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[EIGHTH SERIES.]

"..... per litora spargite muscum,
Naiades, et circum vitreos considite fontes:
Pollice virgineo teneros hic carpite flores:
Floribus et pictum, divæ, replete canistrum.
At vos, o Nymphæ Craterides, ite sub undas;
Ite, recurvato variata corallia trunco
Vellite muscosis e rupibus, et mihi conchas
Ferte, Deæ pelagi, et pingui conchylia succo."

N. Parthenii Giannettusi, Eol. 1.

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I.—*The British Fishes of the Subfamily Clupeinæ and Related Species in other Seas.* By C. TATE REGAN, M.A.

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[Plates I.–III.]

I. SYSTEMATIC.

IN the 'Catalogue of Fishes' Günther included in the genus *Clupea* all the Clupeidæ with mouth terminal, teeth minute or absent, a complete mid-ventral series of scutes, and the anal fin of moderate length, with less than 30 rays.

This conception of a large, varied, and cosmopolitan genus is not well adapted for modern work on the relationships and distribution of the species, and it is generally recognized that the genus *Clupea* should be split up into several. But there is no general agreement as to the limits and contents of these genera, nor can there be until a thorough revision of the whole group has been made.

The present paper is a systematic revision of the three genera—*Clupea*, *Alosa*, and *Sardina*—represented on the coasts of Britain. In his memoir on the Clupeoids of the Caspian Sea (Ann. & Mag. Nat. Hist. (2) xi. 1913, pp. 472–480), L. Berg, Professor of Ichthyology in the Moscow

Ann. & Mag. N. Hist. Ser. 8. Vol. xviii.

Academy of Agriculture, has defined the genera that occur in Russian seas. It will be seen that I differ from him in uniting *Spratella* with *Clupea* and in separating *Sardina* from *Sardinella*; the last-named includes a number of tropical and subtropical species that differ from the sardines in more than one character, notably in that the operculum has a single groove near its anterior edge instead of several radiating grooves.

CLUPEA, Linn.

Elongate, compressed. Maxillary extending to below anterior part or middle of eye; lower jaw projecting; upper not notched; teeth minute. Operculum smooth. Dorsal fin of 15 to 21 rays; origin nearly equidistant from end of snout and base of caudal. Anal of 14 to 21 rays; two last rays not enlarged. Caudal forked; no enlarged caudal scales. Pelvics 7- to 10-rayed, inserted below or in advance of middle of dorsal. 44 to 65 scales in a longitudinal and 12 to 16 in a transverse series. Vertebrae 46 to 59.

In his classical research Heincke has discussed at length the variation and specific characters of the herring and sprat as found in the North Sea and the Baltic, and has summarized his conclusions on p. 59 of his second report (Viert. Ber. Comm. Unters. Meere, Kiel, 1882).

Some authors regard the sprat as the type of a genus, *Spratella*, distinct from *Clupea*, the principal difference being the absence of vomerine teeth. It is here shown that three closely related species from the Southern Hemisphere, which resemble the sprat rather than the herring in the number of fin-rays, scales, vertebrae, and gill-rakers, and in the form of the opercular bones, approach the herring in having the pelvic fins 8-rayed and the maxillary longer than in the sprat. Moreover, one of them, from Stewart Island, has the dentition of the herring, and another, from Magellan and the Falklands, has the ventral scutes weakly keeled, the vertebrae in increased number, and the pelvic fins often inserted a little behind the vertical from the origin of the dorsal fin, all characters of *C. harengus*.

It would be of considerable interest to ascertain whether these southern species show more resemblance to *C. harengus* or to *C. sprattus* in breeding-habits and structure of eggs.

There are some little fishes from the Black and Caspian Seas, three or four species in all, that bear a considerable resemblance to the sprat. Berg refers them to the genus *Harengula*, Val., which, according to his diagnosis, differs

from *Spratella* only in having the dorsal fin a little farther forward and the pelvic fins a little farther back. The only species of this group that I have seen (*Clupea delicatula*, Nordm.) differs from *Clupea* in the structure of the anal fin, which has the third last ray shorter than the one preceding it and the last two rays enlarged, almost forming separate finlets, just as in *Sardina* and *Sardinella*. This is an important character, and, in my opinion, shows that these little fishes are not at all closely related to *Clupea sprattus*, and do not belong to the genus *Clupea* as restricted above.

Synopsis of the Species.

- I. Pelvic fins 9- (rarely 8- or 10-) rayed, inserted behind vertical from origin of dorsal; præoperculum as broad as operculum; vomer toothed. Dorsal 17-21. Anal 14-20. Vertebrae 50-59. Gill-rakers on lower part of anterior arch, in adult, 40-51.

