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A Description of Two Species of Bonito Sarda Orientalis and S. Chiliensis And a Consideration of Relationships Within the Genus

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1. INTRODUCTION

This paper represents the final portion of a series of descriptions of the tunas and tuna-like fishes of the Pacific. It describes two species of bonito, the Peruvian and the Oriental, whose relationship to the two previously described species, the California and the Mexican, was obscure.

Within recent years there has been a vast expansion in the fisheries of the world. This has been in response to two principal factors. Both the necessity of economic development of innumerable maritime nations, and the need for additional protein foods have stimulated a world-wide interest in, and exploitation of the latent fishery resources of the oceans.

One of the most abundant sources of protein food is found in the "Scombroid" group of fishes, including such fish as the tuna, skipjack, bonito and mackerel. These are streamlined, pelagic, schooling fishes distributed, in greater or less abundance, in almost every ocean of the world. Although widely distributed and generally similar in appearance, there is reason to suspect that in some instances individual species are confined to a given ocean or to a restricted portion of that ocean, and that the stocks of the world are made up of such distinct groups. In other instances it appears that species are in reality cosmopolitan. If our fishery resources are to be intelligently exploited, management will require a precise knowledge of the composition of the total stock and the geographical range of the component species.

Such knowledge is the framework into which life history studies must be fitted. The recognition of larval and juvenile stages, the significance of spawning areas and nursery grounds become productive assets when properly correlated with individual species. The aggregate of such knowledge will provide another measure of abundance to guide those responsible for sustained exploitation. To this end numerous state and federal—domestic and foreign—research agencies have, within recent years, directed their concerted efforts to collecting the necessary information concerning the tunas and tuna-like fishes. The information obtained from this study is presented as a further contribution towards the eventual understanding of the stocks of tuna-like fishes and the relationships of the stock from different areas.

The procedures followed, the terms used and the methods of measuring and counting in this work are identical with those described in earlier reports (Godsil and Byers, 1944; Godsil and Holmberg, 1950; and Godsil, 1954) and need not be duplicated here.

It is again a pleasure to acknowledge the considerable help received from Mr. S. Imamura and Mrs. Hellen Freshour, who have compiled the notes and assisted throughout in innumerable ways.

2. DESCRIPTION OF SARDA CHILIENSIS

This description is based upon five specimens ranging in body length from 606 to 659 mms. Numbers 1, 2, 3 and 4 were from a commercial load caught by a San Pedro seiner in November, 1953, 400 miles south of Cape Blanco, between Paita and Lima, Peru. Number 5 was donated by the U. S. Food and Drug Administration. Their specimen had been in local cold storage for a period of five or six years. It was derived originally from an experimental shipment of bonito sent from South America to a local canner.

2.1. EXTERNAL CHARACTERS

The body was completely scaled. The scales were minute and inconspicuous except in the region of the head and corselet.

The markings consisted of a series of variable black stripes on the back, and characteristic black spots (Figures 1 and 14). The stripes extended from the level of the pectoral insertion to the mid-dorsal line. There were generally about seven stripes, but they were quite variable in number and obliquity. In two specimens (Numbers 3 and 4) they were conspicuously oblique, running posteriorly and upwards from the belly to the mid-dorsal line. In the remaining three (Numbers 1, 2 and 5) the stripes were horizontal or nearly so. A larger series would probably reveal all intergradations. of the horizontal stripes there were two predominantly below the lateral line on the level of the pectoral fin; three predominantly above the lateral line and two crossing the lateral line. The stripes were superimposed upon a brilliant blue background fading to dusky and then silvery on the belly. A conspicuous black spot was found on all specimens at the dorsal insertion of the pectoral fin. There was a black or dark spot or area at the upper extremity of the gill cover and a dusky irregular area adjacent to the posteroventral margin of the eye. No specimens had belly spots. The sides of the head were metallic silvery and this color extended to and delimited the corselet to the tip of the pectoral. The color of the fins was in general dark but quite variable. The pectoral, the dorsal fins, and finlets were

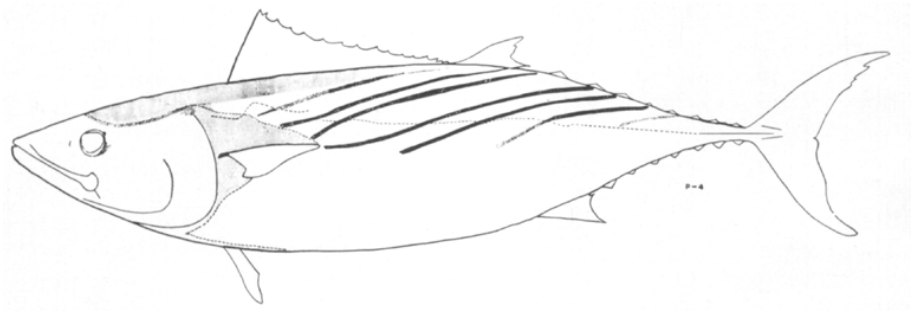

FIGURE 1. *S. chiliensis*. Sketch of a typical specimen to illustrate the markings, the shape of the gill cover, the shape and extent of the corselet (the heavily-scaled, triangular area in the pectoral region), the shape and extent of the maxillary and the course of the lateral line. The discontinuity in the latter is atypical. The outline serves merely to orient the structures enumerated.

FIGURE 1. S. chiliensis. Sketch of a typical specimen to illustrate the markings, the shape of the gill cover, the shape and extent of the corselet (the heavily-scaled, triangular area in the pectoral region), the shape and extent of the maxillary and the course of the lateral line. The discontinuity in the latter is atypical. The outline serves merely to orient the structures enumerated

blackish, while the anal fin was yellowish in color. The axial or inner side of the pectoral fin was black while the ventral fins were silvery to yellowish externally and of a nondescript color internally.

In view of Walford's (1936) use of the corselet to separate lineolata from chiliensis this character was particularly observed. In all specimens the corselet extended approximately to the tip of the pectoral fin. In Numbers 3 and 4 the corselet extended to the tip of the pectoral; in Numbers 1 and 2 it extended to within 2 or 3 mms. of the tip of the fin and in Number 5 it extended 4 mms. beyond the tip of the pectoral. Direct comparison with a local specimen of lineolata showed the condition to be identical. From the tip of the pectoral the corselet expanded anteriorly as a "V," the dorsal arm of which extended straight to the upper extremity (or just above) of the gill cover. The ventral arm of this "V" followed the ventral outline of the pectoral fin and thence curved ventrally following the posteroventral margin of the gill cover. This was true of all individuals.

The lateral line was conspicuous and highly variable. In three fish it was relatively straight while in two (especially in fish Number 2) it was very irregular. Anteriorly, the lateral line appeared first just posterior to the upper extremity of the gill cover. For a distance of an inch or less it sloped slightly downwards. A few millimeters posterior to the pectoral insertion (dorsal extremity) the lateral line swung upward at an angle approximately 45° to form a bulge or wave roughly ¾" in height. From the crest of this wave (which was approximately beneath the fifth dorsal spine) the line sloped gently downwards in a relatively straight line to the region of the third dorsal finlet from whence it leveled off and ran horizontally on the caudal peduncle coinciding with and terminating in the caudal keels. Figure 1, illustrates an extreme variation in the lateral line. In this specimen (Number 4) there was a discontinuity in the line above the pectoral fin, roughly beneath the ninth and tenth dorsal spines. There were apparently no sensory pores on the head.

The free posterior margins of the opercular bones were smoothly rounded. There was some variation in this character but it was of no diagnostic value. The maxillary extended definitely beyond the vertical through the center of the eye and in at least two specimens appeared to extend beyond the posterior margin of the eye. In every case the distance from the tip of the snout to the posterior margin of the eye was less than the comparable distance from the tip of the snout to the posterior extremity of the maxillary. The shape of the distal portion of the maxillary was characteristic. On the one hand it was comparable with lineolata, and on the other diagnostically different from velox and orientalis. In chiliensis the width of the terminal "U" was actually or very nearly equal to the depth of the "U." This was conspicuous, diagnostic and perhaps the most reliable superficial difference between chiliensis and velox.

There were 20 to 25 teeth on each side of the lower jaw. The teeth were largest posteriorly and became progressively shorter approaching the symphysis. At the symphysis, however, there were on each side of the lower jaw from one to three fairly large teeth which curved conspicuously posteriorly and inwards. The teeth on the upper jaw were in general smaller and less regular. There were no vomerine teeth but the

TABLE 1

S. chiliensis: Meristic Counts

Fish number	No. 1	No. 2	No. 3	No. 4	No. 5
1st dorsal rays	17	18	18	18	18
2d dorsal rays	15	12	15	14	14
Dorsal finlets	7	7	8	8	8
Anal rays	14	14	14	14	14
Anal finlets	7	6	7	7	6
Gill rakers:					
Upper limb	8	8	8	8	8
Angle	1	1	1	1	1
Lower limb	18	15	18	16	18
Total count	27	24	27	25	27
Gill teeth		8–17	7–15	7–13	7–17

TABLE 1

S. chiliensis: Meristic Counts

palatine teeth were large and conspicuous to the touch in all specimens. There were 10 to 19 teeth on each palatine. The tongue was pointed anteriorly but entirely lacking in the lateral dorsally-projecting cartilaginous ridges of the Plecostei.

The first dorsal fin had a relatively straight rather than a concave dorsal outline. The second ray was the highest and each subsequent ray became progressively and uniformly lower. The first ray was almost as long as the second. There were either 17 or 18 rays in this fin (Table 1). The first dorsal was of approximately the same height as the second dorsal fin, but the relative heights varied in the several specimens (see measurements). The first dorsal fin was entirely recessed into a groove. There were 12 to 15 rays in the second dorsal fin, and seven or eight dorsal finlets. The anal fin was comparable in height with the second dorsal and contained consistently 14 rays. There were six or seven anal finlets. The pectoral fin was moderately long and extended to, approximately, the eleventh dorsal spine. It was inserted slightly anterior to the vertical through the first dorsal and ventral insertion. A distance of two to five millimeters separated the dorsal extremity of the pectoral insertion from the margin of the gill cover. The anal fin was inserted between the end of the second dorsal base and the first dorsal finlet. The interpelvic process was small and irregularly divided, and in no specimen were the two portions equal. The right portion was longest in three and the left in two. The vent was round or at most an elongated oval. Cartilaginous caudal keels were present and conspicuous, and a pseudofin was present on the caudal fin above and below the posterior extremity of the caudal keel.

Gill rakers were developed on the first arch only. The remaining arches had undeveloped basal plates in place of gill rakers, although two or three of these at the angle of the arch were partially developed as rudimentary rakers, and stood up perceptibly above the arch. The rakers on the first arch were long, e.g., 2 cm. in fish Number 2, and fully developed. There was a raker in the angle of the arch, and this raker had both a dorsally and a ventrally projecting process, whereas the remaining rakers had but a single basal process. The gill raker count, made consistently on the right side, was 8 + 1 + 15 to 18 = 24 to 27 (Table 1).

Gill teeth, or posterior rakers, were likewise developed on the first arch only, where they attained a height of four or five millimeters. The gill teeth on the lower limb of this arch were conspicuously more developed than those of the upper limb, which approached the condition on the subsequent arches. On each of the latter there was a complete set of basal plates, each of which bore a rudimentary raker approaching, at a maximum, a millimeter in height. Hence, the difference on the first and subsequent arches was relative. The varying degree of development of the gill teeth rendered a count unreliable and quite arbitrary. The count on the first arch, recorded in Table 1, excluded mere basal plates. Had these been included, the count on the lower limb could have been increased by as much as seven in some cases. This description is applicable to all specimens examined.

TABLE 2

S. chiliensis: The Measurements Made Upon Five Specimens. The Last Column Lists the Range in the Resulting Ratios of Body Length ÷ Individual Measurement. The Last Three Measurements Are Related to Head Length.

