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Report of blended vertebral deformity in the caudal region of narrow-barred Spanish mackerel, *Scomberomorus commerson* (Lacepede, 1800), from India: A case study

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Among the four available seerfishes (*Scomberomorus commerson*, *S. guttatus*, *S. lineolatus*, *and Acanthocybium solandri*) along the Indian coast, *S. commerson* (27,334 tonnes) is a significant contributor to the seerfish landings. The trawlers from the Versova fish landing centre carried out fishing operations between 20°21′21.29″ N, 19°55′03.01″ N latitude and 72°36′24.32″ E, 72°36′12.23″ E longitude in the depth ranges from 5 to 50 m. An abnormal specimen of seerfish was collected from the trawler landed at Versova fish landing centre from the Mumbai, Arabian Sea. The collected specimen was compared with the typical 46 specimens, which showed similar morphological characteristics except for the vertebral deformity near the caudal region (Lumber portion). The deformed fish was radiographed, which showed a distal malformation at about 40th to 49th amphicoelomic vertebral bone. The current work reports blended vertebral column deformity, particularly in the caudal region (a combination of Scoliosis-Lordosis-Kyphosis or LSK syndrome) in a large Narrow-barred Spanish mackerel (*S. commerson*) specimen from India. In the present study, the exact cause for such a deformation could not be established; however, the possible reasons behind the vertebral deformity are discussed.

[**Keywords**: Arabian Sea, Caudal vertebrae, Deformity, Lordosis, Scoliosis, Seerfish]

Introduction

Scomberomorus commerson (Lacepede, 1800) is a highly migrating surface feeder and carnivorous fish, mainly feeding on small-sized teleost species, predominantly on *Sardinella* spp. and *Stolephorus* spp.[1]. During the year 2022, the contribution of seer fish (*Scomberomorus commerson*, *S. guttatus*, *S. lineolatus* and *Acanthocybium solandri*) landing from the Indian marine water was about 43,533 tonnes, out of which *S. commerson* had a lion share of 27,334 tonnes[2]. Diseases and abnormalities in finfishes due to environmental stresses and nutritional deficiencies that come under non-infectious disorders are often less investigated. Morphological deformities in fish refer to external or internal deviation or the absence of some parts of the body. Such deformities have prolonged and adverse effects on fish development. It also recesses the economic value as the abnormalities demote the consumer preference and market price of the fish. Compared to other skeletal deformities, deformities in neurocranium or head, vertebral column, and appendicular areas are the most significant as they have a direct effect on production[3].

Skeletal deformities of fishes are not understood entirely, especially in wild fishes, as it is a complicated task to investigate in the natural population compared to the culture system[4]. Skeletal malformations are mostly related to several causes, such as nutritional, environmental, infectious, xenobiotic, and genetic factors[3,5]. Skeletal deformities include jaw, operculum, spinal (lordosis, kyphosis, scoliosis, platyspondyly and vertebrae fusion), and fin malformations. Lateral deviation of the vertebral column is referred to as "Scoliosis" (also called

"broken back disease"). In scoliosis, the back exhibits undesirable lateral curves either in a "C" or "S" shape. Curvature of the vertebral column towards the ventral is called as "Lordosis" a most severe and frequently noticed anomaly and dorsal is called as "Kyphosis". In addition to the above, "Ankylosis" is the kind of aberration, in which vertebrae gets deformed and fused[6].

Abnormal fishes are widely used as biomarkers of water quality assessment (degradation) because of their high occurrence in polluted areas *i.e.*, waters are multisource of pollutants[7]. Studies until now are unable to explain the single etiological agent or mechanism behind the individual defects[8] as they may be a consequence of mutations affecting the expression of the critical genes[9]. Gradual increase of industries, mining, and power plants in the west coast region of India, discharge a huge number of pollutants into the environment. Because of this, the water quality of both fresh and marine water is rapidly deteriorating, and some of the pollutants are transferring through the food chain into the aquatic dwellers[10].

