BEAUFORTIA

SERIES OF MISCELLANEOUS PUBLICATIONS

ZOOLOGICAL MUSEUM - AMSTERDAM

No. 42 Volume 5 February 23, 1955

Plecospondylic spinal column in the viviparous Cyprinodont *Lebistes reticulatus* (Peters)*

by

A. STOLK

(Histological Laboratory, Free University, Amsterdam)

INTRODUCTION.

Deformities of the spinal column do not only occur in man and mammals but also in fishes. These deformities may be classed in the following groups:

1. Lordosis: a ventrodorsal curvature of the spinal column, in which a segment of the spinal column bends upwards with its convexity ventrally. This relatively rare deformity is usually found as a secondary phenomenon to an enlargement of the body cavity, which may be due to several causes.
2. Kyphosis: a ventrodorsal curvature of the spinal column, in which a segment of the spinal column bends downwards with its convexity dorsally.
3. Scoliosis: a lateral curvature of the spinal column, in which a segment of the spinal column bends with its convexity to the left or to the right side. This lateral bending of the spinal column is accompanied by a twist of the vertebral bodies. It appears that the vertebral bodies are always twisted towards the convexity of the curvature. Consequently the spinous processes are directed towards the concavity.
4. Kyphoscoliosis: combination of a kyphosis and a scoliosis. The kyphosis is accompanied by a compensatory scoliosis.
5. Kypholordosis: combination of a kyphosis and a lordosis. The kyphosis is accompanied by a compensatory lordosis.
6. Plecospondylic spinal column: several consecutive lateral curvatures of the spinal column. Consequently, the body of the fish has a wave-like appearance.

Lordosis in fishes has been described by ROTH (1922) in a bitterling (*Rhodeus amarus* BLOCH), a young minnow (*Phoxinus phoxinus* (LINNÉ)), and a pike (*Esox lucius* L.). In the bitterling the lordosis appeared to have been caused by a highly developed tumour of the ovary, in the

*) Received August 1953.

minnow by a large intestinal parasite and in the pike by an inflammatory process, followed by the coalescence of two vertebrae. The lordosis in the minnow is clearly shown to have been a secondary deformity, as, on removal of the intestinal parasite, the lordosis disappeared entirely after some weeks.

PLEHN (1924) reported lordosis in a pike (*Esox lucius* L.), which, as her figure indicates, resembles the case described by ROTH.

Brief mention of kyphosis of the spinal column in toothcarps (*Cyprinodonts)* was made by ROTH. In fishes with a kyphosis the ventral body wall appeared to be flattened, and, in extreme cases, even somewhat concave; in the latter the fishes seemed to be in a very reduced state of growth. According to ROTH (1922) the kyphosis is occasionally observed in several specimens from the same stock; for this reason it has sometimes been considered to be a symptom of degeneration resulting from inbreeding.

Scoliosis was relatively often met with in the carp *(Cyprinus carpio* L.) and therefore most extensively studied in this species (HOFER, 1904; ROTH, 1922; PLEHN, 1924). The greater part of cases of scoliosis appeared not to be pure. Usually the deformity was found combined with kyphosis. In this kyphoscoliosis, which relatively often occurred in toothcarps *(Cyprinodonts)* according to ROTH (1922), the curvature almost without exception was localized in the transitional area between trunk and tail. However, HOFER found the curvature of the spinal column directly behind the skull in a good many specimens of the golden orfe (*Idus idus var. orfus*). As this deformity occurred in a great many specimens derived from the same pond, it was considered to be due to an inflammation; which, however, could not be proved.

The kypholordotic shortening of the spinal column was examined by SPICZAKOW (1935). This deformity was often found in the highly arched Aischgründer race of carp. During life this kypholordosis appeared to be ascertainable because of a splitting of the side-line. It must be noted, however, that this splitting of the side-line need not necessarily result from a kypholordosis, but that it may be caused by the coalescence of the vertebrae. In practice this deformity is very important, since carps with kypholordosis are not allowed for breeding. SCHÄPERCLAUS (1941) reported that several carps, which on account of their thick-set build had seemed to suffer from dropsy (hydrops) on examination showed, actually to be suffering from a shortening of the spinal column.

