造は認められない．

なお異常耳石は1個体の左右いずれか一方の小嚢にのみ出現する場合が多いが，左右両小嚢より共に異常な耳石が発見される場合もあった．

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