Ventral scutes keeled both in front of and behind pelvic fins 1. *harengus*.
 Ventral scutes in front of pelvic fins not keeled 2. *pallasii*.

- II. Pelvic fins inserted nearly in vertical from origin of dorsal; operculum broader than præoperculum. Dorsal 15-19. Anal 17-21. Vertebrae 46-51. Gill-rakers on lower part of anterior arch, in adult, 34-41.

A. Pelvic fins 8-rayed.

Vomer toothless; vertebrae 49-51 3. *fuegensis*.
 Vomer toothless; vertebrae 46 4. *bassensis*.
 Vomer toothed 5. *holodon*.

B. Pelvic fins 7-rayed; vomer toothless 6. *sprattus*.

1. *Clupea harengus*.

Clupea harengus, Linn. Syst. Nat. ed. 10, p. 317 (1758); Günth. Cat. Fish. vii. p. 415 (1868); Day, Fish. Britain, ii. p. 208, pl. cxxxviii. fig. 2 (1884); Smitt, Scandinavian Fish. p. 954, pl. xliii. fig. 1, & xliv. fig. 1 (1895); Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 421.

Depth of body from less than 4 to more than 5 times in the length, length of head $3\frac{1}{2}$ (young) to $4\frac{1}{2}$. Snout as long as or longer than diameter of eye, which is $3\frac{1}{2}$ to $4\frac{1}{2}$ in the length of head; maxillary extending nearly to below middle of eye, or sometimes beyond. An elongate-ovate patch of teeth on the vomer. 44 to 51 gill-rakers on lower part of anterior arch. Præoperculum nearly or quite as broad as operculum, which is narrower than diameter of eye. 55 to 65 scales in a longitudinal and 14 to 16 in a transverse series. Ventral scutes, except sometimes a few anterior ones, all distinctly keeled; 12 to 20 between pelvic fins and anus. Dorsal 17 to 21;

origin equidistant from end of snout and base of caudal or a little nearer the former. Anal 14 to 20. Pelvics 9- (8- to 10-) rayed, inserted below anterior part or middle of dorsal. Vertebrae 51 to 59 (54 to 59 in the few examples that I have examined). Silvery; back greenish.

Northern Europe and Iceland to New York and the Bay of Biscay.

Here described from numerous examples up to 400 mm. long.

2. *Clupea pallasii*.

Clupea pallasii, Cuv. & Val. Hist. Nat. Poiss. xx. p. 253 (1847); Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 422.

Clupea mirabilis, Girard, Proc. Ac. Philad. 1854, p. 138; Günth. Cat. Fish. vii. p. 418 (1868).

Closely related to *C. harengus*, differing especially in that the scutes in front of the pelvic fins are not keeled. 10 to 13 keeled scutes between pelvic fins and anus. Dorsal 18 to 19. Anal 14 to 18. 40 to 48 gill-rakers on lower part of anterior arch. 53 to 58 scales in a longitudinal series. Vertebrae 50 to 53 (50, 51, 52, 53 in four specimens examined).

North Pacific, from Bering Sea to San Diego, the middle of Hokkaido and Fusan.

Here described from ten examples, 160 to 300 mm. in total length, from Alaska and California.

3. *Clupea fuegensis*.

Clupea fuegensis, Jenyns, Zool. 'Beagle' Fish. p. 133 (1842); Smitt, Bihang. Svensk. Vet.-Akad. xxiv. 1898, iv. no. 5, p. 59, pl. v. fig. 41; Regan, Trans. R. Soc. Edinburgh, xlix. 1913, p. 231.

Depth of body 4 to 5 in the length, length of head 4 to $4\frac{1}{2}$. Snout as long as or a little longer than diameter of eye, which is nearly 4 in the length of head; maxillary extending nearly or quite to below middle of eye. An elongate patch of minute teeth on tongue; usually a series on palatines; vomer toothless. 38 to 40 gill-rakers on lower part of anterior arch. Præoperculum narrower than operculum, which is as broad as diameter of eye. About 50 scales in a longitudinal and 14 in a transverse series; ventral scutes feebly keeled and not sharply pointed, 22 to 25 + 10 to 13. Dorsal 16 to 18. Anal 17 to 20. Pelvics 8-rayed, inserted in or a little behind the vertical from origin of dorsal, rarely a little in advance of it. Vertebrae 49 to 51.

Magellan; Falklands.

Several examples, 140-170 mm. in total length, from the Falklands.

4. *Clupea bassensis*.

Clupea bassensis, McCulloch, Biol. Res. 'Endeavour,' i. 1911, p. 16, pl. iv. fig. 2.