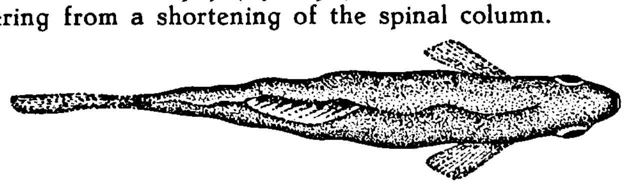

FIGURE 1. Plecospondylic spinal column in the guppy, *Lebistes reticulatus* (PETERS) Dorsal side. Several successive wavelike curvatures.

The plecospondylic spinal column, among other things, was described in the eel (*Anguilla anguilla* LINNÉ) by SCHÄPERCLAUS (1941). On the röntgenogram the fish (length 33 cm) showed, besides the alternating lordotic and kyphotic curvatures, also a number of scolioses. KOCH (1912) has given a description of the occurrence of a spinal column curvature

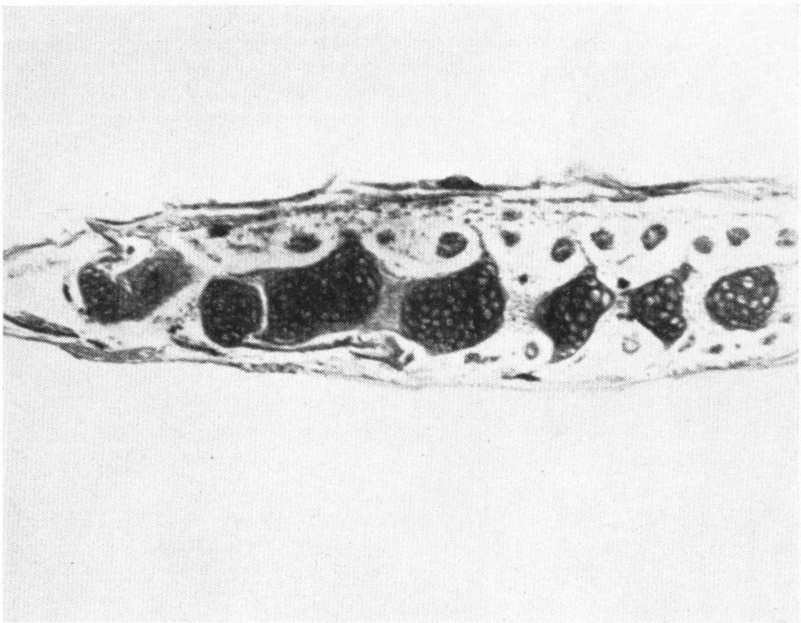

FIGURE 2. Plecospondylic spinal column in the guppy, *Lebistes reticulatus* (PETERS). Frontal section. Displacement of the vertebrae (black), which consists of cartilage. Some vertebrae show an extreme deformation and an important increase in size. The vertebrae are separated by connective tissue. On either sides of the spinal column connectice tissue, musculature and skin.

in fishes. WUNDER (1934) observed spinal column curvature in the carp (*Cyprinus carpio* LINNé) after primary osteomalacia. These literature data may suffice. For a more detailed report see SCHRÄDER's publication (1930), which contains about 55 species and families in which curvatures of the spinal column have been observed.

In a young specimen of the guppy or millionfish (*Lebistes reticulatus* (PETERS)) we ourselves found a clearly developed plecospondylic spinal column (fig. 1). The fish was fixed in BOUIN's fluid and embedded in paraffin. The sections (4—6 μ) were cut frontally and stained either with hematoxylin and eosin or according to the azan method and the VAN GIESON method.

DESCRIPTION.

Macroscopically the plecospondylic spinal column of *Lebistes reticulatus* showed a number of consecutive curvatures, mainly in lateral direction (fig. 1). In consequence of these curvatures the spinal column was shortened substantially.

The histological examination of the plecospondylic spinal column revealed several phenomena, namely:

1. displacement of the vertebrae,
2. transformation of the vertebrae,
3. increase in size of the vertebrae,
4. decrease in size of the vertebrae,
5. coalescence of the vertebrae.