Fish number	No. 1	No. 2	No. 3	No. 4	No. 5	Range in Ratios
Body length	606	659	613	623	647	
Head length	158	181	165	169	175	3.64– 3.84
1st dorsal insertion	168	196	176	179	172	3.36– 3.76
2d dorsal insertion	339	378	349	341	ca366	1.74– 1.83
Anal insertion	403	434	411	411	ca425	1.49– 1.52
Ventral insertion	176	198	190	193	197	3.23– 3.44
Greatest body depth	126	145	139	147	147	4.24– 4.81
Greatest body width	88	95	91	90	101	6.41– 6.94
Dorsal-ventral distance	122	138	125	133	134	4.68– 4.97
Dorsal-anal distance	259	276	262	259	ca284	2.28– 2.41
Ventral insertion to vent	229	233	224	223	228	2.65– 2.84
Length 1st dorsal base	171	187	177	165	ca196	3.30– 3.78
Length 2d dorsal base	56	59	51	58	ca 58	8.21–12.02
Length of anal base	42	48	43	50	ca 52	12.44–14.42
Pectoral length	91	103	86	90	90	6.39– 7.19
Height of 1st dorsal	72	ca 67	ca 60	ca 65	69	8.42–10.22
Height of 2d dorsal	60	69	62	62	ca 64	9.55–10.11
Height of anal	60	73	60	61	ca 63	9.03–10.27
Diameter of iris	ca 16.5	ca 18	ca 16.5	ca 17	16	9.58–10.94
Maxillary length	74	87	79	81	80	2.08– 2.18
Snout to posterior margin of eye	71	84	75	78	77	2.16– 2.27

TABLE 2

S. chiliensis: The Measurements Made Upon Five Specimens. The Last Column Lists the Range in the Resulting Ratios of Body Length ÷ Individual Measurement. The Last Three Measurements Are Related to Head Length

The measurements made are recorded in Table 2. They are compared with comparable measurements of S. lineolata in a later section.

Superficial comparison of these specimens with one of lineolata revealed no differences. In particular, the shape and extent of the corselet was identical and the two varieties were not superficially distinguishable.

2.2. INTERNAL ANATOMY

2.2.1. Ventral View of the Viscera

The visceral view was similar in all specimens. The caecal mass occupied the anterior third of the body cavity, and superimposed upon this organ at its extreme anterior end, on the right side, was

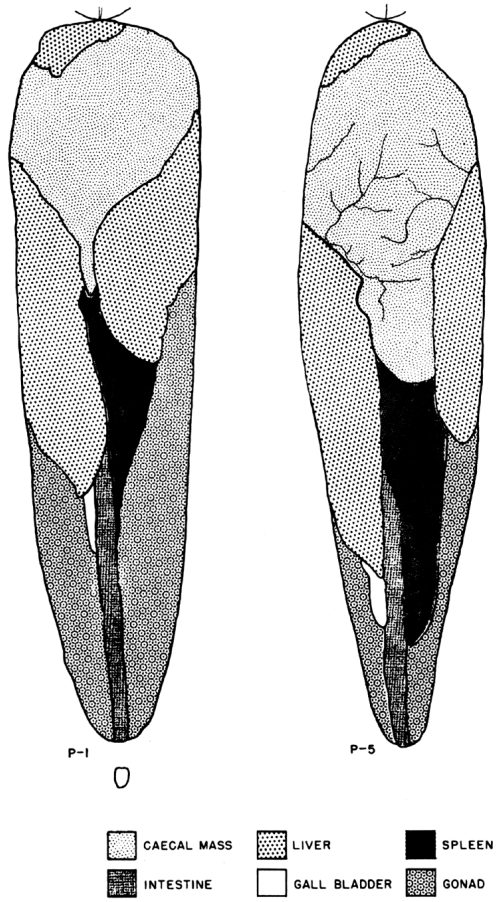

FIGURE 2. S. chiliensis. Ventral view of the viscera, in situ, in two specimens, to show both the consistency and variation in pattern. The markings on the caecal mass in P-5, are the injected arteries

the small center lobe of the liver. The distal portion of the caecal mass was framed by the right and left lobes of the liver. These were large and conspicuous and the right lobe was invariably appreciably longer than the left. Extending posteriorly from the distal extremity of the caecal mass was the large conspicuous and characteristic spleen. This lay along the center line, and occupied approximately the center third of the body cavity. Running with the spleen and extending beyond to the vent was the straight intestine. The latter, with the spleen, overlay the stomach which in these specimens could not be seen in this view. In three of the five fish (and possibly a fourth) the gall bladder projected posteriorly

from the tip of the right lobe of the liver. It continued beyond this lobe a variable distance and was attached to the right wall of the straight intestine, thus lying on the right side of the fish. All specimens, of which three were females and two males, were gravid; and the large gonads occupied, in this view, the lateral margins of the body cavity.

This view was diagnostic of the genus but was not specifically distinct. It appeared to be essentially similar to all other species of the genus. Perhaps the spleen was less massive and extensive than in the lineolata type but a direct comparison with the latter failed to reveal anything more than a relative difference.

2.2.2. Caecal Mass

The caecal mass was a triangular organ of appreciable depth. The apex lay posteriorly, superimposed upon the stomach and spleen. From the tip of the heart the caecal mass extended posteriorly a distance equal to 0.4 the length of the body cavity. The range in these five specimens was from 0.22 to 0.49. The caecal mass was intimately attached to the left lobe of the liver, the head of the right lobe, the intestine and duodenum. In fresh material the individual caeca were plainly discernable on the surface, as in the tunas; while in stale specimens the caecal mass appeared granular. In an injected fish, radiating arteries could be seen over the entire ventral surface. The caecal mass was connected with the duodenum by approximately six compound ducts.

2.2.3. Liver

This consisted of three lobes, of which the center lobe was very small and inconspicuous, while the lateral lobes were long. The right lobe was consistently and appreciably longer than the left, averaging about 0.7 the length of the body cavity, and between four and five centimeters longer than the left. Both right and left lobes were massive. *In situ*, the right lobe extended from 0.63 to 0.81 the length of the body cavity while the left lobe averaged 0.49 the body cavity length. The excised liver is shown in Figure 3. There were no surface markings on any lobe. Occasional traces of veins were seen but no trace of an arterial injection showed on any lobe.

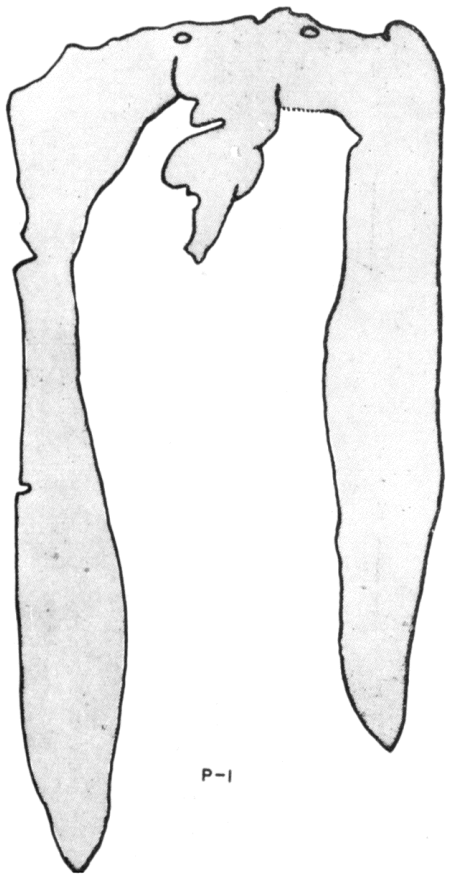

FIGURE 3. S. chiliensis. Ventral view of the excised liver

2.2.4. Stomach and Intestine

The stomach was casually observed. It extended from 0.76 to 0.82 the length of the body cavity. It was a thin-walled conical sac with the apex lying beneath the spleen in the mid-dorsal line. The pylorus opened from the extreme anterior end of the stomach and ran, as the duodenum, transversely and anteriorly to the extreme anterior end of the body cavity on the right side. The duodenum was only slightly distended. In this region all the caecal ducts emptied. Reaching the anterior end of the body cavity the duodenum constricted, and as the small intestine ran directly to the vent without a fold or convolution. The small intestine was slightly on the right side, but approached the median line.

2.2.5. Spleen

The spleen was an elongated, conspicuous organ lying ventral to the remaining viscera. In two specimens it measured 105 and 110 millimeters in length. The anterior end lay dorsal to the distal end of the caecal mass, and hence was hidden *in situ*. The posterior end extended roughly to 0.80 the length of the body cavity. The color of the spleen was dark reddish black. In shape it was quite regular, being fusiform, with a rounded anterior end and tapering to a fine point posteriorly. It lay in the membrane enveloping the straight intestine, and while the anterior end was firmly held in this membrane the posterior end was attached loosely only to the straight intestine. It appeared less massive than that of lineolata and in none of these fish was the posterior end rounded. It did not seem as expansive as that of lineolata although a direct comparison with a small specimen of the latter revealed no actual difference.

2.2.6. Gall Bladder

The posterior portion of the gall bladder was typically visible and sometimes conspicuous in ventral view of the viscera *in situ*. It consisted of a tubular sac which tapered imperceptibly anteriorly into a bile duct. Throughout its length it was attached to the dorsal wall of the small intestine more intimately than it was attached to the liver. Actually, it lay in the membrane between liver and straight intestine. *In situ*, the liver concealed much of the gall bladder, and only the distal extremity of the latter showed. Approximately at the mid-length of the right lobe of the liver there was an appreciable constriction in the diameter of the gall bladder and probably that portion anterior to this comprised the bile duct. The latter followed the intestine to its junction with the duodenum and recurved posteriorly towards the left side. Its ultimate fate was not investigated.

2.2.7. Air Bladder

There was no air bladder in this species.

2.2.8. Excretory System

2.2.8.1. Kidney

The kidney was a narrow wedge of tissue extending practically the full length of the body cavity to within three centimeters or less of the vent, or to the vertical through the twenty-sixth vertebra. (The vent was on the vertical through the twenty-eighth vertebra.) In four of the five fish it overlapped the tip of the urinary bladder. The margins of the kidney were almost straight, and there was little visual evidence of crenulations. Anteriorly there was only a slight expansion of the kidney mass into the lateral body walls in the pectoral region.

2.2.8.2. Ureter

From the urinary bladder the ureter ran anteriorly in the mid-dorsal line within the substance of the kidney, as a single large trunk. It continued undivided to the vertical through the nineteenth vertebra, where the division into the two branches took place. This corresponded to a distance of approximately 110 millimeters from the vent. From the division the two branches ran anteriorly, separated by the width of the postcardinal vein. In this extent the branches were moderately large and straight. Anteriorly, approaching the pectoral region, the ureters diminished in size and their course became more erratic. Reaching the expanded portion of the kidney the ureters swung laterally. In the one specimen sufficiently injected, the ureters, after proceeding laterally a short distance, turned anteriorly again and continued forward (Figure 4). Throughout their extent the ureters received numerous small collecting tubules from all directions.

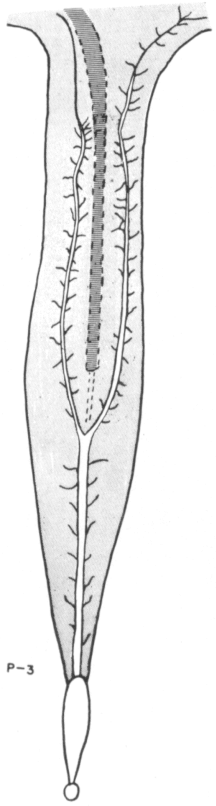

FIGURE 4. S. chiliensis. Ventral view of the kidney, the ureters and urinary bladder. The course of the postcardinal vein is indicated by horizontal shading

2.2.8.3. Urinary Bladder

The urinary bladder was a long cylindrical sac with a rounded anterior end. Posteriorly the bladder tapered into a duct. In these specimens it extended anterior to the vent a distance varying from 36 to 47 mms. It lay against the dorsal wall of the body cavity, between the gonads, which in the case of the female, were fused posteriorly, thus concealing the bladder. Despite this, it was easily located, being moderately conspicuous. The ureter joined the bladder within a centimeter of its anterior tip, but ran within its dorsal wall for an additional few millimeters, before opening through a covered passage.