Scarcely distinct from *C. fuegensis*, but vertebræ fewer (46) and scutes more strongly keeled. Scales 46 to 48 in a longitudinal, 12 to 14 in a transverse series. Pelvic fins inserted a little in advance of vertical from origin of dorsal.

South Australia and Tasmania.

Two examples, 110 and 130 mm. in total length, from Hobart.

5. *Clupea holodon*, sp. n.

Depth of body $4\frac{1}{4}$ in the length, length of head $4\frac{1}{4}$. Snout a little longer than diameter of eye, which is nearly 4 in the length of head; maxillary extending to below anterior $\frac{1}{3}$ of eye. An ovate patch of teeth on vomer, a single series on palatines, a broad-ovate patch on tongue. 36 gill-rakers on lower part of anterior arch. Præoperculum narrower than operculum, which is as broad as diameter of eye. About 48 scales in a longitudinal and 14 in a transverse series; ventral scutes keeled and pointed, 21+12. Dorsal 17. Anal 18. Pelvics 8-rayed, inserted below origin of dorsal.

Stewart Island, New Zealand.

A single example, 122 mm. in total length, from Stewart Island, presented in 1889 by C. Traill, Esq.

6. *Clupea sprattus*.

Clupea sprattus, Linn. Syst. Nat. ed. 10, p. 318 (1758); Günth. Cat.

Fish. vii. p. 419 (1868); Day, Fish. Britain, ii. p. 231, pl. cxxxix. fig. 2 (1884); Smitt, Scandinavian Fish. p. 974 (1895).

Meletta phalerica (Risso), Moreau, Poiss. de France, iii. p. 445 (1881).

Meletta vulgaris, Moreau, t. c. p. 447.

Clupea sulinæ, Antipa, Denkschr. Akad. Wien, lxxviii. 1906, p. 38, pl. iii. figs. 1-6.

Depth of body $3\frac{1}{2}$ to $5\frac{1}{2}$ in length, length of head $3\frac{3}{4}$ (young) to $5\frac{1}{5}$. Snout as long as or a little longer than diameter of eye, which is $3\frac{1}{3}$ to $4\frac{1}{4}$ in the length of head. Maxillary extending to below anterior $\frac{1}{3}$ of eye. No teeth or vomer. 34 to 40 gill-rakers on lower part of anterior arch. Præoperculum narrower than operculum, which is as broad as diameter of eye. 44 to 50 scales in a longitudinal and 12 to 15 in a transverse series. Ventral scutes keeled and pointed; 9 to 13 between pelvic fins and anus. Dorsal 15 to 19;

origin a little nearer to base of caudal than to end of snout. Anal 17 to 21. Pelvics 7-rayed, inserted below or a little in advance of origin of dorsal. Vertebrae 46 to 49.

Western and Southern Europe, from Norway to the Black Sea.

Numerous examples up to 175 mm. in total length.

In specimens from the Black Sea, Dalmatia, and Nice I count respectively 48, 48, and 49 vertebrae.

ALOSA, Cuv., 1829.

Règne Animal, ed. 2, ii. p. 319.

Deep or elongate, compressed; abdomen sharp-edged. Mouth large, the maxillary extending to below posterior part of eye; lower jaw included; upper with median notch; teeth minute or absent, none on vomer. Operculum with grooves radiating towards suboperculum. Dorsal fin of 16 to 22 rays; origin nearer to end of snout than to base of caudal; a low basal sheath, not extending upwards on last ray. Anal of 18 to 27 rays; basal sheath low; two last rays not enlarged. Caudal forked; lobes scaly; a pair of enlarged scales on each side. Pelvics 9-rayed, inserted below anterior part of dorsal. 55 to 86 scales in a longitudinal and 16 to 26 in a transverse series; ventral scutes prominent, with strong keels ending posteriorly in sharp points. Vertebrae 52 to 59.

North Atlantic and Mediterranean.

Clupeonella, Kessler, with four species from the Black Sea and nine from the Caspian (Berg, Ann. & Mag. Nat. Hist. (8) xi. 1913, pp. 472-480), differs from *Alosa* in having three patches of teeth on the palate, borne by the vomer and palatine bones. The value of this character is somewhat discounted by the fact that two closely related species of *Clupea* (*C. bassensis* and *C. holodon*) scarcely differ except in this respect; also I find that in large adult specimens of *Clupeonella caspia* the palate is toothless. *Pomolobus*, Raf., with four species from the Atlantic coast of North America, is distinguished from *Alosa* principally by the prominent lower jaw, its tip not included within the upper.

The species of all three groups appear to be migratory, spawning in fresh water, and perhaps *Alosa* and *Clupeonella* should rank only as subgenera of *Pomolobus*.