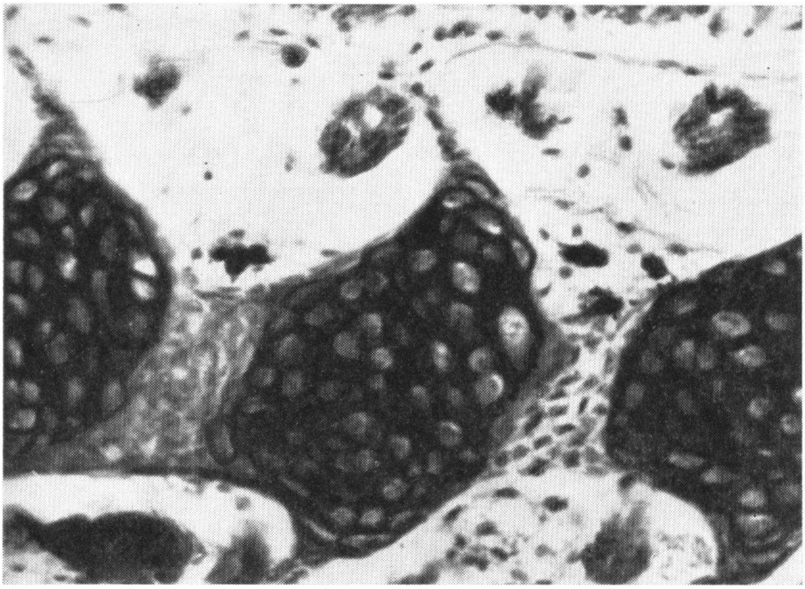

FIGURE 3. Plecospondylic spinal column in the guppy, *Lebistes reticulatus* (PETERS). Frontal section. More magnified as figure 2. Displacement of the vertebrae (black), which consists of cartilage. The vertebrae show an extreme deformation and an important increase in size. The vertebrae are separated by connective tissue. On either sides of the spinal column connective tissue and musculature.

These phenomena will be described separately.

Ad 1. Locally, several vertebrae were displaced with respect to each other, sometimes to a great extent (figs. 2 and 3). It looked as if one vertebra had been pushed aside by the two adjacent vertebrae. As a result some segments of the spinal column showed a zigzag appearance.

The cartilage cells of the vertebrae were compact. The perichondrium around the vertebrae consisted of a thin layer of flattened connective tissue cells with fusiform nuclei.

In a segment of the spinal column with displaced vertebrae the connective tissue of the perichondrium sometimes seemed to be connected with vertebrae situated further on instead of with the adjacent vertebrae. In this case the connective tissue of the perichondrium is situated along the displaced vertebrae, as it were.

Ad 2. Some vertebrae were greatly deformed. The normal, regular form is lost, the vertebrae having grown into an irregular piece of cartilage (figs. 2 and 3). The smooth surface of the vertebrae showed no lacunae nor chondroklasts. Locally, several transitions were found between fibroblasts of the perichondrium and cartilage cells.

Ad 3. An increase in size of the vertebrae was met with in several segments of the plecospondylic spinal column. By means of a formation of cartilage from the perichondrium some vertebrae were much enlarged. Thus some of the vertebrae were about five and a half times as large as the normal ones (figs. 2 and 3), the formation of cartilage having

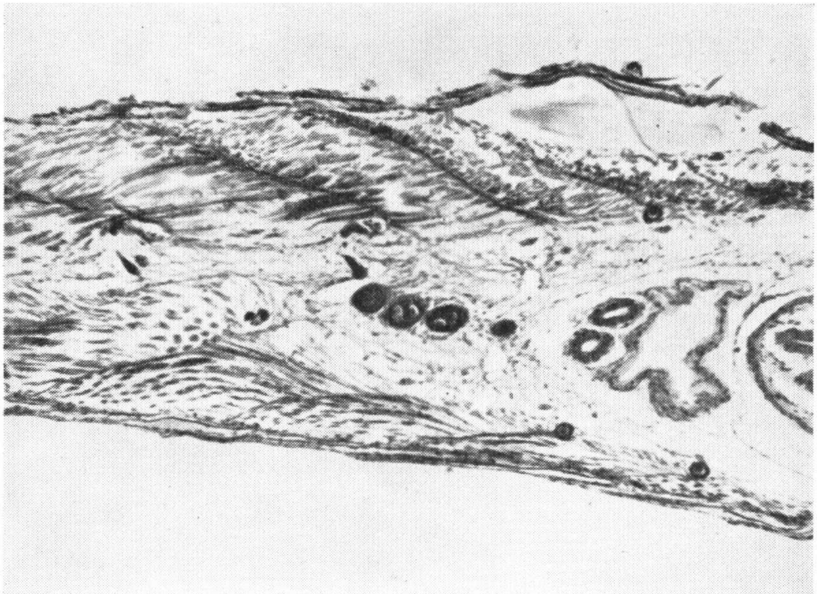

FIGURE 4. Plecospondylic spinal column in the guppy, *Lebistes reticulatus* (PETERS). Frontal section. Disappearance of vertebrae. In the centre some small vertebrae consisting of cartilage (black) remained. On the left side a very small vertebra is present. The vertebrae are separated by connective tissue. On either sides of the vertebrae connective tissue, musculature (muscle bundles between myosepta) and skin. To the right, two urinary ducts and intestine.