2.2.9. Circulatory System

2.2.9.1. Anterior Arterial

This system, which was visually similar in all specimens, was carefully investigated in three. The anterior efferent branchials fused in an acute angle to form the aorta, beneath the first vertebra or the junction of the first with the second vertebra. The angle contained was of the magnitude of 75° in most cases, but approached 90° in some. The posterior efferent branchials fused on each side into a short to moderate trunk which joined the aorta beneath the junction of the second and third vertebrae. The pair on each side enclosed a very small angle (Figure 5). The coeliac mesenteric artery arose invariably on the right side, beneath the fourth vertebra. The brachials originated likewise beneath the fourth vertebra. That of the right side arose from the dorsolateral face of the aorta, generally directly beneath the coeliac mesenteric, or occasionally just posterior to this. The brachial of the left side generally arose in the lateral face of the artery but sometimes in the dorsolateral face. There were no cutaneous arteries, but beneath the fifth, sixth, seventh, eighth, ninth, and probably subsequent vertebrae, small segmental vessels arose laterally, as depicted in Figure 5.

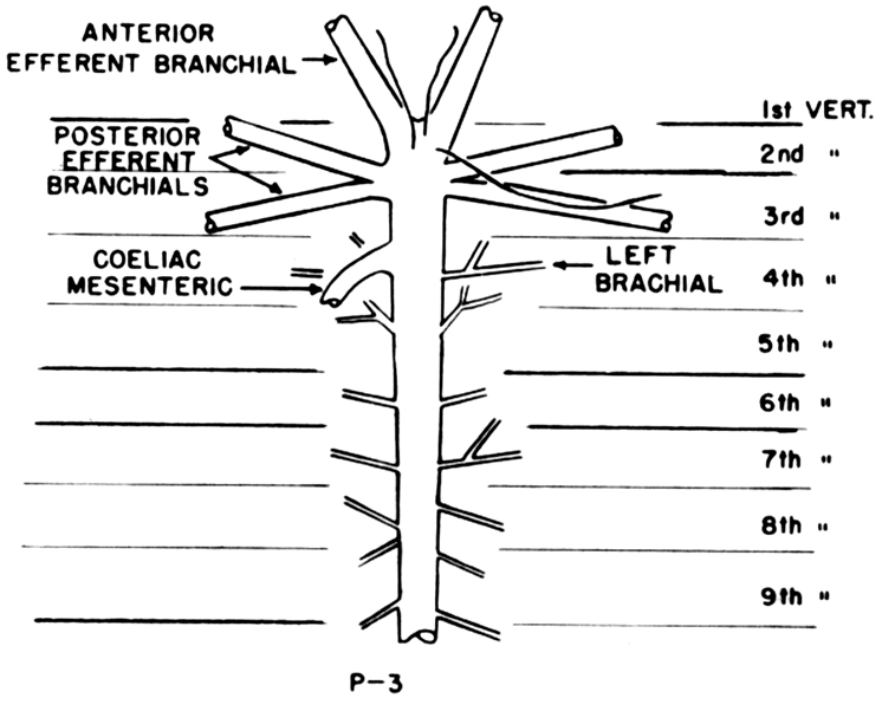

FIGURE 5. *S. chiliensis.* Ventral view of the anterior arterial system.

FIGURE 5. S. chiliensis. Ventral view of the anterior arterial system

The course of the brachial artery was followed wherever possible. Each divided typically into two parts. One branch ran anteriorly and dorsally towards the skull, and was not followed. The second branch ran laterally, then curved posteriorly and ventrally running through the kidney tissue towards the pectoral insertion. At the dorsal extremity of the pectoral insertion the brachial divided. One branch went laterally, probably to the fin, while the other continued ventrally between the clavicle and the spinous portion of the postclavicle to the ventral extremity of the pectoral insertion, where it apparently terminated. In no case did any portion of it go into the surface musculature.

The anterior segmental arteries, depicted in the sketch, were somewhat variable in their course. Some ran laterally from the aorta, while others ran diagonally forward. Many divided, like the brachial, with one branch going dorsally and anteriorly, and the other laterally. There appeared to be considerable variation in these vessels. A detailed description of each vessel was made, but did not warrant publication. One of these segmentals, that arising beneath the seventh or eighth vertebra was of interest because it was the first of a series that subsequently nourished the dark meat of the lateral line. This system is described later. The dorsal aorta entered the haemal canal through the first completed haemal arch on the thirteenth or fourteenth vertebra.

2.2.9.2. Coeliac Mesenteric Artery

This artery arose in the dorsal aorta on the right side, and curved posteriorly around the lateral margin of the pharyngeal muscle. Between one-half inch and three-quarters of an inch from its origin it divided into three major branches. In some specimens the three branches arose simultaneously. In others, the trunk divided into two, the Number II and Number III branches, and just beyond this division the Number II branch gave rise to the Number I branch.

From its origin the Number I branch ran transversely to the left side of the fish on the dorsal wall of the esophagus. Reaching the left side, the Number I branch turned posteriorly, and ran to the tip of the stomach in its left dorsolateral wall, giving rise throughout its length to small tributary vessels into the adjacent stomach wall. At the point where the Number I branch turned posteriorly, near its origin, this vessel gave rise to an appreciable artery which ran in the mesentery directly to the head of the left gonad. Contacting this, the artery continued posteriorly on the dorsomesial face of the gonad to approximately its mid-length, at which point it apparently entered the substance of the gonad. The Number I branch was the simplest of the three major branches, and its course was consistent in all specimens examined.

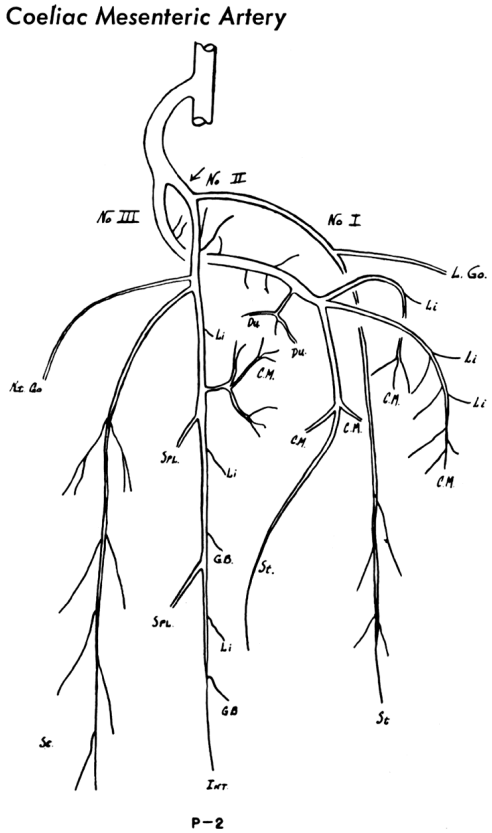

FIGURE 6. S. chiliensis. Diagrammatic sketch, ventral view, of the coeliac mesenteric artery. cm = caecal mass: du = duodenum: gb = gall bladder: int = intestine: l.go = left gonad: li = liver: rt.go = right gonad: spl = spleen: st = stomach

From its origin the Number II branch ran in the mesentery toward the head of the liver. Approaching this it divided, typically into two major components. In the majority of specimens an additional small strand arose at or near this bifurcation and either independently or merging with a similar strand from the Number III branch, ran to the head of the right gonad, continuing on its dorsomesial face to its mid-length. This vessel to the right gonad was invariably present, but its origin was variable. In some specimens it arose entirely in the trunk of the Number II branch: in others it arose entirely in the trunk of the Number III branch, while in some, contributing strands arose in

both these major divisions to fuse into a single vessel which ran to the head of the right gonad.

of the two major portions of the Number II branch, the dorsal-most ran to the head of the stomach, and contacting this, continued posteriorly to its tip in its right dorsolateral wall, giving off tributary vessels in its course to the stomach wall. This vessel also gave rise near its origin, in some specimens, to one or two small strands which ran anteriorly on the right wall of the stomach and esophagus.

The second, or ventral, branch ran posteriorly in the mesentery enveloping the right lobe of the liver and intestine. In most specimens the artery was adherent to or intimately associated with the liver, but in one specimen this portion of the vessel ran on the right edge of the caecal mass. In this course the artery sent numerous small strands into both the caecal mass and the right lobe of the liver. In one specimen this branch also gave rise to a moderate vessel which ran into the substance of the caecal mass, and through two or three branches nourished the right side of this organ. This may have been overlooked in other dissections. Reaching the head of the spleen, this vessel divided, normally into two but occasionally into three. One branch invariably continued posteriorly in the mesentery with the intestine, nourishing this organ throughout its posterior extent, the gall bladder and the distal portion of the right lobe of the liver. The remaining branch—or two branches where such were present—entered the spleen, and ramified throughout the substance of this organ. The Number II branch thus nourished, primarily, the right side of the stomach, the right lobe of the liver, the gall bladder, the intestine and the spleen.

The detailed course of the Number III branch was the most difficult to follow. The present description is general, and does not attempt to portray the detail in any one specimen. Shortly beyond its origin the Number III branch gave rise to two or more minute vessels which appeared to run in the pericardial septum and to the wall of the esophagus. The trunk continued ventrally and transversely toward the head of the liver. In this extent it gave rise, in some specimens, to a small vessel which ran to the right gonad, as described under the Number II branch. Reaching the liver the Number III trunk traversed the head of this organ, on or within its dorsal face, and thence crossed to the duodenum and anterior caecal mass. At this point the trunk gave rise to a small vessel, which through subsequent branches to left and right, nourished the duodenum and anterior margins of the caecal mass. Just beyond this the trunk of the Number III divided into approximately three main branches. One went to the left, nourishing the left margin of the caecal mass and the left lobe of the liver; a second went into the central portion of the caecal mass, while the third continued posteriorly on the dorsal face of the caecal mass, thence between the pylorus and ventral stomach wall to the distal portion of the caecal mass. Here this terminal portion of the Number III branch broke up into, generally, three portions, two of which radiated throughout the distal portion of the caecal mass, while the third invariably crossed in the mesentery to the ventral wall of the stomach and ran posteriorly thereon in the mid-ventral line to the tip of the stomach. An additional vessel, invariably seen but with an obscure origin, ran anteriorly from the caecal mass to

the anterior ventral stomach wall. The Number III branch thus nourished primarily the caecal mass and the ventral wall of the stomach. The supply to the center and left lobes of the liver was nominal, and via minute vessels which crossed to the liver from the contiguous caecal mass. Within no portion of the liver were there any large arterial branches.

In addition to the supply received through branches of the coeliac mesenteric artery, the gonads received in their posterior extent arterial blood from segmentals arising in the dorsal aorta. Beginning about the mid-length of the gonads, large segmentals emerged through the peritoneum from the dorsal musculature and entered the gonads via the enveloping membranes. Separate segmentals arose on each side and ran to the respective gonad. Such segmentals appeared to originate in every other vertebral segment.

2.2.9.3. Cutaneous System

There was no cutaneous artery, and nothing comparable with the cutaneous system of the Plecostei. In place of it, the dark meat in the lateral musculature was nourished by a system of moderate segmental arteries which arose in the dorsal aorta. These were present only in alternate segments. Each ran obliquely from the aorta, in a posterior lateral direction. Approaching the apex of the "V" of dark meat along the lateral line, each segmental divided into a dorsal and a ventral branch, which ran both dorsally and ventrally into the dark meat into which they sent numerous minute branches, while the diminishing branches of each segmental continued beyond into the dorsal and ventral musculature. of these segmentals only the anterior two or three were followed to an origin in the dorsal aorta. Invariably the most anterior one arose beneath the seventh or eighth vertebra as one of the paired vessels depicted in Figure 5. The lateral branch of this vessel ran to the ribs and followed one of the intermuscular bones to the median lateral plane, and thence to the dark meat. This series of segmentals continued far posteriorly, and the last one seen was beneath the end of the second dorsal base, or below the first dorsal finlet.

2.2.9.4. Postcardinal Vein

The postcardinal vein, though large, was not conspicuous. Possibly due to the condition of the fish, or more probably because it was covered ventrally by an appreciable thickness of kidney tissue, the postcardinal was not seen upon the exposed ventral surface of the kidney. However, it was easily found by making a median incision, and with the ventral wall opened its path was obvious.