It is generally recognized that there are two species of shad on the Atlantic coast of Europe—*A. alosa*, L., and *A. finta*, Cuv., the former differing from the latter especially in the more numerous gill-rakers, and also in the somewhat

deeper form, smaller scales, and longer anal fin. Hoek (Tijdschr. Nederl. Dierk. Vereen. (2) vi. 1900, pp. 212-240) has published the results of a detailed examination of a large number of examples of these two species from the Rhine; the characters given by him hold good for specimens of both species from the coasts of the British Isles and Portugal. But the material in the British Museum collection indicates that *A. alosa* may be replaced on the coasts of Morocco and Algeria by a form with fewer gill-rakers, and that in the same regions *A. finta* is represented by a race with the gill-rakers in slightly greater number, and in the Mediterranean by another race with fewer gill-rakers than the typical form; moreover, both these southern forms of *A. finta* have the body as deep as in *A. alosa*. *A. finta* has also given rise to non-migratory colonies, one in the Lakes of Killarney, a second in Lakes Maggiore and Lugano, and a third in Lake Garda. All these lacustrine races have the gill-rakers in increased number, but whereas the Killarney shad is deeper in form than the typical *A. finta*, the Italian ones are more slender than the migratory shad of the Mediterranean.

The problem of species and subspecies is a difficult one, and it is not pretended that the course here adopted has finally solved it.

Synopsis of the Species and Subspecies *.

I. 21 to 26 scales in a transverse series.

- 55-85 gill-rakers on lower part of anterior arch . 1. *alosa*.
45 gill-rakers on lower part of anterior arch 2. *africana*.

II. 16-20 scales in a transverse series.

A. American.

- a. 60-70 gill-rakers on lower part of anterior arch. 3. *sapidissima*.
b. 40-50 gill-rakers on lower part of anterior arch.

- Depth $3-3\frac{1}{2}$ in the length 4. *alabamæ*.
Depth $3\frac{1}{2}-4\frac{1}{2}$ in the length 4 a. *alabamæ ohiensis*.

B. Eastern Atlantic and Mediterranean.

- 24-27 gill-rakers; depth $3\frac{2}{5}-4\frac{1}{4}$ 5. *finta*.
33 gill-rakers; depth 3 5 a. *finta killarnensis*.
29 gill-rakers; depth 3 5 b. *finta algeriensis*.
20-23 gill-rakers; depth $3-3\frac{3}{4}$ 5 c. *finta nilotica*.
30-34 gill-rakers; depth about $4-4\frac{1}{2}$ 5 d. *finta lacustris*.
36-40 or more gill-rakers; depth $4\frac{2}{3}$ 5 e. *finta gracilis*.

* This synopsis applies to specimens of 200 mm. or more. Smaller fishes have fewer gill-rakers and may be more slender.

1. *Alosa alosa*, Linn.

Clupea alosa (part.), Linn. Syst. Nat. ed. 10, p. 318 (1758).

Clupea alosa, Günth. Cat. Fish. vii. p. 433 (1868); Day, Fish. Britain, ii. p. 235, pl. cxl. (1884); Hoek, Tijdschr. Nederl. Dierk. Vereen. (2) vi. 1900, pp. 182-240.

Alosa vulgaris, Moreau, Poiss. de France, iii. p. 453 (1881).

Depth of body 3 to 4 in the length, length of head $3\frac{3}{4}$ to $4\frac{1}{2}$. Dorsal 18 to 21. Anal 22 to 27. 70 to 86 scales in a longitudinal and 22 to 26 in a transverse series. 55 to 85 gill-rakers on lower part of anterior arch.

Coast of Europe, from Norway to Portugal.

Eight specimens examined, 200-500 mm. in total length.

2. *Alosa africana*, sp. n.

Depth of body $3\frac{1}{2}$ in the length, length of head $3\frac{3}{4}$. 45 gill-rakers on lower part of anterior arch. Dorsal 19. Anal 25. 68 scales in a longitudinal and 22 in a transverse series.

A single specimen, 300 mm. in total length, from Algeria (*Playfair*).

A smaller example, 140 mm. from Mogadore, is very similar, but has only 33 gill-rakers on the lower part of the anterior arch (*A. alosa* of this size would have 40 to 50).

Günther (Cat. Fish. vii. p. 36) has described a fish of 470 mm., without locality, as a hybrid between *A. alosa* and *A. finta*. This is, perhaps, correct, as Hoek has shown that specimens with an intermediate number of gill-rakers occur in the Rhine. My material is insufficient for determining the characters that distinguish *A. africana* from *A. alosa* × *A. finta*; but the improbability that this hybrid should be represented in the collection of the British Museum by two African specimens and *A. alosa* by none from Africa is so great that I have but little doubt that these examples belong to a southern species standing in much the same relation to *A. alosa* that *A. alabamæ* does to *A. sapidissima*.