exceeded the absorption of cartilage. It is worth mentioning that in general the increase in size occurred in several of the vertebrae of a segment of the spinal column, but not in one isolated vertebra.

Ad 4. Just as the increase in size, also decrease in size was observed in several vertebrae of the spinal segment, but not in one separate vertebra only. Here the absorption of cartilage seemed to have exceeded the formation of cartilage. Figures 4 and 5 show some of these very small vertebrae.

Ad 5. Locally, a number of vertebrae had grown together and had formed a cartilaginous stick. The connective tissue situated between the vertebrae had been transformed into cartilage. This must at first have been visible as cartilaginous bridges, but afterwards the growing together of the bridges and the vertebrae had caused the limitations of the cartilaginous vertebrae to be no longer visible whilst a cartilaginous stick had come about.

Ad 6. Disappearance of vertebrae was occasionally noticed. Owing to the absorption of the cartilage the vertebrae had become very small and at last had vanished completely (figs. 3 and 4). At the margins of the regions in which the vertebrae disappeared, sometimes very small ones were found. Surely, these would also have vanished after some time. The process of the disappearance of vertebrae did not seem to have yet come to a stop.

Inflammatory cells, such as lymphocytes and polynuclear granulocytes

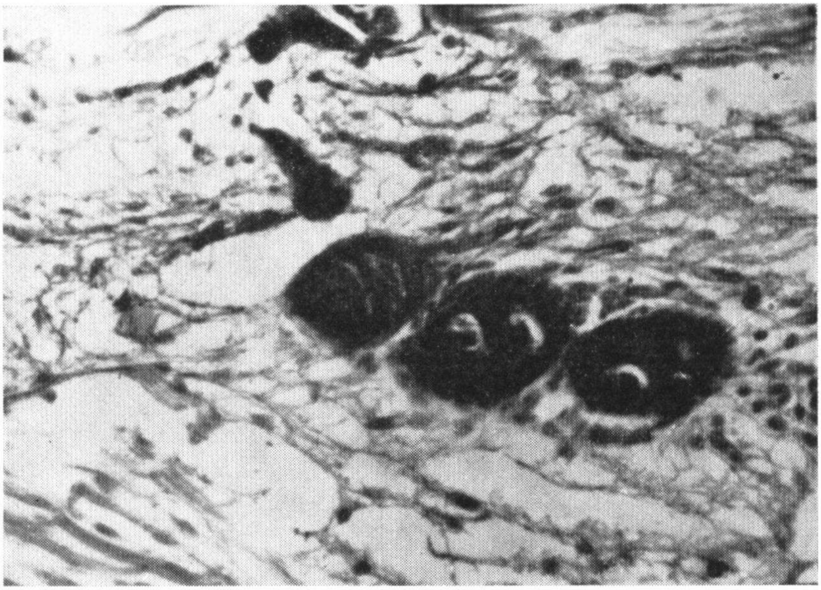

FIGURE 5. Plecospondylic spinal column in the guppy, *Lebistes reticulatus* (PETERS). Frontal section. More magnified than figure 4. Disappearance of vertebrae. In the centre some small vertebrae consisting of cartilage (black), remained. The vertebrae are separated by connective tissue. On either sides of the vertebrae connective tissue. In left lower corner the musculature is visible.

were not encountered in the plecospondylic spinal column of *Lebistes reticulatus*. Also cells with club-shaped inclusions, elsewhere observed not only in inflammations but in tumours of fishes as well, were lacking in these tissues. These cells were found by STOLK in the inflammation of gills in *Lebistes reticulatus* (1950 *a*, 1954 *a*), in the thyroiditis of *Lebistes reticulatus* (1950 *a*, 1954 *b*), and in a mesenchymal tumour of the skin in *Xiphophorus maculatus* (red variety) (1954 *c*). DUTHIE (1939) and CATTON (1951) considered these cells as coarse granulocytes in the discharging state. ARONOWITZ, NIGRELLI and GORDON (1951) noted these cells in a spontaneous epithelioma in the platyfish, *Xiphophorus* (*Platypoecilus*) *variatus*.