The postcardinal emerged from the haemal canal through the arch on the 18th vertebra (the 17th in one specimen) which was generally the sixth completed haemal arch, or between one and two centimeters anterior to the division of the ureter. It ran anteriorly within the substance of the kidney, in the median line, to the pectoral region, and thence curved to the right and discharged directly into the right Cuvierian duct. There were apparently no perforated membranes at this juncture. Just posterior to this confluence, the postcardinal vein received a tributary vessel which ran transversely from the left side. As in the remaining bonitos, the walls of the postcardinal (and in fact all the large veins) were entirely devoid of enmeshing arterial capillaries.

At the point where the postcardinal emerged from the haemal canal, it was joined by a renal vein which appeared to come from the distal portion of the kidney. It appeared that this vein was ventral to the ureter, and the intimate association of the two undoubtedly explains why an injection of the ureter invariably introduced latex into the venous system.

2.3. SKELETON

The skeletons of the five specimens of Peruvian bonito were prepared and each portion was compared with a series of the comparable bone in the collection of S. lineolata. This examination included:

Skull	Vertebral column
Subopercle	Clavicle
Opercle	Postclavicle (upper and lower)
Preopercle	Hypocoracoid
Interopercle	Supraclavicle
Posttemporal	Hyomandibular
Metapterygoid	Pterygoid
Mesopterygoid	Quadrate
Palatine	Premaxillary
Maxillary	Dentary
Articular	Auxiliary maxillary
Epihyal	Ceratohyal
Basihyals	Glossohyal
Preorbital	Urohyal
Pelvic girdle	

The meristic characters of the vertebral column, the count of teeth and the measurements of the auxiliary maxillary bones are recorded in Table 3.

TABLE 3

Recorded Meristic Characteristics of the Vertebral Column and Certain Bones of *S. chiliensis*

Character	No. 1	No. 2	No. 3	No. 4	No. 5
Number of vertebrae:					
Precaudal	23	23	23	23	23
Caudal	22	21	21	21	22
Total	45	44	44	44	45
Vertebra supporting first complete haemal arch:	13	13	13	13	14
Caudal keels mainly on vertebra number	38-39-40	37-38-39	38-39	38-39	38-39-40
Number of teeth on left lower jaw:	23	20	25	20	25
Auxiliary maxillary					
Left side:					
Greatest length-mm.	23.0	24.8	23.2	23.0	22.6
Greatest width-mm.	6.4	6.7	6.7	6.0	6.7
Length ÷ Width	3.59	3.70	3.46	3.83	3.37
Right side:					
Greatest length-mm.	23.0	25.7	22.9	22.7	22.8
Greatest width-mm.	6.3	7.2	6.9	7.3	6.9
Length ÷ Width	3.65	3.57	3.32	3.11	3.30
Number of palatine teeth:					
Left side	16	13	16	11	10
Right side	19	14	13	15	12

TABLE 3
Recorded Meristic Characteristics of the Vertebral Column and Certain Bones of S. chiliensis

In the vast majority of cases the bones of chilensis and lineolata were identical, and in no case could a positive identification of a specimen be made upon the entire skeleton or any part of it. The skeletons were, in other words, individually indistinguishable.

There is, however, a suggestion of a biometrical difference in the skull, although the present data are too limited to evaluate this suggestion. A visual comparison of the lateral view of the skull of these two varieties revealed that the height of the orbit, in the median plane, was proportionately less in S. chiliensis than in S. lineolata. To check this impression measurements of the length and height of the orbit were made in each of the five specimens of chiliensis, and in six of lineolata, with the following results.

S. chiliensis					*S. lineolata*				
Spec. No.	Body length	Length of orbit	Height of orbit	Length ÷ height	Spec. No.	Body length	Length of orbit	Height of orbit	Length ÷ height
1	606mm	35mm	6mm	5.83	5	558mm	31mm	7mm	4.43
2	659	41	6	6.83	6	563	31.5	8	3.94
3	613	36	6	6.00	8	647	36	8	4.50
4	623	38	6.5	5.85	11	458	25.5	7	3.64
5	647	38.5	6	6.42	12	439	25.5	7.5	3.40
					13	441	26	7	3.71

TABLE

The length was defined as the distance, measured along the shaft of the parasphenoid, from the prefrontals to the point where the parasphenoid expands dorsally and anteriorly to form the margin of the anterior aperture of the myodome. The height of the orbit was defined as the least distance separating the shaft of the parasphenoid from the anterior portion of the ventrally projecting alisphenoids. It can be seen from the table that the ratio of height to length varied from 5.83 to 6.83 in chiliensis, and from 3.40 to 4.50 in lineolata. However, it should be emphasized that the data show also that the height of the orbit decreased proportionately with increasing size of fish, and that only one of the local specimens was comparable in size with the Peruvian. In this particular comparison the respective ratios were 4.50 and 6.42. In the remaining instances the local bonito were much smaller, and the resulting ratios were all smaller. On the basis of one specimen it was therefore not safe to conclude that an actual difference existed. It is possible, and indeed probable, that a larger sample of comparably sized fish would have yielded overlapping if not coincident ratios. The present difference was merely recorded as an isolated observation. If this is substantiated by future work, the difference would be of a biometrical nature and would not necessarily permit a positive identification of a single specimen.

There was likewise a possible difference in the proportions of the urohyal. It appeared longer and more slender in the chiliensis variety. Unfortunately there were only two of these bones in the collection of local bonito because they had not been saved as a routine. Hence the observation is of limited value.

In a previous publication (Godsil, 1954), a difference was recorded between S. velox and S. lineolata in the glossohyal. In these two distinct species the proportions of the bones differed, the shape differed, and lineolata possessed a groove or depression on the ventral surface which was entirely lacking in velox. This bone was therefore carefully examined in the present study. It was found that the proportions and the shape were highly variable. The ratio of width to length varied in the five specimens from 2.00 to 2.27, compared with 1.8 and 1.9 in two specimens of lineolata, and 1.90 to 2.04 in velox. Furthermore, the shape of the bone was variable and not diagnostic. In all specimens of chiliensis, however, there was present a groove or depression on the ventral surface, exactly as in lineolata. Such a groove was again consistenly lacking in S. orientalis. Hence, it appears that the presence or absence of this groove is probably a valid difference between the chiliensis-lineolata complex and the velox-orientalis complex, whereas the shape and proportions of the glossohyal were so variable as to be of no diagnostic value. S. lineolata cannot be separated positively on the basis of the glossohyal from S. chiliensis. If any actual difference exists, it is at best biometrical.

3. DESCRIPTION OF SARDA ORIENTALIS

In a study recently completed (Godsil, 1954) the writer noted a striking similarity between Sarda velox from the Galapagos Islands, and Kishinouye's (1923) description of S. orientalis from Japan. Only three possible differences appeared to exist, and without a direct comparison of specimens it was impossible to decide whether these were factual or interpretive. S. orientalis was credited by Kishinouye with 25 precaudal vertebrae, whereas velox was found to have but 24. Kishinouye's illustration (a drawing) showed S. orientalis with a relatively straight, approximately vertical posterior preopercular margin whereas that of S. velox was found to be smoothly rounded. Kishinouye portrayed the liver of S. orientalis with the right lobe nearly twice the length of the left, whereas in S. velox these two lobes were found to be nearly equal in length, the right being consistently but only slightly longer. In all other respects the two species appeared to be identical.

In November, 1953, a shipment of five specimens of Japanese bonito from the Tokyo Fish Market, Japan, was sent to the California State Fisheries Laboratory by Dr. Bruce W. Halstead, School of Tropical and Preventive Medicine, Loma Linda, California. These specimens were frozen, but because the shipment had suffered considerable delay in

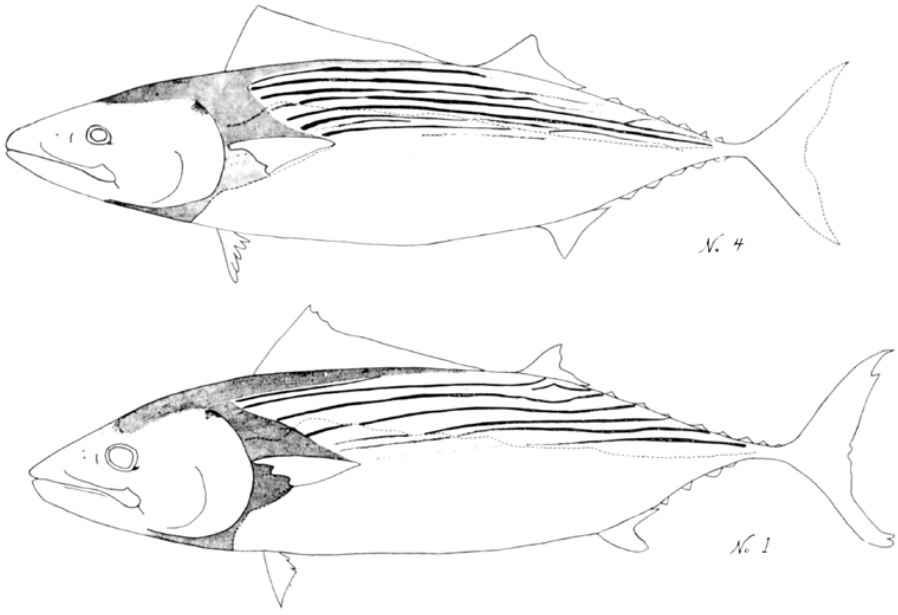

FIGURE 7. *S. orientalis.* Sketches of two specimens to illustrate the markings, the shape of the gill cover and snout, the shape and extent of the corselet (the heavily-scaled, triangular area in the pectoral region), the shape and extent of the maxillary and the course of the lateral line. The outlines were made from tracings of the actual specimens.

FIGURE 7. S. orientalis. Sketches of two specimens to illustrate the markings, the shape of the gill cover and snout, the shape and extent of the corselet (the heavily-scaled, triangular area in the pectoral region), the shape and extent of the maxillary and the course of the lateral line. The outlines were made from tracings of the actual specimens

transit, their condition was poor. They nevertheless offered the opportunity to check the illustrations of Kishinouye and establish either the validity or the synonymy of the two species. Accordingly, four specimens were subjected to a complete dissection, the results of which are recorded in this article. Because of the condition of the specimens, some of the external and all of the visceral measurements must be accepted as approximations. The condition of the viscera precluded a complete description in some instances. The fifth specimen was retained and preserved after measurements and counts were made upon it.

3.1. EXTERNAL CHARACTERS

In external appearance these specimens were superficially identical with S. velox. The horizontal black, dorsal stripes, the long maxillary, reaching well past the posterior margin of the eye, and the narrow, deep U-shaped extremity of the maxillary, separated this species—with velox—immediately from the chiliensis-lineolata complex.

The outline of the body is best described by Figure 7, and the bottom fish in Figure 14. The latter was a photograph of specimen Number 5 while the former portrays the appearance of two of the four specimens dissected. The outlines of these sketches are actual tracings of the respective fish, and the markings and the several structures illustrated were placed by transferring measurements made directly on the specimens to the full-size tracings. In other words, every effort was made to depict correctly the structures described.

The body of the fish appeared to be completely scaled. of this there can be little doubt, although the condition of these fish precluded a positive statement. There was a relatively inconspicuous plaque of scales surrounding the ventral fins, extending about 1 cm. beyond the tip of the fins. The small interpelvic processes are illustrated in Figure 8. They were invariably divided, but the two portions were variable in length. In two specimens they were equal, and in two the left process was longer than the right. The apex of the plaque of scales constituting the corselet extended posteriorly to but not beyond the tip of the pectoral fin. This was true of all specimens.

FIGURE 8. *S. orientalis.* The interpelvic process in two specimens.

FIGURE 8. S. orientalis. The interpelvic process in two specimens

The markings consisted of horizontal black stripes or bars on the dorsal surface, and one or two small black areas on the head. The dorsal stripes were narrow and more or less horizontal, and extended from the pectoral region to the caudal region. There were approximately seven such stripes, equally spaced on each side of the dorsal surface. Typically, these stripes were continuous, but occasionally they were interrupted or partial. Occasionally there were short, irregular bars or markings between continuous stripes.

There was in all specimens a dusky area or spot at the upper extremity of the gill cover and another such area in some specimens at the posteroventral margin of the eye. The latter was not conspicuous, and was not noted in all specimens. The belly of the fish was silvery,

without spots or markings. The area above the lateral line was blue, while the extreme dorsal surface was black.