3. *Alosa sapidissima*, Wilson.

Alosa sapidissima, Jord. & Everm. Bull. U.S. Nat. Mus. xlvii. 1896, p. 427, fig. 191.

Depth of body 3 to $3\frac{1}{2}$ in the length, length of head $3\frac{3}{4}$ to $4\frac{1}{2}$. Dorsal 17 to 19. Anal 20 to 22. 55 to 62 scales in a longitudinal, 18 or 19 in a transverse series. 60 to 68 gill-rakers on lower part of anterior arch.

Atlantic coast of U.S.A.

Four specimens examined, 300-400 mm. in total length.

4. *Alosa alabamæ*, Jord. & Everm.

Alosa alabamæ, Jord. & Everm. Rep. U.S. Fish. Comm. 1895, p. 203;
Bull. U.S. Nat. Mus. xlvii. 1898, p. 2810, figs. 192, 192 a.

Differs from the preceding only in the fewer gill-rakers, less than 50 on lower part of anterior arch.

Alabama River and Pensacola, Florida.

4 a. *Alosa alabamæ ohiensis*, Everm.

Alosa ohiensis, Evermann, Rep. U.S. Fish. Comm. 1901, p. 277, figs. 1, 2 (1902).

More slender than typical *A. alabamæ*, the depth $3\frac{1}{2}$ to $4\frac{1}{2}$ in the length. 43 to 49 gill-rakers on lower part of anterior arch.

Total length 350–450 mm.

Mississippi.

5. *Alosa finta*, Cuv.

Clupea finta (part.), Cuv. Règne Anim. ed. 2, ii. p. 320 (1829);
Günth. Cat. Fish. vii. p. 435 (1868); Day, Fish. Britain, p. 236,
pl. cxli. (1884).

Alosa finta (part.), Moreau, Poiss. de France, iii. p. 456 (1881).

Depth of body $3\frac{2}{5}$ to $4\frac{1}{4}$ in the length, length of head $3\frac{3}{4}$ to $4\frac{1}{3}$. 24 to 27 gill-rakers on lower part of anterior arch. Dorsal 16 to 20. Anal 19 to 23. 55 to 65 scales in a longitudinal, 16 to 20 in a transverse series. Ventral scutes 20 to 23 + 13 to 16.

Atlantic coast of Europe.

Several specimens from Britain and Portugal, up to 380 mm. in total length.

5 a. *Alosa finta killarnensis*, subsp. n.

Depth of body 3 in the length, length of head 4. 33 gill-rakers on lower part of anterior arch. Dorsal 17 to 19. Anal 19 to 21. 55 to 60 scales in a longitudinal, 17 to 19 in a transverse series. Ventral scutes 21 to 22 + 15 to 16. Silvery; back purplish; a dark humeral spot; a lateral series of about seven vertically expanded dark spots running from behind operculum towards posterior end of anal fin.

Killarney.

A specimen of 210 mm. taken in January 1912. Two smaller examples, 155 mm. long, taken in November 1875, have the depth of the body $3\frac{1}{2}$ in its length and 30 gill-rakers on the lower part of the anterior arch.

5 b. *Alosa finta algeriensis*, subsp. n.

Depth of body 3 in the length, length of head 4. 29 gill-rakers on lower part of anterior arch. Dorsal 18. Anal 22. 58 scales in a longitudinal, 20 in a transverse series. Scutes 21 + 15.

A single specimen, 300 mm. in total length, from Algeria (*Playfair*). A young fish of 170 mm. from Mogadore has the depth $3\frac{2}{3}$ in the length and 24 gill-rakers on the lower part of the anterior arch; it seems more likely that it pertains to this race than to the typical *A. finta*.

5 c. *Alosa finta nilotica*, Geoffr.

Clupea nilotica, I. Geoffr. Descr. Egypte Poiss. p. 286, pl. x. fig. 1 (1827).

Clupea finta, Bouleng. Cat. Afr. Freshwater Fish. i. p. 154, fig. 123 (1909).

Depth of body 3 to $3\frac{3}{4}$ in the length, length of head $3\frac{2}{3}$ to $4\frac{2}{5}$. 20 to 23 gill-rakers on lower part of anterior arch. Dorsal 17 to 20. Anal 20 to 24. 55 to 63 scales in a longitudinal, 18 to 20 in a transverse series. Scutes 20 to 24 + 14 to 15.

Mediterranean.

Several examples, up to 420 mm. in total length, from Egypt, Constantinople, and the Adriatic. From Moreau's enumeration of the gill-rakers (Poiss. de France, iii. p. 456), it seems that this form occurs also on the Mediterranean coast of France. The two examples from Algeria listed by Boulenger are not of this subspecies—one has 29, the other 45 gill-rakers on the lower part of the anterior arch.