Multiple cases of vertebral deformities have been reported from various countries in different marine fishes[11-17]. However, limited reports are available on the vertebral deformities from the Indian marine fishes[18-20]. Diagnosis of skeletal anomalies in fishes is crucial for monitoring the quality of the environment. To date, this is the third report after Sonali *et al.*[18], and Mariasingarayan *et al.*[20], that has documented severe cases of vertebral deformities in seerfishes from India. In addition, this is the first report with multiple anomalies (Lordosis – Scoliosis – Kyphosis or LSK syndrome) exclusively in the caudal region of *S. commerson* from the Northwest coast of India. Main objective of this report is to present the severe deformities in the vertebral column of wild-caught seerfish from the Mumbai coast of Maharashtra, India.

Materials and Methods

In total, 47 specimens of *S. commerson* were collected from trawl nets of 30 mm mesh size operated from trawlers at Versova fish landing centre (19°08′36.6″ N latitude; 72°48′13.68″ E longitude) Mumbai coast, during the period of March to May 2018 (Fig. 1). The trawlers from Versova fish landing centre carried out fishing operations between 20°21′21.29″ N, 19°55′03.01″ N latitude and 72°36′24.32″ E, 72°36′12.23″ E longitude in a depth ranges from 5 to 50 m. The specimens were collected in an ice pack and transported to the laboratory within an hour. Further, the collected specimens were

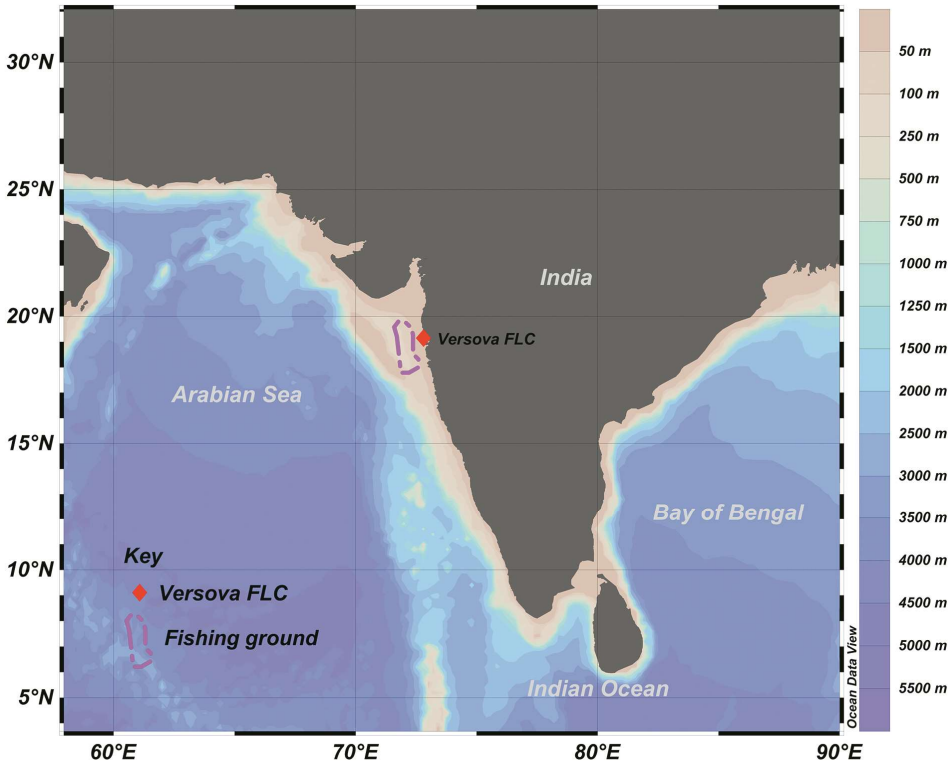

Fig. 1 — Map showing the Versova fish landing center, Mumbai

identified using the standard keys and verified according to Van der Laan *et al.*[21]. Among the collected specimens, one of the specimens, having a standard length of 51 cm, and weighing about 2.3 kg, showed deformation of the vertebral column (Table 1). After thawing, the samples were subjected to morphological, morphometric, and radiological examinations (AeroRAD Digital X-ray System). Both the abnormal and normal specimens were compared to observe the morphological differences.