The lateral line was conspicuous, but somewhat variable in course. Beginning over the pectoral insertion adjacent to the margin of the gill cover, the lateral line rose as a low wave, with a crest at about the mid-length of the pectoral fin. From this crest it fell gradually, in a fairly straight line to the caudal peduncle in two specimens while in two others there were marked undulations beneath the base of the first dorsal fin, Figure 7.

The shape of the gill cover was not specifically distinct. The free margin of the preoperculum was distinctly rounded as in other bonitos and not relatively straight and vertical, as depicted by Kishinouye. This eliminated one of the potential differences between orientalis and velox. The two cannot be separated on the basis of this character. The opercular margin was likewise rounded and in no way distinctive.

The maxillary extended unmistakably in all specimens beyond the vertical through the posterior margin of the eye. In all cases the length of the maxillary exceeded the distance from snout to posterior margin of eye. The distal portion of the maxillary (including the auxiliary maxillary bone) was shaped exactly as in velox. This characteristic U-shaped extremity was long and narrow, being nearly twice as long as wide, and this character separated this species from both lineolata and chiliensis.

There appeared to be some variation in the shape of the snout. In two specimens the snout was pointed in lateral view (Figure 14, bottom, and Fish Number 1, Figure 7) whereas in specimens Numbers 3 and 4 the dorsal outline was appreciably rounded. The tongue was pointed anteriorly, and completely lacked the dorsally projecting cartilaginous lateral ridges characterizing the Plecostei. The jaw teeth were large and widely spaced, as in velox. There were from 10 to 13 teeth on each side of the lower jaw, including one or two large teeth on each side at the symphysis which curved conspicuously inwards and backwards. Such teeth were not present on the upper jaw. There were no vomerine teeth in these specimens. Palatine teeth were present though easily overlooked in some cases.

The first dorsal was higher than the second dorsal, the latter being 0.7 to 0.8 the height of the former. The first dorsal had a straight rather than a concave dorsal outline, the second ray being the longest. The two dorsal fins were contiguous. There were consistently 18 rays in the first dorsal fin. There were 15 or 16 rays in the second dorsal fin, of which the fifth was generally the longest, and the first the shortest. The anal fin was of the same height as the second dorsal fin, and possessed consistently 15 rays. of these the first was extremely short. The anal insertion was below the first dorsal finlet in all specimens. There were eight dorsal finlets and either six or seven anal finlets. The pectoral fin was inserted extremely close to the opercular margin, there being no more than five millimeters intervening. The pectoral fin extended to the vertical through the insertion of the tenth dorsal ray. The caudal fin was damaged in all specimens, but it appeared comparable with Kishinouye's illustration and that of velox, illustrated by Walford (1937). Cartilaginous caudal keels were present, and there was a pseudofin above and below each caudal keel. The vent was small, measuring from 4 to 6 mm., and consisted of a narrow slit.

TABLE 4

***S. orientalis:* Meristic Counts**

Fish number	No. 1	No. 2	No. 3	No. 4	No. 5
1st dorsal rays	18	18	18	18	18
2d dorsal rays	16	16	15	16	–
Dorsal finlets	8	8	8	8	8
Anal rays	15	15	15	15	15
Anal finlets	6	7	6	6	6
Gill rakers:					
Upper limb	3	3	2	3	3
Angle	1	1	1	1	1
Lower limb	9	8	8	8	9(+ 1 ?)
Total count	13	12	11	12	13 (or 14)

TABLE 4

S. orientalis: Meristic Counts

There were developed gill rakers on the first arch only. Here they were stout and moderately long. There was consistently a raker at the angle of this arch, with a basal process extending both dorsally and ventrally. These processes were equally developed and conspicuous. The gill rakers were few and widely spaced. The count, made on the right side, was 2–3 + 1 + 8–10 = 11–14, with a modal count of 3 + 1 + 8 = 12. On the second and subsequent arches there were roughened basal plates on the arch in lieu of gill rakers. At the angle of the second arch there were generally 1 or 2 rudimentary rakers, barely projecting from the basal plate above the surface of the arch.

There were no gill teeth, or posterior rakers, on any arch. In lieu of teeth there were on all arches undeveloped basal plates, and these were more regular on the upper limb of the first arch. The individual raker counts are shown in Table 4.

TABLE 5

***S. orientalis:* The Measurements Made Upon Five Specimens. The Last Column Lists the Range in the Resulting Ratios of Body Length ÷ Individual Measurement. The Last Three Measurements Are Related to Head Length.**

Fish number	No. 1	No. 2	No. 3	No. 4	No. 5	Range in Ratios
Body length	506	488	483	506	495	
Head length	140	135	132	139	141	3.51– 3.69
1st dorsal insertion	148	139	140	143	146	3.39– 3.54
2d dorsal insertion	300	289	285	297	244(?)	1.69– 1.70
Anal insertion	348	333	334	347	343	1.44– 1.47
Ventral insertion	146	147	143	148	156	3.17– 3.47
Greatest body depth	113	113	115	127	113	3.98– 4.48
Greatest body width	87	79	80	84	74	5.82– 6.69
Dorsal-ventral distance	106	104	105	110	102.5	4.60– 4.83
Dorsal-anal distance	236	225	227	237	222	2.13– 2.23
Ventral insertion to vent	199	185	191	198	189	2.53– 2.64
Length 1st dorsal base	160	153	150	159	153	3.16– 3.24
Length 2d dorsal base	51	48	43	47	45	9.92–11.23
Length of anal base	37	39	37	39	39	12.51–13.68
Pectoral length	64	58	57	61	60	7.91– 8.47
Height of 1st dorsal	51	54	49	54	57	8.68– 9.92
Height of 2d dorsal	37	38	–	43	–	11.77–13.68
Height of anal	40	37	36	–	42	11.79–13.42
Diameter of iris	17	17	17	15.5	17	7.76– 8.97
Maxillary length	74	71	71	73	73	1.86– 1.93
Snout to posterior margin of eye	68	65	64	65	66	2.06– 2.14

TABLE 5

S. orientalis: The Measurements Made Upon Five Specimens. The Last Column Lists the Range in the Resulting Ratios of Body Length ÷ Individual Measurement. The Last Three Measurements Are Related to Head Length

The measurements made are listed in Table 5. As they are of interest only in comparison with other species of bonitos, they will be discussed in a later comparative section.

3.2. INTERNAL ANATOMY

3.2.1. Ventral View of the Viscera

This view of the viscera, *in situ*, was dominated by the caecal mass anteriorly, and by the spleen posteriorly. These two organs occupied the entire mesial extent of the body cavity. Superimposed upon the caecal mass a portion of the small center lobe of the liver was seen at the extreme anterior end, while the left lobe of the liver was conspicuous between the caecal mass and the left body wall. The right lobe of the liver was frequently concealed. The straight intestine was invariably seen, running from the margin of the caecal mass and to the right of the spleen directly to the vent. The gonads occupied the space on either side against the lateral body wall.

3.2.2. Caecal Mass

This was an ovoid organ, extending posteriorly from the heart a distance averaging 0.4 (0.36 to 0.47) the body cavity length. The visceral organs were in poor condition and the observations made upon these specimens were accordingly limited. The caecal mass was made up of myriads of individual caeca which discharged through an extensive

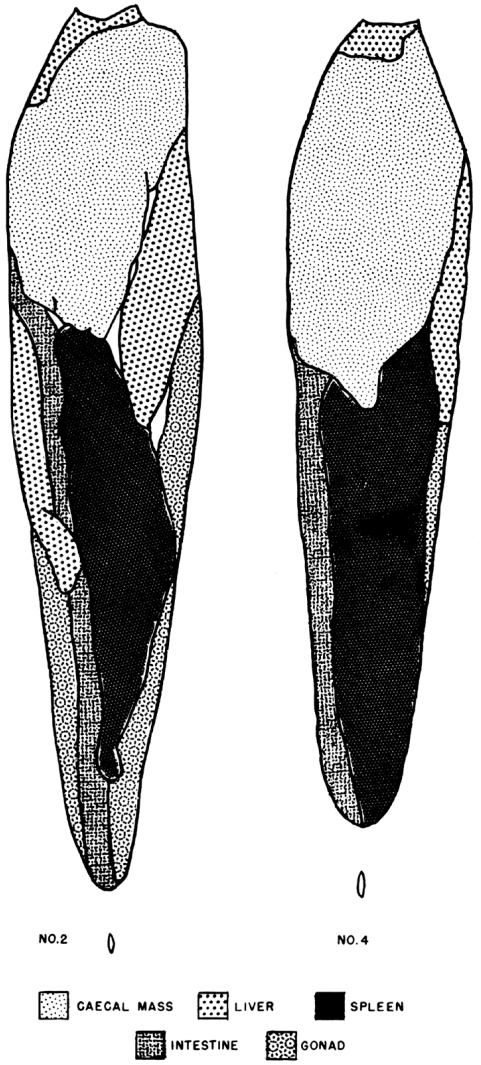

FIGURE 9. S. orientalis. Ventral view of the viscera, in situ, in two specimens

system of collecting ducts, as in the tunas, into the duodenum. The number of ducts emptying into the duodenum was not counted, but appeared to be small, probably six to eight.

3.2.3. Liver

Although the right lobe of the liver was generally or largely concealed in ventral view, *in situ*, it was in reality slightly but consistently longer than the left lobe. From the tip of the heart the right lobe extended 0.6 (0.51 to 0.66) the body cavity length, while the left lobe reached to 0.45 (0.43 to 0.49) the length of the body cavity. The excised liver is shown in Figure 10. It consisted of three lobes, of which the center lobe was insignificant, and the right and left lobes were large and attenuated. Invariably the right lobe was slightly longer than the left, but in no case was the difference excessive, nor did it approach the condition portrayed by Kishinouye, who illustrated (in his Figure N) this liver with the right lobe about twice the length of the left. This, incidentally, eliminated the second of the two apparent differences between velox and orientalis. The surface of all lobes was uniform in color and texture, and entirely devoid of vascular markings.

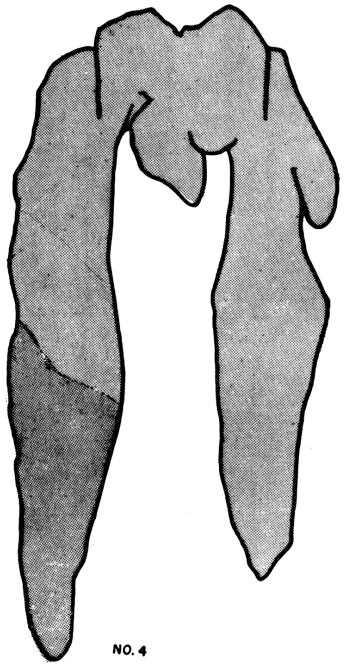

FIGURE 10. S. orientalis. Ventral view of the excised liver

3.2.4. Stomach and Intestine

The stomach was a blind sac about 0.75 the length of the body cavity. The pylorus opened from the anterior end of the stomach, on the left side. It projected posteriorly a short distance and thence, as the duodenum, recurved anteriorly to the right side. Reaching the anterior end of the cavity, the duodenum constricted, and as the small intestine ran directly to the vent as a straight tube. The intestine was very small in diameter, and there were no surface indications of physiological divisions. The duodenum was slightly expanded, and received all the caecal ducts.

3.2.5. Spleen

The spleen was in part decomposed, and no detailed description of it was possible. Because of its color it was undoubtedly the most striking organ seen in the ventral view of the viscera, occupying the median portion of the posterior half of the body cavity, ventral to the remaining viscera. The anterior end of the spleen was hidden beneath the distal portion of the caecal mass, while the posterior extremity of the spleen extended from 0.76 to 0.90 the length of the body cavity. It was a somewhat amorphous, greatly elongated organ, frequently pointed at its posterior end. The head of the spleen was contained in the mesentery enveloping the right lobe of the liver and the intestine, and posteriorly it was associated in the mesentery with the small intestine. There were indications of the olive, surface mottling observed in other bonitos.

