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Note on a Robust Tonguefish with a Sinuous Spine from the Yellow Sea

Tetsushi Senta
and Muhammad Husni Amarullah

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A robust tonguefish, *Cynoglossus robustus* Günther, with five sinuosities in the vertebral column was found by a housewife in Osaka. As this represents a rare case of vertebral sinuosities in the members of the family Cynoglossidae, we describe the case and illustrate the specimen.

Origin of the specimen

On February 17, 1988 or a little earlier, a housewife in Osaka bought several frozen robust tonguefish, the head, viscera and skin of the eyed-side of which were removed, through a livelihood cooperative association. She fried the fish in butter. On picking up some meat from the eyed-side of one of the fish to eat, she noticed an abnormal appearance of the backbone. Feeling uneasy, she took the fish to the office of the association to complain the next morning. The fish was sent back to the fish processing company near Nagasaki which had processed it, and was finally forwarded to us for examination.

Frozen robust tonguefish has been one of the main products of the company since September 1982. All the material has been purchased from trawl catches landed at the Shimonoseki Fish Market by Korean trawlers which operate in the Yellow Sea. The abnormal specimen was one of the fish landed on around February 12, 1988.

According to the manager of the company, the total amount of frozen robust tonguefish which the company has sold so far, mainly in the Kansai and Fukuoka districts, is about 420 tons, or approximately eight million fish, and this is the first case of an abnormal spine reported from a consumer to the company. On our request, the company presented us, for comparison, with an intact specimen of normal fish among the material they had also purchased at the Shimonoseki Fish Market on February 25, 1988.

The abnormal and normal specimens of tonguefish reported here are now deposited at the National Science Museum (Nat. Hist.) under the catalogue numbers of NSMT-P 29844 and 29845, respectively.

Observation of the vertebral anomaly

Size of the specimens. The distance between both extremities along the longitudinal axis of the abnormal specimen was 167.0 mm. An X-ray photograph showed that eight trunk and 44 caudal vertebrae remained in this specimen. We counted nine plus 50 vertebrae in the normal, intact specimen, while it is known that the total number of the vertebrae in this fish ranges from 59 to 64 (mostly 61 to 62) (Yamada et al., 1986). This made us assume that, when the abnormal specimen was processed at the company, its head had been cut off between the first and second vertebrae, and its posterior eight or nine vertebrae had also been cut off. In the normal specimen which was 227.6 mm SL, the length of the head anterior to the second vertebra measured 35 mm and that of the posterior eight vertebrae 22 mm. These added, the abnormal specimen was estimated to have been about 225 mm SL.

The depth of the body was 58.0 mm in the abnormal specimen and 54.8 mm in the normal specimen.

Sinuosity in the spine. Five sinuosities in the dorso-ventral plane were seen in the spine of the abnormal specimen, of which the first one was the most prominent, being abruptly bent almost at a right angle between the seventh and eighth vertebrae (Figs. 1A, 2A). The other curvatures followed a smooth sine curve, with the ratio of the height to length of a wave (Fig. 2B, h/l) ranging from 13.5% of the fifth sinuosity to 25.0% of the third.

Distortion in vertebral centra. In the normal specimen, each centrum was dorso-ventrally symmetrical, showing a clear X-ray image like a conical cup with its bottom directing forward (Fig. 1B); the length of the dorsal margin of a centrum expressed as the length of the upper side of the said cup (Fig. 2C: dc) was almost the same length as that of the ventral margin (vc).

In the abnormal specimen, most of the centra were not dorso-ventrally symmetrical. The dorsal margin of a centrum in an ascending part of the

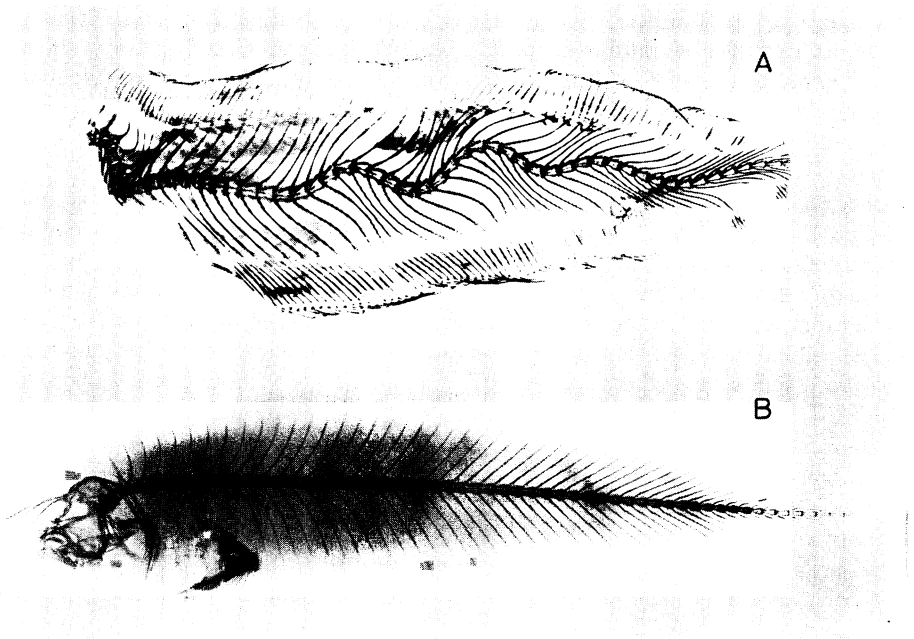

Fig. 1. X-ray photographs of the robust tonguefish. A, the specimen, estimated to be 225 mm SL, with the abnormal vertebral column; B, a normal specimen, 227.6 mm SL.