Results and Discussion

Morphological observation and radio-graphical examination of the deformed seerfish (*S. commerson*) showed an aberrant curvature in the vertebral column near the caudal region. However, the rest of the morphological features (in the thoracic region) were same in the case of healthy and deformed fish. Morphological characteristics of normal (healthy) and deformed fish are shown in Table 1. For the morphological comparison, the healthy and deformed fish specimens are shown in Figure 2. The malformation is recorded in the latter portion of the lateral line and at the finlets of the anal fin. A compression (coalescence) of vertebrae (Ankylosis) in the caudal portion can also be seen in association with the destruction of cartilage nearby (Fig. 2b). As a result of this deformity, the fish seemed to be shortened in comparison with normal specimens because of the twisted caudal portion (Fig. 2b). The

Table 1 — Descriptive statistic of seerfishes. HL = Head length, PDFL = Pre dorsal fin length, PoDFL = Post dorsal fin length, PAFL = Pre anal fin length, PoAFL = Post anal fin length, TL = Total length, ED = Eye diameter, POBL = Post orbital length, BD = Body depth, N = Sample size, SD = Standard deviation, SE = Standard error. All memasurements are in centimeters

Variables	Normal seerfish					Deformed seerfish	
	N	Min	Max	SD	SE	N	Value
HL	46	0.154	0.278	0.028	0.004	01	0.269
PDFL	46	0.484	0.589	0.028	0.004	01	0.613
PoDFL	46	0.640	0.723	0.021	0.003	01	0.606
PAFL	46	0.511	0.641	0.033	0.005	01	0.679
PoAFL	46	0.664	0.762	0.023	0.003	01	0.751
TL	46	1.167	1.388	0.055	0.008	01	1.334
ED	46	0.027	0.054	0.007	0.001	01	0.058
POBL	46	0.028	0.077	0.012	0.002	01	0.052
BD	46	0.234	0.307	0.018	0.003	01	0.264

Fig. 2 — Seerfish (*S. commerson*) specimen: a) Normal/healthy specimen with 2nd dorsal fin and anal fin at the central position of the total length of the fish, showing the body is approximately distributed equally on both sides; and b) Deformed specimen affected by severe anomalies, portraying stumpy body, where the second half of the body outline is significantly less in comparison with the first half

radiographed image of normal fish revealed that the vertebral column is straight, with a total of 51 amphicoelomic vertebrae present in the vertebral column. Whereas, in the case of abnormal fish, unusual curvature (upward and downward arching) was observed in about 40th to 49th vertebrae in the vertebral bone. Comparison of healthy and deformed fish radiographs is illustrated in Figure 3(a – e). Dorsal view of abnormal specimen, clearly portray the vertebral curvature (Scoliosis) with vertebral displacement, compression of vertebrae, deformed centra, Ankylosis, and terminal vertebral coalescence (Fig. 3d). These vertebrae are shown to be wavy instead of straight, as in the standard specimen. Lateral view of the abnormal specimen show the signs of Lordosis-Scoliosis-Kyphosisor (LSK) syndrome where terminal vertebrae are possessed with malformed and coalescent vertebrae, deformed centra. Furthermore, distorted haemal and neural spines (double-headed arrow) and an unusual alignment of pterygiophore and neural spine (pterygiophore anomalies) following caudal deviation can be noticed, which led to a reduction in the vertebral length (Fig. 3e).

In the case of the aberrant specimen, the vertebral disposition was noticed in two places of the caudal peduncle (lumber) region. In reference to the total length (68 cm) and weight (2.3 kg), this deformed adult specimen of *S. commerson* was identified by an unusual sign of curvature, which is referred to be scoliosis. The body of the fish was distorted from the posterior edge of the anal fin to the base of the caudal fin. In general, such deformities have a severe impact on the morphology and movement of fish, which in turn affects the feeding activity (leading to poor growth) and avoidance from predators, and also makes hosts susceptible to infectious diseases. On the other hand, it even has a significant influence on consumer preference and the market value of fish[4].