3.2.6. Gall Bladder

In all probability the gall bladder should be included in the ventral view of the viscera; but because of the condition of the fish, it was collapsed and indistinguishable from the enveloping mesentery. It was removed and observed with the excised liver. The gall bladder was a long, tubular structure contained in the mesentery connecting the right lobe of the liver and the small intestine. It lay dorsal to the spleen, but it is probable that its distal extremity projected posterior to the tip of the spleen, and would therefore be seen in ventral view of the viscera. The bile duct, which was not distinguishable from the tapering bladder, continued anteriorly with the intestine to the duodenum. With the latter it recurved posteriorly, but its fate was not investigated.

3.2.7. Air Bladder

There was no air bladder in this species.

3.2.8. Excretory System

3.2.8.1. Kidney

The posterior kidney mass consisted of a narrow tongue of tissue in the mid-dorsal wall of the body cavity, extending nearly the full length of the latter, to within about 3 cm. of the vent. The latter was below the twenty-ninth vertebra, while the kidney extended roughly to the twenty-seventh vertebra. In all cases the kidney reached to or beyond the tip of the urinary bladder. This portion of the kidney was relatively deep and suggested a rod rather than a plate of tissue. The margins of the kidney were regular, and showed only slight indications of crenulations. The posterior extremity of the kidney tapered gradually to a blunt point, and anteriorly the kidney expanded abruptly into the lateral body wall in the pectoral region. This, and the anterior portions of the kidney were not investigated.

3.2.8.2. Ureter

The ureter joined the bladder near its mid-length. From this point the ureter ran anteriorly in the mid-dorsal line, traversing the heavy connective tissue lining of the body cavity, to enter the substance of the kidney in which it ran at an appreciable depth. It ran thus for a variable distance before dividing. In two specimens it divided respectively 44 and 53 mm. from the vent (on the vertical through the twenty-fourth vertebra), whereas in the two remaining specimens the ureter continued farther anteriorly and divided 81 and 100 mms. from the vent, or beneath the twentieth and nineteenth vertebra. Thus

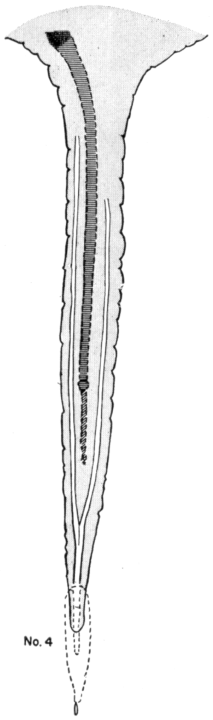

FIGURE 11. S. orientalis. Ventral view of the kidney, ureters and urinary bladder, with the course of the postcardinal and renal veins indicated

the point of division of the ureter was not constant. Likewise the nature of the division was erratic. In two specimens the two branches diverged gradually. In one the two branches ran together and adherent for 5 or 6 mms. before diverging, while in another the branches diverged immediately at a wide angle. In all cases the two branches continued anteriorly separated by the postcardinal vein. The branches did not run in close proximity to the vein, but at a distance of several millimeters from it. The ureters were relatively small in diameter, and became progressively smaller as they approached the expanded portion of the kidney. Injection was incomplete and they were not followed beyond the pectoral region. Throughout their extent the ureters, both the branches and the undivided posterior trunk, received collecting tubules which were more numerous anteriorly. These ran in all directions, but the majority were perpendicular to the path of the ureters.

3.2.8.3. Urinary Bladder

The urinary bladder lay adherent to the dorsal wall at the extreme posterior end of the body cavity. It was a relatively long, moderately thick walled cylindrical sac, tapering into a duct posteriorly, with a rounded anterior end. It measured, from tip of bladder to anterior margin of vent, between 37 and 44 mms., which was equivalent to 0.17 to 0.20 the length of the body cavity. It was easily located, lying dorsal to and between the gonads. In the female the gonads were fused for a considerable distance posteriorly, thus concealing the bladder, while in the male the bladder was generally apparent in ventral view. The ureter joined the bladder near its mid-length, but the actual aperture was several millimeters posterior to this juncture. As in the tunas, the ureter actually discharged into the bladder through a covered passage in the dorsal wall of the latter. In the majority—if not in all specimens—the tip of the bladder covered the posterior extremity of the kidney.

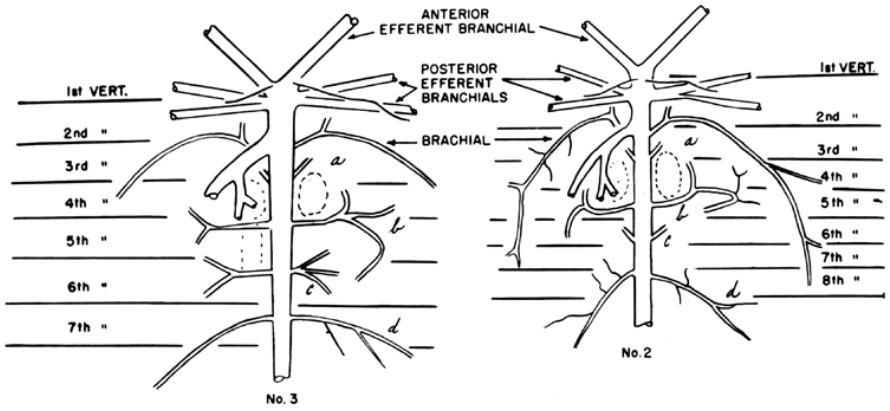

FIGURE 12. *S. orientalis.* Ventral view of the anterior arterial system in two specimens. "a," "b," "c" and "d" are the segmentals discussed in the text.

FIGURE 12. S. orientalis. Ventral view of the anterior arterial system in two specimens. "a," "b," "c" and "d" are the segmentals discussed in the text

3.2.9. Circulatory System

3.2.9.1. Anterior Arterial

This description is based upon a detailed dissection of two injected specimens and a cursory examination of two partially injected specimens.

The anterior efferent branchials fused in a wide angle beneath the first vertebra to form the dorsal aorta. The posterior efferent branchials on each side fused into an extremely short common trunk before joining the aorta. There appeared to be an exceptionally short distance separating the anterior from the posterior efferent branchials, and the latter joined the aorta beneath the second vertebra.

The coeliac mesenteric artery originated on the right side beneath the third vertebra, and the brachial of the right side arose directly dorsal to the coeliac mesenteric vessel. The brachial of the left side arose opposite its mate, but from the lateral face of the aorta. The pharyngeal muscles were attached to the fifth and sixth vertebra.

The brachial artery was followed wherever possible. Just beyond its origin it divided characteristically into two branches. One ran dorsally and anteriorly towards the skull, but was not further investigated. The second branch ran laterally through the anterior kidney tissue and thence to the pectoral region. Approaching the pectoral fin, it first gave rise to one branch which ran to the bones of the pectoral girdle, dorsal to the fin, and then to a second branch going to this fin or its supporting bones. The third branch, or terminal portion, curved posteriorly and appeared to terminate in the adjacent muscles. In no case did any portion of the brachial artery reach the superficial musculature.

While there were no major vessels arising posterior to the coeliac mesenteric artery, a series of relatively large segmentals arose, which appeared to have a constant course. The first pair, "a" in Figure 12, ran diagonally forward and went into the deeper musculature towards the spinal column. The second pair, "b" in the sketches, arose beneath the fifth vertebra, immediately posterior to the severed pharyngeal muscles. These vessels, which were perhaps the largest of the segmentals, ran laterally, and beyond the lateral margin of the pharyngeal muscle, each vessel divided into either two or three equal branches. One ran anteriorly and dorsally into the muscles surrounding the vertebral column. The second branch was both peculiar and interesting. It ran ventro-laterally, and then in all cases made a complete loop and doubled back towards the vertebral column. Approaching the column this branch passed, approximately, between the second and third ribs, and thence seemed to recurve into the dorsal musculature. In each case the vessel was lost at this point, and its ultimate fate could not be determined. However, to this point the condition in each fish was the same. When a third branch was present, this went into the substance of the kidney and appeared to disintegrate therein.

The next segmental, "c," was a small one arising beneath the sixth vertebra. It branched into the substance of the kidney and into the muscles dorsal to the vertebral column.

The segmentals posterior to "c," appeared to run, primarily, posteroventrally with the ribs into the lateral wall of the body cavity, and

thence into the lateral musculature. of these segmentals, only the first, "d," was followed, because beyond this point the aorta shortly entered the haemal canal.

Segmental "d" was invariably a large one, comparable in size with segmental "b." It arose beneath the seventh or eighth vertebra and ran laterally, gradually curving posteriorly. It appeared to pass between the ribs, sending one branch with the rib along the wall of the body cavity, while a second branch or the main trunk continued laterally with the intermuscular bone to the lateral musculature. The latter branch was apparently the one seen as the first of the series of segmentals nourishing the dark meat of the lateral line.

3.2.9.2. Coeliac Mesenteric Artery

From its origin in the dorsal aorta the coeliac mesenteric artery curved posteriorly around the lateral margin of the pharyngeal muscle and then, about one-half inch from its origin, divided into two. The lateral vessel was the Number III branch, and the mesial one gave rise, through a subsequent division a few millimeters beyond, to the small Number I and the larger Number II branch.

The Number I branch ran transversely in the anterior dorsal wall of the stomach to the left side of the fish, and then turned posteriorly on the stomach wall and ran in its left dorsolateral face to the tip of the stomach. At the point where it turned posteriorly it gave rise to a small vessel which ran in the mesentery to the head of the left gonad. This vessel was joined by a small arterial strand, arising in an anterior but unknown source dorsal to the heart. The Number I branch thus nourished only the stomach and the left gonad.

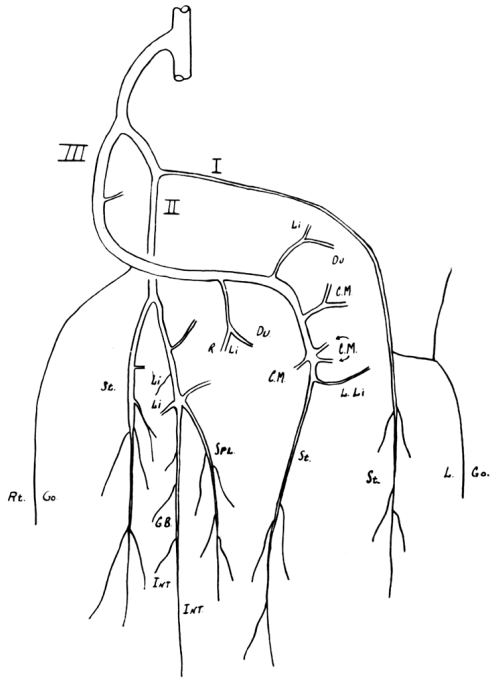

FIGURE 13. S. orientalis. Diagrammatic sketch, ventral view, of the coeliac mesenteric artery. cm = caecal mass: du = duodenum: gb = gall bladder: int = intestine: l.go = left gonad: li = liver: L.li = left lobe of live: R.li = right lobe of liver: rt.go = right gonad: spl = spleen: st = stomach

The Number II branch ran posteriorly on the right side in the mesentery between liver and stomach. Here it divided into two major components. The dorsal-most vessel was the simplest, and ran directly to the right dorsolateral wall of the stomach and continued thereon to its tip, giving rise to occasional branches to the adjacent stomach walls. In one specimen a branch from

this vessel arose anteriorly and ran to the anterior portion of the stomach, continuing on to the esophagus.

The second component of the Number II trunk was more complex. It ran in the mesentery between the dorsal face of the right lobe of the liver and the small intestine. In this extent it gave rise to a series of small to moderate vessels. of these, one or more ran into the right lobe of the liver, one to the anterior caecal mass, and thence to the duodenum, and a relatively large vessel branched extensively in the right side of the anterior caecal mass. At the head of the spleen, this trunk of the Number II branch divided into two portions, which went, respectively, to the spleen exclusively and to the small intestine, rectum and gall bladder. The Number II branch thus nourished in part, all the visceral organs.