If the cells with club-shaped inclusions had been found in the plecospondylic spinal column of *Lebistes reticulatus*, it might have been assumed that inflammatory processes had played an important part in the origin of this spinal column deformity. This however, was not the case.

The skeleton of the head and of the extremities did not show deformities. It was only the spinal column, which was afflicted by the pathological process.

Nor were any anomalies found in the musculature nor in the skin.

DISCUSSION.

The wave-like curvature and the shortening of the spinal column as seen in *Lebistes reticulatus* appeared to be a typical case of a plecospondylic spinal column and corresponded very well with the cases described in literature. What is (are) the causal factor (factors) of this deformity?

The plecospondylic spinal column in *Lebistes reticulatus* cannot have arisen by a displacement of one vertebra with respect to an other, the so-called spondylolisthesis, only. Then the vertebrae had to show about the normal structure without deformation. The extreme deformation and the important increase in size of the vertebrae suggest that an absorption of the cartilage occurred on the one side and a formation of cartilage on the other side.

As the histological examination revealed no lacunae on the surface of the vertebrae, it may be assumed that probably the absorption of the cartilage is to be ascribed to so-called smooth absorption, in which the cartilage disappears because of the adjacent perichondrium's exerting a more equal and obviously dissolving action on the cartilage. This smooth absorption of the cartilage may be considered as a moderate form of lacunar absorption, in which the cells (chondroklasts) locally play an important part, corroding the cartilage and in this way forming lacunae in the initially smooth surface of the cartilage.

The formation of cartilage took place by appositional growth, by direct transformation of the perichondrial connective tissue. Probably this appositional growth occurred in the normal way, thus: The innermost fibroblasts of the perichondrial connective tissue are transformed directly into cartilage cells surrounded by capsules. Besides, these cells lose their spindle shape, they accumulate large amounts of fluid in vacuoles in their cytoplasm and consequently become spherical or polyhedral. The spaces between the cells become smaller. The cells acquire the characteristic appearance of cartilage cells and become separated from each other by increased formation of the intercellular substance.

In addition to the occurrence of absorption and formation of cartilage, the displacement of the vertebrae with respect to each other could undoubtedly have played a part as etiological factor in the origin of the plecospondylic spinal column.

Only little is known concerning the cause of the plecospondylic spinal column. Of course, a local inflammation was thought of, followed by a secondary growing together of the vertebrae. Indeed ROTH (1922) found a case of lordosis in the pike (*Esox lucius*), in which the deformity seemed to have been caused by an inflammatory process. Yet these processes probably play no part in the etiology, as then an inflammatory process would have to be present in several places, which is not very likely. Moreover, as a rule no inflammation is found, not even a small number of inflammatory cells. PLEHN (1924) reported that the bacteriological examination of the curvatures of the spinal column of carps yielded no results. Also in our case of plecospondylic spinal column in *Lebistes reticulatus* inflammatory cells were lacking. So a distinct causative agent of the curvatures cannot be demonstrated.

Osteomalacia also was considered, because it is capable of afflicting the entire skeleton; for this reason osteomalacia may more correctly be considered to be the preceding stage of the plecospondylic spinal column than an inflammation. WUNDER (1934) observed in the carp (*Cyprinus carpio*) a secondary curvature of the spinal column after a primary osteomalacia.

The frequent occurrence of the plecospondylic spinal column in pox disease ("Pockenkrankheit") and rachitis, which are attended by osteomalacia, also points to osteomalacia as a cause of the plecospondylic spinal column.

In the plecospondylic spinal column of *Lebistes reticulatus* probably also osteomalacia occurred, resulting in the coalescence of the vertebrae and, consequently, in a wavelike curvature. However, it cannot be determined to what extent the osteomalacia is a result of hereditary factors in this case.

It should be pointed out that fishes with plecospondylic spinal column are extremely low-graded and consequently cannot be used for breeding purposes. This holds for the generally small aquarium-fish, as well as for the larger consumption-fish in fish-hatcheries.

SUMMARY.