Moreover, there exists a fusion of vertebrae on one side of the vertebral column *i.e.*, Ankylosis. Such a complexation leads to the stiffening of vertebrae in the spine, which hinders the mobility of fish. Additionally, external anatomical manifestations of healthy and deformed fish's dorsal and lateral views are portrayed for clarity over the diagnosis of deformity externally (Fig. 4a – d). In this study, abnormal specimens portrayed the vertebral curvature (Scoliosis) and also showed the compression of vertebrae (Wedge bone) on one side. Lateral view of the abnormal specimen shows the signs of Scoliosis-Lordosis-Kyphosis, where the curved vertebrae depict the dorsal face of typical vertebrae. The dorsal view represents the "S" shaped curve in the caudal portion

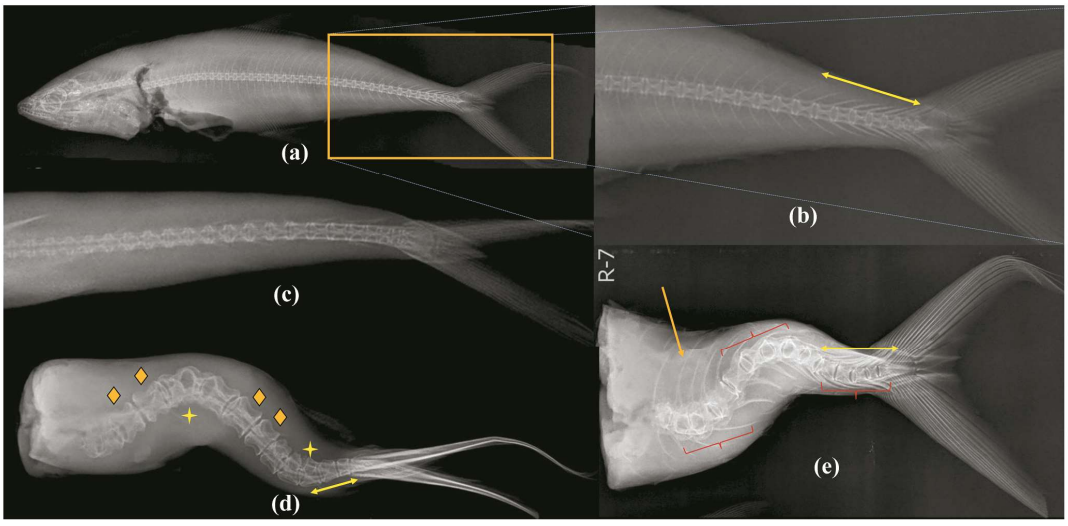

Fig. 3 — X-ray radiographs of seerfish (*S. commerson*): a) Lateral view of the typical specimen; b) Enlarged view of normal specimen's caudal peduncle region with healthy and properly arranged vertebrae and typically oriented haemal and neural spines (double headed arrow); c) Dorsal view of normal specimen; d) Dorsal view of abnormal specimen, clearly portraying the vertebral curvature (Scoliosis) with Ankylosis ( ), vertebral displacement, deformed centra ( ) and terminal vertebral coalescence (double headed arrow) in association with the destruction of cartilage nearby; and e) Lateral view of the abnormal specimen showing the signs of Scoliosis-Lordosis-Kyphosis or LSK syndrome where all the curved vertebrae depicting the dorsal face of typical vertebrae clearly presenting the malformed and coalescent vertebrae (Ankylosis), deformed centra (vertebrae in brackets), distorted haemal and neural spines (double-headed arrow), unusual alignment of pterygiophore and neural spine (arrow)

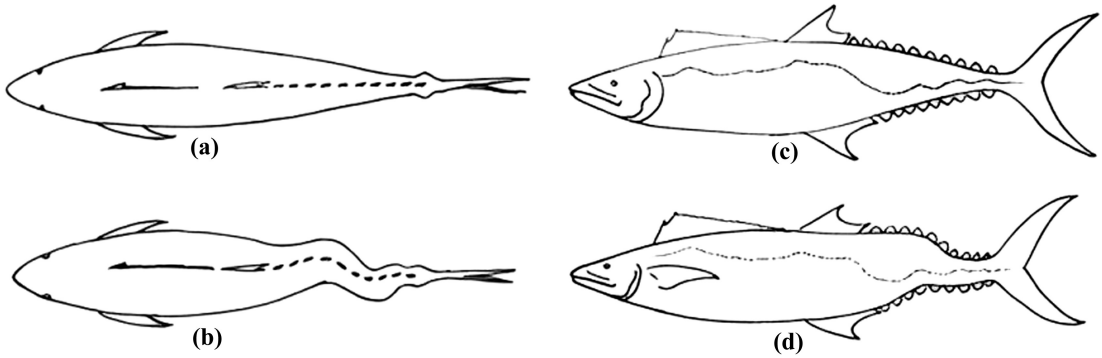

Fig. 4 — a) Dorsal view of normal seerfish; b) Dorsal view of abnormal seerfish; c) Lateral view of normal seerfish; and d) Lateral view of abnormal seerfish