5 d. *Alosa finta lacustris*.

Alosa vulgaris, Pavesi, Pesci e Pesca Ticino, p. 54 (1872).

Alosa finta, var. *lacustris*, Fatio, Faune Vert. Suisse, v. p. 51 (1890).

Depth of body 4 to $4\frac{1}{2}$ in the length, length of head 4. 30 to 34 gill-rakers on lower part of anterior arch. 63 to 70 scales (? including some on base of caudal) in a longitudinal and 17 to 20 in a transverse series. Ventral scutes 38 to 41. Vertebrae 59.

Lakes Maggiore, Como, and Lugano.

Length 160–300 mm. or more.

5 e. *Alosa finta gracilis*, subsp. n.

Depth of body $4\frac{2}{3}$ in the length, length of head 4. 36 gill-rakers on lower part of anterior arch. Dorsal 17 to 19.

Anal 19 to 21. 55 to 60 scales in a longitudinal, 17 or 18 in a transverse series. Scutes 23 or 24 + 14 to 16. Silvery; back bluish.

Lake Garda.

Here described from a specimen of 150 mm.

Two others, 100 and 125 mm. long, have respectively 28 and 32 gill-rakers on the lower part of the anterior arch.

Pavesi ('Pesci e Pesca Ticino,' 1872) quotes Canestrini to the effect that there may be as many as 61 gill-rakers on the anterior arch (*i. e.* about 40 on the lower part); this form is said to attain a length of 400 mm., and it is probable that in specimens of that size the number of gill-rakers is still greater.

SARDINA, Antipa, 1906.

Denkschr. Akad. Wien, lxxiii. p. 54.

Clupanodon (part.), Lacép. Hist. Nat. Poiss. v. p. 468 (1803); Jordan & Evermann, Bull. U.S. Nat. Mus. xlvii. 1896, p. 423 (nec Jord. & Gilb. 1883).

Elongate, moderately compressed; abdomen not sharp-edged. Mouth moderate, the maxillary not extending beyond middle of eye; lower jaw not prominent; upper without or with slight median notch; teeth minute or absent, none on vomer. Eye with well-developed adipose lids. Operculum with grooves radiating towards suboperculum. Dorsal fin of 16 to 20 rays, highest anteriorly, in the middle of the length of the fish, its origin nearer to end of snout than to base of caudal; a scaly sheath at base extending to tip of last ray. Anal of 16 to 20 rays, low, depressible in a scaly sheath; two last rays enlarged. Caudal forked; on each side enlarged scales at the inner edge of the scaly part of each lobe. Pectorals scaly at base; pelvics 8-rayed, inserted below middle or posterior part of dorsal. About 54 scales in a longitudinal and 10 to 14 in a transverse series; ventral scutes keeled, but not projecting beyond the edges of the groove in which they lie. Vertebrae 50 to 53.

Synopsis of the Species and Subspecies.

- I. Scales unequal, the oblique rows alternately of larger and smaller scales, the former covering the latter, so that 30 or less are counted in a longitudinal series.

More than 60 gill-rakers on lower part of anterior arch	1. <i>pilchardus</i> .
Not more than 60 gill-rakers on lower part of anterior arch	1 a. <i>pilchardus sardina</i> .

II. Scales all exposed, about 54 in a longitudinal series.

Head $3\frac{1}{3}$ to 4 in length; maxillary nearly or quite reaching middle of eye, in adults; 70 (young) to 110 gill-rakers on lower part of anterior arch 2. *sagax*.

Head $3\frac{2}{3}$ to $4\frac{1}{2}$ in length; maxillary not reaching middle of eye; 60 (young) to 75 gill-rakers on lower part of anterior arch . 3. *neopilchardus*.

Authors who have described *Sardina pilchardus* from specimens that had lost their scales, and who have therefore counted the scale-pockets, have assigned to it more than 50 scales in a longitudinal series (*e.g.*, Günther, Antipa); others who have examined better-preserved material have counted 30 scales or less in a longitudinal series. The explanation of this is that the scales are unequal in size and the smaller ones are hidden by the larger; every oblique row that is visible conceals the row behind it, which is formed of smaller scales.

In some examples the scales in certain areas may be of equal size, or nearly so, and in rare cases nearly all the scales of one side may be equal and regularly arranged, as in the example described and figured by Day (P. Z. S. 1887, p. 129, pl. xv.) as a hybrid pilchard and herring. This is a typical *Sardina pilchardus*, except that on one side it is scaled almost as in *S. sagax*, *i. e.*, nearly all the scales are exposed and one can count more than 50 in a longitudinal series; but a few anterior scales on the upper part of the side have the *S. pilchardus* arrangement.