The Number III branch gave rise near its origin to one or more minute strands which appeared to nourish the pericardial septum, and to a larger vessel which ran in the mesentery to the head of the right gonad. The main trunk ran transversely and ventrally, traversed the dorsal surface of the head of the liver, and beneath (dorsal to) the loop of the duodenum it entered the caecal mass. Here it gave rise to a branch which consistently ran to the anterior face of the duodenum, branching thereon in all directions and frequently onto the right lobe of the liver, and to a second branch which ran to the left, nourishing the anterior portions of the caecal mass and left lobe of the liver and possibly portions of the duodenum. The trunk of the Number III continued posteriorly within the substance of the caecal mass, or on its dorsal face, and next gave rise to a large vessel which branched throughout the left half of the caecal mass. Approaching the distal portion of the caecal mass the trunk of the Number III disintegrated into several separate branches. One, a large one, crossed invariably in the mesentery to the ventral stomach wall and ran thereon to its tip: one, a small one, crossed to the distal portion of the left lobe of the liver, while the remaining two or three moderate branches radiated throughout the distal portion of the caecal mass. Thus the Number III branch nourished, principally, the caecal mass and the stomach, and secondarily the liver, duodenum and the right gonad.

3.2.9.3. Cutaneous System

There was no cutaneous artery in this species (or in the genus). and nothing remotely comparable with the cutaneous system of the Plecostei. In place of this system, the lateral blood meat was nourished by segmental arteries arising in the dorsal aorta. These segmentals arose in alternate segments. Each one ran laterally—seemingly with an intermuscular bone— to the apex of the lateral blood meat. Here it divided, sending a branch dorsally and ventrally along the boundaries of the dark meat, into which each branch sent occasional small vessels. The first of these segmentals was the vessel designated "d", and described with the anterior arterial system.

3.2.9.4. Postcardinal Vein

A large postcardinal vein was present in this species, although it was rarely apparent on the surface of the kidney. It was generally

concealed by a covering layer of kidney tissue. This vein emerged from the haemal canal through the arch on the eighteenth vertebra in three specimens and through the arch on the seventeenth vertebra in one. From this point it ran anteriorly within the substance of the kidney along the median line. Approaching the heart it curved to the right and appeared to join directly the right Cuvierian duct, without the intervention of perforated membranes. As in other bonitos, there were no arterial capillaries in the walls of the postcardinal (or any other) vein, and this immediately distinguished it from any member of the Katsuwonidae.

At the point where the postcardinal emerged from the haemal canal, it was joined by a small to moderate renal vein running ventral to the fused ureters, and coming from the distal portion of the kidney. This appeared to discharge through a single median aperture into the post-cardinal as that emerged from the haemal canal. The existence and location of this vein was responsible for the difficulties experienced in injecting the ureter in this and other species of the genus.

3.3. SKELETON

The skeleton of this species is described only in relation to that of S. velox. The elements compared are listed below.

Skull	Vertebral column
Opercle	Hyomandibular
Preopercle	Pterygoid
Subopercle	Mesopterygoid
Interopercle	Metapterygoid
Symplectic	Quadrate
Palatine	Articular
Dentary	Maxillary
Epihyal	Premaxillary
Ceratohyal	Auxiliary maxillary
Basihyals	Preorbital
Urohyal	Posttemporal
Glossohyal	Clavicle
Hypercoracoid	Supraclavicle
Hypocoracoid	Postclavicle
Pelvic girdle	

The meristic characters of the vertebral column are tabulated, with other incidental data, in Table 6.

With one possible exception no diagnostic differences were detected, and neither the skeleton *in toto*, nor any constituent element of it could be identified positively by species. Suspected differences proved to be as great within as between the species.

of such differences, one is worthy of record because it might, upon further study, serve to distinguish the two stocks collectively, though not specifically or individually. The ventral surface of the expanded portion of the vomer in orientalis was flat. While vomerine teeth were entirely lacking, there was in this location a small roughened spot or area, the extent and development of which was quite variable. In velox this portion of the vomer was slightly cupped, or concave ventrally, and there was no indication of any roughened area. This is recorded as a limited observation and not a general fact.

The one exception that might constitute a diagnostic difference concerns the vertebral count. S. orientalis, while having the same total

TABLE 6

Recorded Meristic Characteristics of the Vertebral Column and Certain Bones of *S. orientalis*

Character	No. 1	No. 2	No. 3	No. 4
Number of vertebrae:				
Precaudal	25	25	25	25
Caudal	20	20	20	20
Total	45	45	45	45
Vertebra supporting first complete haemal arch	13	—	14	13
Caudal keels mainly on vertabra number	39-40	39-40	38-39-40	38-39-40
Number of teeth on left lower jaw	11	13	10	13
Auxiliary maxillary				
Greatest length, mm.	20.8	21.8	20.4	23.4
Greatest width, mm.	5.1	5.0	5.0	5.2
Length ÷ width	4.08	4.36	4.08	4.5
Number of Palatine teeth (approximate)	12	14	10	13

TABLE 6

Recorded Meristic Characteristics of the Vertebral Column and Certain Bones of S. orientalis

number of vertebrae as velox, had 25 precaudal and 20 caudal vertebrae in all specimens, whereas velox had 24 precaudal and 21 caudal vertebrae in the three available specimens. Kishinouye likewise found 25 precaudal vertebrae in orientalis. In the limited material at hand, this difference would suffice to identify positively any of the specimens; but in such a meristic character one must anticipate variation, and without a greater knowledge of the degree of such variation, it is difficult to evaluate this character.

This comparison of the skeleton has likewise contributed to the knowledge of variations in characters previously described as possible differences between velox and lineolata. In these species the hyomandibular bone was previously found to differ in two respects. Examination of this bone in orientalis revealed that one such difference was probably relative rather than positive. The dorsally projecting spine which in velox projected beyond the center condyle, when viewed from the internal face of the bone, projected similarly in three specimens of orientalis. In the fourth, however, this spinous process was extremely short on one side, comparable with the condition in lineolata, while on the other side of the same fish development was intermediate. Hence this character must be considered as a corroboratory rather than as a positive one.

The spinous process projecting posteriorly from the center condyle, however, confirmed the previous description of velox. In every case this process formed with the vertical shaft of the bone an angle of 90 degres or less, and in no case did it slope upwards from the condyle as it does in lineolata and chiliensis.

The glossohyal was found to contradict the provisional statements made in the comparison of lineolata and velox, (Godsil, 1954). This bone proved to be extremely variable in shape and proportions. In two of the four specimens of orientalis it appeared to be incomplete or broken, and these two bones were eliminated from the comparison. In the remaining

two, the ratio of width to length was 1.90 and 2.04, and these values were intermediate between those of lineolata and velox. Hence this ratio is probably useless, diagnostically.

The second difference in the glossohyal was confirmed by this study. Every specimen of orientalis lacked the short, longitudinal depression on the ventral face of the proximal portion of this bone, characterizing the lineolata-chiliensis complex. In every case the ventral surface of this bone in orientalis was strongly concave, exactly as it was in velox.

I take this opportunity to modify a statement made in my preceding publication (Godsil, 1954). On page 60 of that bulletin the statement was made: "There is a deep-rimmed, crater-like depression in the basioccipital, adjacent to the point where that abuts against the first vertebra, and directly ventral to the projecting margin of the exoccipital where that joins the overhanging margin of the opisthotic. This character is sufficient to separate Sarda from any species of the Plecostei."

The present study showed that there is invariably such a crater-like depression in this location but it is quite variable. When typically developed it readily serves to distinguish Sarda from all members of the Plecostei. However in extreme cases this depression is not conspicuous or obviously apparent, and in such cases it fails to serve as a satisfactory diagnostic difference.

A re-examination of all the material showed convincingly that the depression is more consistently developed in and characteristic of S. chiliensis and S. lineolata. In these two forms the depression is deep, rimmed and tear-drop shaped, with the taper anteriorly. In both velox and orientalis the depression is shallower and more superficial, generally rounded and lacking in a delimiting rim. The structure can be seen in all specimens, but when poorly developed could be easily over-looked in these two species. Hence it is not a positive diagnostic generic character.

4. A COMPARISON OF THE DESCRIBED SPECIES AND AN EVALUATION OF THEIR VALIDITY

The present analysis is based upon the conviction that a species is valid only if any specimen can be positively identified by anatomical characters. Biometrical differences that require large samples to define are not, from this practical viewpoint, adequate grounds for specific segregation. Such differences are invaluable in the study of geographic and separate stocks of fish, but since such characters invariably integrate over the entire distributional range, they do not permit (without knowledge of the precise geographical origin) positive specific identification.

The four species of Sarda described in this and an earlier publication, fall into two recognizable moulds, the lineolata-chiliensis and the velox-orientalis complexes. Any representative of these four species could unquestionably be assigned to one of these two groups. It would, provisionally, require a knowledge of the geographic origin, however, to assign the specimen to the precise species. Under the stated premise, this would not justify specific rank, unless constant and diagnostic anatomical differences differentiated geographic stocks.

4.1. S. VELOX AND S. ORIENTALIS

Considering, first, the velox-orientalis complex, a detailed comparison of the two descriptions revealed the following secondary differences.

Character	*velox*	*orientalis*
External		
1. Ventral plaque of scales	extends 4 mms. or less beyond tip of ventral fins	extends about 1 cm. beyond tip of ventral fins
2. Gill rakers		
modal count	3+1+6=10	3+1+8=12
range, upper limb	2 to 3	2 to 3
lower limb	5 to 8	8 to 9
total count	8 to 11	11 to 13
Internal		
3. Ureter	a. joins bladder near tip b. divides beneath 20th to 22nd vertebra	joins bladder near mid-length divides beneath 19th to 24th vertebra
4. Anterior arterial posterior efferent branchials arise	about 1 vertebra from anterior efferent branchials	less than 1 vertebra from anterior efferent branchials
brachial artery arises	perpendicular to aorta	forming an acute angle with the aorta, anteriorly
major vessels included under this heading arise	about 1 vertebra more posteriorly than in *orientalis*	about 1 vertebra more anterior than in *velox*
segmental 'b'	does not form a loop	forms a loop
5. Postcardinal vein	renal vein encircles postcardinal (constancy of this doubtful)	renal vein discharges directly into postcardinal
6. Skelton	24 precaudal vertebrae 21 caudal vertebrae	25 precaudal vertebrae 20 caudal vertebrae
	vomer slightly cupped; no roughened area	vomer flat, with variable roughened area
7. Proportions	a. anal insertion more anterior b. pectoral fin longer	anal insertion more posterior pectoral fin shorter

TABLE

Since the validity of the specific names depends upon the constancy of these differences, it seems advisable to discuss briefly the several characters.

Concerning the ventral plaque of scales, this character is unsatisfactory and definitely variable. The original dissectional notes describing S. orientalis, state: "The plaque of scales surrounding the ventral fins is not conspicuous; however it can be made out. It extends about 1 cm.—very little less—beyond the tip of the ventral fins." There are no individual measurements. In all probability a more extensive and detailed study of this character would show overlapping variation.

The difference in the gill raker count is small, Table 7. Moreover, in the earlier description of velox, it was shown that the recorded counts could be increased in some cases by the inclusion of minute rakers, barely showing above the surface of the lower limb. Such rudiments have apparently been included in the count of nine rakers on the lower limb given by Hildebrand (1946). In view of this, one must conclude that any reported difference in gill raker count is interpretive.

TABLE 7

The Range in Meristic Counts in the Four Species

	S. velox	*S. orientalis*	*S. lineolata*	*S. ciliensis*
Number of specimens	4	5	8	5
1st dorsal rays	17–19	18	18–19	17–18
2nd dorsal rays	15–16	15–16	14–16	12–15
Dorsal finlets	7–9	8	7–9	7–8
Anal rays	14–16	15	12–13	14
Anal finlets	6	6–7	6–7	6–7
Gill rakers:				
Upper limb	2–3	2–3	7–10	8
Angle	1	1	1	1
Lower limb	5–8	8–9	11–18	15–18
Total	8–11	11–13	20–27	24–27
Gill teeth	none	none	present	7–8+13–17

TABLE 7

The Range in Meristic Counts in the Four Species

Concerning the internal characters, that listed under No. 5, can be rejected without question. This was an isolated and incidental observation. The course of the renal vein was not included in the routine comparison because it was not particularly noted in the earlier dissections of velox.