(Fig. 4c). Comprehensively, a severely malformed seerfish was observed in the present study with reduced bone slenderness and thickness, vertebral displacement, compression of vertebrae, deformed centra, Ankylosis, and terminal vertebral coalescence. Similar to this report, Jawad[3] and Jawad & Ibrahim[22] documented a merged form of lordosis-kyphosis (L-K syndrome), and Jawad *et al*.[23] reported Lordosis-Kyphosis-Ankylosis in various wild fishes. Notably, the reported specimen was also noticed with the pterygiophore meeting the neural spine (pterygiophore anomalies). Whereas, in a healthy specimen, the pterygiophore and neural spine are organized alternately.

Certain reports are available on the vertebral malformations in the Indian marine fishes like *Rastralliger kanagurta*[19,20,24-27], *S. commerson*[18,20], *Epinephelus coioides* and *Cynoglossus cynoglossus*[28], *Trachinotus blochii*[29], *Sillago sihama*, *Netuma thalassina*, *Chanos chanos* and *Pampus chinensis*[20]. Abnormalities in fish are generally induced by physical factors such as temperature fluctuations[30], currents or abnormal migration behavior[31] and chemical elements, *i.e.*, variation in salinity[32], depletion in dissolved oxygen content, and presence of high free CO_2[(ref. 33)]. Deformities in fish are also attributed to several biological factors like predation, physical injury[34], nutritional deficiency or excess of nutrients like Calcium, Phosphorus, Tryptophan, Vitamin A, C and K, microbial infection by parasites (*Myxobolus* sp.), bacteria (*Flavobacterium* sp.)[35] and genetics[36]. Afonso[37] and Jawad & Ibrahim[22], reported that lordosis and kyphosis (L-K) might be genetically originated. However, Jawad *et al*.[31] revealed the connectivity of environmental pollutants with Lordosis-Kyphosis-Ankylosis deformity[31] and studies have proven the effect of environmental pollutants like heavy metals on bone health in developing fishes[4,38,39]. According to earlier reports, these deformities are also considered to have originated from mutagenic and teratogenic chemicals of adverse environmental factors via metabolic interference and mutagenesis[40]. It is difficult to define the aetiology of deformities in wild fish due to the wide range of possible factors. One or a few of these abiotic factors might have directly contributed to the appearance of these deformities in *S. commerson*. The examined specimen in the present study is an adult fish, which that the malformations noticed in the present study are not fatal, as in the case of Jawad & Ibrahim[22], but they certainly impact negatively to the fish movement and growth.

In conclusion, limited reports are available on the vertebral deformity in the Indian marine fishes. In addition, this is the third report from India that has documented severe cases of vertebral deformities in seerfishes, and it is the first report from the Northwest (Maharashtra) coast of India. A case of vertebral deformity in the same fish (*S. commerson*) was published previously[18], where authors noticed dorsal and ventral curvatures in the vertebral column in the abdominal region of the fish. While, the current case is a documentation of severely distorted seerfish with multiple bone and cartilage anomalies, exclusively at the caudal peduncle region. Studies on bone malformation and its effects on body shape play a vital role in fisheries management. Deformities in natural stock are exclusively ignored in the marine fish population. Further investigations are necessary to confirm the primary factors involved in severe deformities in wild seerfishes.

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Conflicts of Interest

The authors declare no conflict of interest.

Ethical Statement

This research did not require IRB approval because the research was supported from the dead specimen obtained from the commercial fish catches procured for ichthyological studies under lab condition at fish landing centre, Mumbai.

Author Contributions

BMR & VP: Research idea and conceptualization; BMR, NP, CB, ADPR & OS: Literature collection and critical review of the work; SC, VP, BMR & NP: Figures, sampling and data analysis.

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