1. *Sardina pilchardus*.

Clupea pilchardus, Walbaum, Artedi Pisc. iii. p. 38 (1792); Günth. Cat. Fish. vii. p. 439 (1868); Day, Fish. Britain, ii. p. 224, pl. cxxxix. (1884).

Depth of body 4 to 5 in the length, length of head $3\frac{3}{4}$ to $4\frac{1}{2}$. Snout as long as or longer than diameter of eye, which is $3\frac{1}{2}$ to $4\frac{1}{2}$ in length of head; maxillary extending to below anterior $\frac{1}{4}$ or $\frac{1}{3}$ of eye, sometimes a little beyond; depth of cheek (from eye to anterior end of præoperculum) not greater than diameter of eye. 63 (young) to 88 gill-rakers on lower part of anterior arch. Scales unequal, the oblique rows alternately of larger and smaller scales, the former nearly or quite concealing the latter. Vertebrae 52 or 53. Silvery or golden; back greenish or bluish; a dark humeral spot often followed by a series which may be invisible unless the scales be removed.

Atlantic coast of Europe from Portugal northward to the British Isles.

In examples from Cornwall, 180–220 mm. in total length, I count 69 to 88 gill-rakers on the lower part of the anterior branchial arch; in specimens from Santander and Coruña, 150–180 mm. long, I find 66 to 82, and in young fish of 110 mm. 63 and 65.

The Cornish specimens of 220 mm. are of about the size usually attained, but not infrequently examples of 250 mm. or more may be captured, and one of 350 mm. has been recorded.

1 a. *Sardina pilchardus sardina*.

Clupanodon sardina, Risso, Hist. Nat. Eur. Mérid. p. 451 (1826).

Clupea pilchardus, var. *sardina*, Günth. Cat. Fish. vii. p. 440 (1868).

Sardina dobrogica, Antipa, Denkschr. Akad. Wien, lxxiii. 1906, p. 42, pl. iii. figs. 7–11.

Distinguished from the typical form by the fewer gill-rakers, not more than 60 on the lower part of the anterior branchial arch.

South-western part of the Black Sea; Mediterranean; Atlantic coast of Morocco; Madeira; Canary Isles.

In specimens from Constantinople (140–150 mm.) I find 55 to 60 gill-rakers on the lower part of the anterior arch, from the Adriatic (110–180 mm.) 50 to 60, and from Madeira (175–180 mm.) 54 to 57.

180 mm. seems to be about the maximum size attained by this form.

2. *Sardina sagax*. (Pl. I. fig. 1.)

Clupea sagax, Jenyns, Zool. 'Beagle,' Fish. p. 134 (1842); Günth. Cat. Fish. vii. p. 443 (1868); Gilchrist, Marine Biol. Rep. S. Afr. i. p. 57, fig. (1913).

Clupea melanosticta, Schlegel, Faun. Japon. Poiss. p. 237, pl. cviii. fig. 3 (1846); Kishinouye, Journ. Imp. Fisheries Bureau, Tokyo, xiv. 1907, pp. 71, 94, pl. xvii.

Clupea ocellata, Pappé, Fish. Cape of Good Hope, p. 20 (1853).

Clupanodon cæruleus (Giard, 1854), Jordan & Evermann, Bull. U.S. Nat. Mus. xlvii. 1896, p. 423.

Depth of body 4 to 5 in the length, length of head $3\frac{1}{3}$ (young) to 4. Snout longer than diameter of eye, which is 4 to 5 in length of head; in adults maxillary extending nearly or quite to below middle of eye and depth of cheek (from eye to anterior end of præoperculum) greater than diameter of eye. 70 (young) to 110 gill-rakers on lower part of anterior arch. Scales normally arranged, becoming quite small towards the base of the caudal fin. Vertebrae 50 to 52.

Silvery or golden; back greenish or bluish; a small dark spot at base of each scale on back; often a series of larger spots running backwards from the shoulder.

Chile and Peru; Pacific coast of U.S.A. and Lower California; Japan; South Africa.

I have examined a fair series of examples: from Chile six, 125–290 mm. in length (to end of middle caudal rays); from California twelve, 150–260 mm.; from Japan more than twenty, 115–210 mm.; and from South Africa six, 160–210 mm. The specimen figured, 210 mm. long, is from South Africa.

I have counted the vertebræ in several, and I find in one from Chile 52; three from California 51, 52, 52; four from Japan 50, 50, 50, 51; and two from South Africa 51, 51.

In specimens from Chile (125–290 mm.) I count 75 to 110 gill-rakers on the lower part of the anterior branchial arch, from California (150–260 mm.) 80 to 100, from Japan (115–210 mm.) 70 to 100, from South Africa (160–210 mm.) 100 to 105.