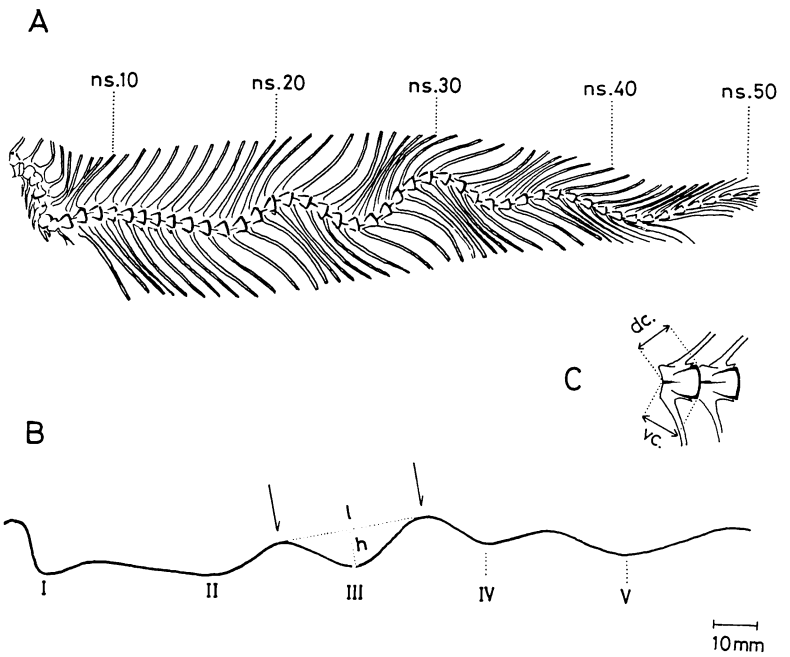

Fig. 2. Schematic illustrations of the vertebral column of the robust tonguefish. A, the specimen shown in Fig. 1A, ns. 10, etc, representing the neural spine on the 10th centrum, etc.; B, line of the curvature in the spine of the same specimen to illustrate how to measure the height (h) and length (l) of a sinuosity, I–V showing the position of the bottom of the first to fifth sinuosity; C, partial enlargement of the vertebrae to show how to measure the lengths along the dorsal (dc) and ventral (vc) margins of a centrum.

spine was longer than its ventral margin; in the 22nd centrum, for example, the ratio of dc/vc was 136.1%. The opposite was seen with a centrum in a descending part of the spine; e.g., in the 26th centrum this ratio was 84.4%. The effect of this is that the angles of the articular faces of the centra against the body axis changed successively so that the centra conformed to sections of a circle.

Variation in neural and hemal spines. The difference in length between the neural and hemal spines of a centrum was small in the normal specimen (Fig. 1B), although a detailed measurement revealed that both spines were of the same length on the 22nd to 24th vertebrae and the neural spines were shorter by 8.5 to 4.0% in the preceeding vertebrae and longer by 0.5 to 2.7% in the succeeding ones than the corresponding hemal spines.

In the abnormal specimen, the neural spines of the vertebrae around the vertex of each of the sinuosities were much shorter than the corresponding hemal spines and the opposite was observed around the bottom of a sinuosity (Table 1). Because of this, the dorsal and ventral contours of the body did not exhibit any marked waving, except for the anteriormost part of the dorsal contour.

The neural and hemal spines in the abnormal specimen showed a variation in the direction of bending. The neural and hemal spines bent backward and forward, respectively, in the ascending part of the vertebral column, while the former bent forward and the latter backward in the descending part. As a result, the intervals between the tips of neighboring spines, both neural and hemal, varied much less irregularly than expected. In the normal specimen, both the spines either slightly bent forward or were almost straight.

Table 1. Positional changes in relative lengths of neural and hemal spines of the centrum on the sinuosities measured from an X-ray film of the abnormal specimen. * and **, situated on the vertex and bottom of sinuosity, respectively.

Centrum no.	Neural spine (ns) mm	Hemal spine (hs) mm	ns/hs %
12*	17.0	22.2	76.6
20**	22.3	21.6	103.2
23*	19.0	23.1	82.3
28**	22.9	19.5	117.4
33*	17.9	22.1	81.0
37**	19.0	19.0	100.0
40*	18.0	19.8	90.9
45**	16.0	16.9	94.7

Remarks

The present specimen made the first case of a complaint from a consumer against the company which had sold eight million processed fish so far. As the unpleasant appearance of a backbone like this specimen's should not be overlooked by any consumers who are so nervous about industrial pollutions nowadays, this anomaly must be a really rare one.