The point of division of the ureter is not in reality different. It is simply more variable in orientalis. It is quite possible that velox would prove equally variable if more specimens were examined.

The differences listed under "4," are mostly relative, and they require an arterial injection to detect. The limited number of dissections showed that appreciable variation is present, and the differences were small enough so that variation in the two varieties would undoubtedly overlap.

The characteristic loop in the segmental "b" in orientalis might prove to be a genuine difference. It was found in each injected specimen of orientalis, and occurred in none of velox. Although it would probably justify a specific separation if it proved invariably present in orientalis, this character would be anathema to systematists. Moreover, it should not serve to establish the species until populations spatially intermediate between these two are similarly investigated.

Similar reasoning applies to the two skeletal differences. The writer believes that samples from Oceania would bridge the differences in the number of precaudal vertebrae and in the structure of the vomer. In any event it is a matter of opinion whether such differences constitute specific or varietal indices.

The differences in proportions are slight. All corresponding proportions are shown in Table 8. Such differences as exist are unquestionably biometrical, and could not serve to identify a specimen.

On the basis of the above findings one must conclude that it would be possible, though entirely impractical, to distinguish, by a detailed dissection, S. orientalis (from Japan) from S. velox of the American coastline. Without an examination of the vertebral column and without an arterial injection, the separation of the two could not be made. Moreover, in the light of experience with other trans-Pacific species, one must anticipate continuous and overlapping variation within the entire distributional range. If such should prove to be the case there

TABLE 8

The Range in Body Proportions in the Four Species of Bonito

Proportion	Range in ratios			
	S. velox	*S. orientalis*	*S. lineolata*	*S. chiliensis*
Body length	433–457	483–506	439–656	606–659
Number of specimens	4	5	8	5
Body length ÷ Head length	3.51– 3.55	3.51– 3.69	3.70– 4.02	3.64– 3.84
Body length ÷ 1st dorsal insertion	3.40– 3.49	3.39– 3.54	3.46– 3.85	3.36– 3.76
Body length ÷ 2nd dorsal insertion	1.69– 1.74	1.69– 1.70	1.71– 1.80	1.74– 1.83
Body length ÷ Anal insertion	1.47– 1.49	1.44– 1.47	1.51– 1.58	1.49– 1.52
Body length ÷ Ventral insertion	3.14– 3.31	3.17– 3.47	3.33– 3.57	3.23– 3.44
Body length ÷ Greatest body depth	4.56– 4.76	3.98– 4.48	4.35– 4.99	4.24– 4.81
Body length ÷ Dorsal-ventral distance	4.76– 5.08	4.60– 4.83	4.71– 5.33	4.68– 4.97
Body length ÷ Dorsal-anal distance	2.22– 2.29	2.13– 2.23	2.29– 2.40	2.28– 2.41
Body length ÷ Ventral insertion to vent	2.65– 2.69	2.53– 2.64	2.57– 2.91	2.65– 2.84
Body length ÷ 1st dorsal base	3.22– 3.45	3.16– 3.24	3.30– 3.44	3.30– 3.78
Body length ÷ 2nd dorsal base	9.93–10.95	9.92–11.23	10.18–11.86	8.21–12.02
Body length ÷ Anal base	12.77–13.97	12.51–13.68	13.05–16.13	12.44–14.42
Body length ÷ Pectoral length	7.47– 7.61	7.91– 8.47	7.32– 8.28	6.39– 7.19
Body length ÷ Height of 1st dorsal	9.76–10.88	8.68– 9.92	8.62–10.97	8.42–10.22
Body length ÷ Height of 2nd dorsal	10.40–12.14	11.77–13.68	11.31–12.54	9.55–10.11
Body length ÷ Height of anal	11.18–12.37	11.79–13.42	12.15–14.16	9.03–10.27
Head length ÷ Diameter of Iris	7.94– 8.90	7.76– 8.97	9.33–10.19	9.58–10.94
Head length ÷ Maxillary length	1.89– 1.91	1.86– 1.93	2.05– 2.15	2.08– 2.18
Head length ÷ Snout to posterior margin of eye	2.06– 2.10	2.06– 2.14	2.21– 2.28	2.16– 2.27

TABLE 8

The Range in Body Proportions in the Four Species of Bonito

would be no justification for a specific separation, and velox would become a synonym of orientalis. Although he fully believes that the names will prove synonymous, the writer proposes that the names of velox and orientalis be retained provisionally until such time as the mid-Pacific forms are similarly investigated. The retention of the presently accepted names will avoid the inevitable confusion that follows repeated and premature revisions.

4.2. S. LINEOLATA AND S. CHILIENSIS

Based only on the writer's observations a similar table of differences existing between these two species is given below:

Character	S. lineolata	S. chiliensis
Shape of preoperculum	Relatively straight	Variable
Branch of coeliac mesenteric artery to right gonad	Absent	Present
Skeleton	High orbit	Low orbit
Proportions	Pectoral fin shorter:	Pectoral fin longer:
	Second dorsal fin lower:	Second dorsal fin higher:
	Anal fin lower:	Anal fin higher:
Counts	12 to 13 anal rays	14 anal rays

It is obviously the prerogative of each individual to evaluate for himself these differences. All proportions and counts are shown in Tables 7 and 8 for this purpose. One character, however, needs present discussion. The branch of the coeliac mesenteric artery to the right gonad was never seen in S. lineolata. For the following reasons I am now of the opinion that this vessel was overlooked. This vessel is small, and enlarges with the onset of spawning. In none of the California specimens were the gonads approaching this condition, whereas all the Peruvian specimens were rapidly approaching a spawning condition. In the latter a number of segmentals were seen running from the dorsal aorta to the posterior half of both gonads, whereas in the California fish only one such segmental was seen running to the right gonad. I now believe that this was due to a partial and inadequate injection. Had the injection been complete, I am convinced that the branch of the coeliac mesenteric artery to the head of the right gonad would have likewise been seen.

It is my measured opinion that such differences as exist between S. lineolata and S. chiliensis should be considered as varietal or population differences, and that both varieties should be assigned to the same species. Without knowing the origin of a given specimen, one could not positively distinguish lineolata from chiliensis. The difference in the extent of the corselet, used by Walford to separate the two, was not corroborated by this material. In all cases the extent of the corselet was essentially the same in both. Since the two species are individually indistinguishable, the name chiliensis has priority, and lineolata can be reduced to synonymy.

5. THE GENUS SARDA

A casual survey of the literature on the bonitos of the world suggests that there are but two basic types, namely, the sarda-chiliensis complex and the orientalis-velox complex. Assuming that, in the following array of characters, S. sarda is comparable with chiliensis, then every described species appears to fit into one of these two groups, a conclusion approximated by Fraser-Brunner (1950). These two groups differ fundamentally, although subtly—in adult speciments—in the following manner:

sarda-chiliensis	orientalis-velox
Superficial diagnostic characters	
1. Gill teeth, or posterior rakers developed on first arch	No gill teeth developed on any arch
2. Posterior "U"-shaped portion of maxillary plus auxiliary maxillary as wide as long	Posterior "U"-shaped portion of maxillary plus auxiliary maxillary about half as wide as long
3. From 7 to 10 gill rakers on upper limb of first arch (excludes raker at angle of arch) Total count : 20 to 27	From 2 to 4 gill rakers on upper limb of first arch (excludes raker at angle of arch) Total count: 8 to 13
4. About 20 to 25 teeth on each side of lower jaw	About 10 to 15 teeth on each side of lower jaw
Superficial corroboratory characters	
5. Head length ÷ maxillary length = 1.86 to 1.93	Head length ÷ maxillary length = 2.05 to 2.18
Skeleton	
6. Glossohyal has a short longitudinal depression on ventral face of proximal portion	Glossohyal lacks this groove and face of bone is convex outwards
7. Auxiliary maxillary: greatest length ÷ greatest width = 3.00 to 3.83	Auxiliary maxillary: greatest length ÷ greatest width = 4.01 to 4.50
8. Clavicle: posteriorly projecting plate expanded near midlength, and tapered distally	Clavicle: posteriorly projecting plate of approximately uniform width
9. Hyomandibular: spine projecting posteriorly from center condyle slopes upwards	Hyomandibular: spine projecting posteriorly from center condyle slopes down, or at most, is perpendicular to shaft of bone
10. Vertebral column: can be positively identified by direct comparison of ventral processes (see Godsil, 1954, p. 65)	Vertebral column: can be positively identified by direct comparison of ventral processes, but probably not without other type for comparison

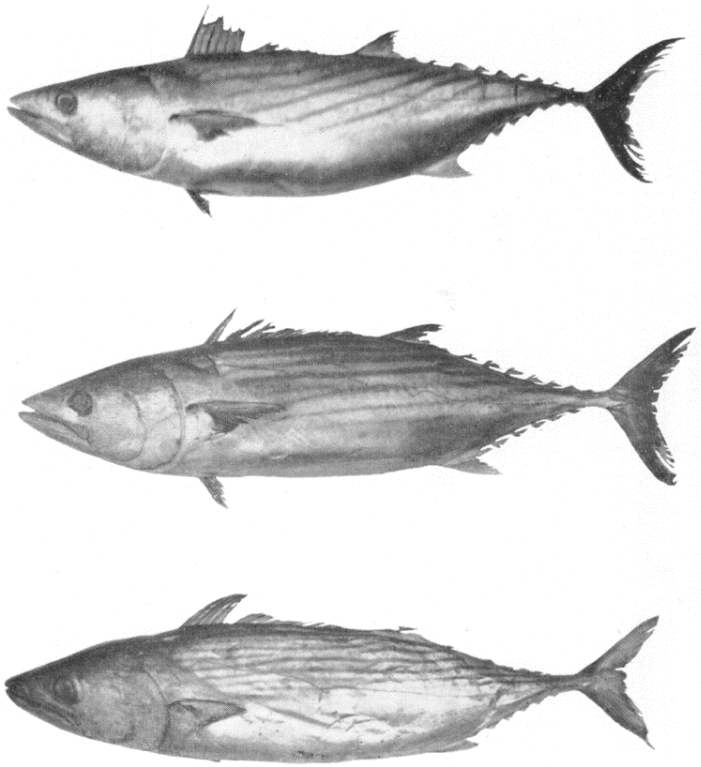

FIGURE 14. S. chiliensis top and center : S. orientalis bottom. This photograph is introduced to show the variation and unreliability of the dorsal markings as specific characters

This list of characters, embodying only my personal observations, calls for some qualifying remarks, and will require testing against future findings. It will be noted that the dorsal stripes are not included. While the markings are frequently of considerable diagnostic value, they are, in the writer's opinion, the cause of much of the confusion in the literature. The obliquity (and number) of stripes was extremely variable as evidenced by the photographs in Figure 14. Two of these specimens were S. chiliensis and one was S. orientalis. If one used the stripes to diagnose the species, two specimens would unquestionably be assigned to orientalis and one to chiliensis. This illustration affords a graphic argument.

In the case of gill rakers it is the count on the upper limb of the arch that is significant. That of the lower limb has the widest range and the least significance, and is inferior even to the total count.

Only one proportion is included in the list because all the others are overlapping, or nearly so.[1] Proportions change with body length, and can be used only when treated as regressions on body length. Otherwise, proportions are valid indices only for fish of the same size.

The several species described in the literature, have, unfortunately, been created upon varying proportional measurements and meristic counts and upon the type of dorsal markings, without regard to fundamental characters. Superficially it appears that chiliensis is nothing more than a geographic variation of sarda, while australis (to judge by a photograph) belongs in the orientalis-velox complex. If this is the case then there are truly only two types of bonito, and the specific separation of members within a group should depend entirely upon the constancy and magnitude of such meristic differences that exist. If sarda in reality has 20 to 22 first dorsal spines with no overlapping of the range in chiliensis, then the latter would merit specific separation. But if australis and velox integrate into orientalis in gill raker count, in number of precaudal vertebrae and in the other minor differences that appear to exist, then in the opinion of the writer there are no legitimate grounds for separating them specifically. A revision of the group should therefore await the investigation of these questions. Other than the elimination of lineolata, the writer proposes no present change.

[1] The ratios, head length ÷ diameter of iris, and head length ÷ distance from snout to posterior margin of eye, could, arbitrarily and legitimately be added to this list.

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