Description of a case of plecospondylic spinal column in the viviparous Cyprinodont *Lebistes reticulatus* (PETERS), the so-called guppy or millionfish. In this deformity the following phenomena have been observed: displacement of vertebrae, transformation of vertebrae, increase in size of vertebrae, decrease in size of vertebrae, coalescence of vertebrae, disappearance of vertebrae.

Inflammatory cells such as lymphocytes, polynuclear granulocytes and cells with club-shaped inclusions (DUTHIE, 1939; STOLK, 1950 *a*, 1954 *a*, 1954 *b*, 1954 *c*; CATTON, 1951; ARONOWITZ, NIGRELLI and GORDON, 1951) were not found. Consequently inflammatory processes have not played an important part in the origin of this spinal column deformity. The skeleton of the head and the extremities and, moreover, the musculature and the skin showed no deformities.

Beside the occurrence of absorption and formation of cartilage the displacement of the vertebrae with respect to each other may undoubtedly have played a role as an etiological factor. Probably an osteomalacia occurred and consequently a growing together of the vertebrae and as a result the successive wave-like curvatures of the spinal column. To what extent this osteomalacia is a result of hereditary factors cannot be determined.

LITERATURE.

ARONOWITZ, O., R. F. NIGRELLI and M. GORDON
1951 A spontaneous epithelioma in the platyfish, *Xiphophorus (Platypoecilus) variatus*. Zoologica, Scientific Contributions of the New York Zoological Society *36*, 239—242.

CATTON, W. T.
1951 Blood cell formation in certain teleost fishes. Blood, Jour. Hematol. *6*, 39—60.

DUTHIE, E. S.
1939 The origin, development and function of the blood cells in certain marine teleosts. Part 1, Morphology. Jour. Anat. *73*, 396—412.

HOFER, B.
1904 Handbuch der Fischkrankheiten. — E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

KOCH
1912 Über ein gehäuftes Vorkommen von Wirbelsäulenverkrümmung bei Fischen. Berl. klin. Wochenschr.

PLEHN, M.
1924 Praktikum der Fischkrankheiten. — E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart.

ROTH, W.
1922 Handbücher für die praktische naturwissenschaftliche Arbeit XI. Die Krankheiten der Aquarienfische und ihre Bekämpfung. Geschäftsstelle des Mikrokosmos, Franckh'sche Verlagsbuchhandlung, Stuttgart.

SCHRÄDER, TH.
1930 Über die Miszbildungen der Wirbelsäule bei Fischen, insbesondere über die Wellenkrümmung (Plekospondylie) beim Aal (*Anguilla vulgaris*). — Z. f. Fischerei *28*, 495—543.

SCHÄPERCLAUS, W.
1941 Fischkrankheiten. — Gustav Wenzel und Sohn, Braunschweig.

SPICZAKOW, T.
1935 Zum Problem der Rasse und des Exterieurs beim Karpfen. — Z. f. Fischerei *33*, 409—472.

STOLK, A.
1950 *a* Enige gevallen van gezwellen en ontstekingen bij poikilotherme Vertebraten. Een bijdrage tot de vergelijkende pathologie. (With an English summary). — Thesis, Utrecht. — G. W. v. d. Wiel en Co., Arnhem.
1950 *b* Het vergelijkingsprincipe in de geneeskunde. — Inaugural oration, Amsterdam. — G. W. v. d. Wiel en Co., Arnhem.
1954 *a* Cell with club-shaped inclusions in the inflammation of gills in the viviparous Cyprinodont *Lebistes reticulatus* (PETERS). — Proc. Kon. Ned. Akad. v. Wetensch., Amsterdam, *C 57*, 46—49.
1954 *b* Thyroiditis in the viviparous Cyprinodont *Lebistes reticulatus* (PETERS). — Proc. Kon. Ned. Akad. v. Wetensch., Amsterdam, *C 57*, 50—56.
1954 c Tumours of fishes VI. — A mesenchymal tumour of the skin in the viviparous Cyprinodont *Xiphophorus maculatus* GÜNTHER (red variety). — Proc. Kon. Ned. Akad. v. Wetensch., Amsterdam, *C 57*, 652—658.

WUNDER, W.
1934 Beobachtungen über Knochenerweichung und nachfolgende Wirbelsäulenverkrümmung beim Karpfen (*Cyprinus carpio* L.) — Z. f. Fischerei *32*, 37—67.

For sale by the Administration of the Zoological Museum, Amsterdam
Price f 0,60 (Dutch Guilders)