Anomalies in the Cynoglossidae had been considered rare until recently (Dawson, 1962; Haaker, 1973). Out of the 1499 papers listed in the bibliographies on fish anomalies prepared by Dawson (1964, 1966, 1971), and Dawson and Heal (1976), only nine concern the family Cynoglossidae. These are either on abnormal coloration, reversal of the eyed- and blind-sides, missing of an eye, anomalous dorsal and caudal fins, irregular scales, or anomaly of the head; no paper on a vertebral anomaly of the family is cited in the lists.

Matsusato (1986) found markedly high incidences of skeletal anomaly in the members of the Cynoglossidae caught in Hiro Bay off Kure City in the Seto Inland Sea; 12.4% in *Cynoglossus joyneri* Günther, 6.4% in Cynoglossidae sp. and 5.5% in *C. robustus*. Of the skeletal anomalies in *C. joyneri*, the highest incidence was seen for vertebral osteoclasis (34%), followed by shortening and deformation of vertebrae (30%). No case of vertebral curvature was found among the family.

Among the fishes of the order Pleuronectiformes, the most frequent anomaly in the spine is synostosis, viz. the fusion of the vertebral centra (Howes, 1894; Ford, 1930; Inoue, 1941; Templeman, 1970; Honma and Suzuki, 1983), while Matsusato (1973) reported a case in *Kareius bicoloratus* (Basilewsky) with three sinuosities in the spine.

A surprising analogy in the vertebral anomaly with our specimen is seen in the sole, *Solea vulgaris* Quensel, reported by Howes (1894). Besides the coincidence of having five sinuosities in the vertebral column, the sole showed similar variations in the vertebrae as the robust tonguefish reported here. Relative lengths of the dorsal and ventral margins of a centrum, relative lengths of the neural

and hemal spines on a centrum, and directions of bending of the neural and hemal spines varied similarly in the two specimens according to the position of the centrum on the sinuosity, resulting in maintaining an approximately normal contour of its body.

Curvature in the spine, either lordo-kyphosis or scoliosis, has been reported in a variety of species among the fishes in the wild (Howes, 1894; Ford, 1930; Honma and Kitami, 1967; Imada and Yoshizumi, 1973; Matsusato, 1973, 1986; Bucke, 1974; Wunder, 1976; etc.) as well as those reared from the eggs (e.g. Kitajima, 1978). In these cases the anomality is externally apparent.

Except that the abnormal fish of the present specimens had a slightly deeper body (ca. 26% of standard length) than the normal one (24%), the former must have had no unusual appearance externally, because the worker in the company did not notice any anomaly in processing the fish. Morphological anomalies in fishes of the Pleuronectiformes are often accompanied by anomalous coloration (Taki, 1938; Moe, 1968; Haaker and Lane, 1973; Maruyama, 1976; Seikai, 1979). Whether or not this was the case with the present specimen is not known because the specimen had been skinned and cooked.

There are many possible factors causing vertebral anomalies and it is usually impossible to specify the factor of a special case with a few specimens (Matsusato, 1986). Be the cause what it may, there is no doubt that the vertebral sinuosity in the present specimen first took place when the fish was in the early stage of its life history, because the asymmetry in the shape of the centra and the variations in the lengths and directions of bending of the neural and hemal spines prove the adaptive modifications taking a long time.

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(Faculty of Fisheries, Nagasaki University, Bunkyo-machi 1–14, Nagasaki 852, Japan)

黄海で漁獲された脊椎湾曲のイヌノシタ

千田哲資・Muhammad Husni Amarullah

脊椎が5箇所で大きく湾曲しているイヌノシタ（推定標準体長 225 mm）が大阪の主婦により発見された．1番目の湾曲は軀幹部（第7・8脊椎骨間）にあり，殆ど直角に曲がり，他は尾部にあり，波長に対して 14–25% の波高をもつ滑らかなサインカーブを描いている．ある脊椎骨が湾曲上のどの位置にあるかに応じて，1) 椎体の背側と腹側の相対的な長さ，2) 神経棘と血管棘の相対的な長さ，3) 両棘の屈曲方向が変化し，結果として，1) 椎体の関節面の体軸に対する角度が次々に変化して各椎体が円孤の一部をなし，2) 体の背腹外郭は蛇行せず，3) 隣接する神経棘または血管棘の先端の間隔が比較的均一に保たれている．この標本は，韓国のトロール船が黄海で漁獲し，諫早市の水産加工会社が頭部・尾部先端・内臓・有眼側の皮を除去して冷凍品として販売したものである．冷凍イヌノシタは 1982 年9月以降同社の主要製品のひとつで，現在までに総計 420 トン，約 800 万尾を出荷しているが，この度の脊椎異常が，消費者よりの報告の最初の例である．

(852 長崎市文教町 1–14　長崎大学水産学部)