It is not improbable that a statistical study of a large series of specimens would lead to the definition of the Japanese (*S. melanosticta*), Californian (*S. cærulæa*), and South African (*S. ocellata*) pilchards as subspecies not fully identical with the typical *S. sagax* from Chile.

The close relationship of this species to *S. pilchardus* is shown not only by the structure of the adult fish, but the eggs and larvæ also are precisely similar (*vide* Kishinouye), and their growth, food, migrations, etc., are the same.

3. *Sardina neopilchardus*. (Pl. I. fig. 2.)

Clupea neopilchardus, Steind. Denkschr. Akad. Wien, xli. 1879, p. 12
Waite, Rec. Canterbury Mus. i. 1911, p. 158.

Clupanodon neopilchardus, Stead, Fishes of Australia, p. 28, fig. 10
(1906); Edible Fish. N.S. Wales, p. 25, pl. iv. (1908).

Closely related to *S. sagax*, differing as follows:—Length of head $3\frac{2}{3}$ (young) to $4\frac{1}{2}$ in the length of the fish. Maxillary extending to below anterior $\frac{1}{4}$ or $\frac{1}{3}$ of eye; depth of cheek not greater than diameter of eye, even in adults. 60 (young) to 75 gill-rakers on lower part of anterior arch.

Western, Southern, and Eastern Australia; New Zealand.

Twelve examples, 110–230 mm. in total length, from New South Wales and New Zealand; the largest specimen, from Wellington, is figured.

II. GEOGRAPHICAL DISTRIBUTION.

In the report on the 'Terra Nova' fishes I gave a general account of the distribution of Antarctic and Subantarctic fishes, and I came to the conclusion that to illustrate the distribution of coast-fishes south of the tropics three zones might be recognized—Antarctic, Subantarctic, and South Temperate; the northern boundaries of these are the mean annual surface-isotherms of 6° , 12° , and 20° C. respectively.

In the Northern Hemisphere the problem is more complicated, and it is more difficult to limit and define the zones of distribution; but, if we regard the isotherms of 12° and 20° C. as bounding the Temperate Zones both in the north and the south, we find that the genus *Sardina* may be described as inhabiting the North and South Temperate Zones, barely overstepping their limits (cf. map, Pl. II.).

Sardina is absent from the Western Atlantic and from China and the west of Corea; the reason for this is unknown, but in the Western North Atlantic the meeting of the Labrador Current and the Gulf Stream produce a sudden transition from subarctic to almost tropical conditions, and the absence of *Sardina* may be connected with this.

The wide distribution of this genus is of interest when the close relationship of the species, and especially the practical identity of the pilchards of South Africa, Japan, California, and Chile, is taken into consideration.

The species are not oceanic, but may be found 50 miles or more from land. The eggs are pelagic and the young fish swim at the surface, so that one can understand how a South American species may have reached New Zealand or South Africa; but the crossing of the Tropical Zone would be more difficult.

There is good evidence that in comparatively recent times the limits of the Temperate Zones have fluctuated considerably. To take only one example, the trout (*Salmo trutta*) of the Atlantic coast of Europe ranges southward as a marine fish to the Bay of Biscay, not much south of the normal northern limit of the pilchard (*Sardina pilchardus*). But the presence of a trout in the rivers of Morocco indicates that not long ago sea-trout ranged as far to the south as the pilchard does now, and at that time the ancestral pilchard may, perhaps, have extended into the area of the present Tropical Zone.

Fishes that descend to considerable depths are less likely than shallow-water species or surface-swimmers to find the Tropical Zone an impassable barrier. It is therefore of some interest to note that Day has written of *Sardina pilchardus*:—

"During the colder months of the year they are frequently found in the stomachs of large ground-fish that have been taken with ground-lines some distance from the shore"; whilst Kishinouye writes of *S. sagax*, "We are told by fishermen that the sardine is often found in the stomach of deep-sea fishes, such as mutsu (*Scombrops chilodipteroides*), gisu (*Pterothrissus gisu*), and tara (*Gadus brandti*)."

It does not seem likely that under present conditions there is any interchange between the different colonies of *Sardina sagax*, Chilean, Californian, Japanese, and South African; but under somewhat different conditions this may not have been the case—with a warmer northern climate *Sardina sagax* may have had a continuous range in the northern part of the Pacific. On the other hand, a contraction of the Tropical Zone on the Pacific coast of America may have permitted an interchange of Chilean and Californian pilchards migrating in moderately deep water. *S. neopilchardus* may have evolved from *S. sagax* in the seas of Australia and New Zealand, whilst the latter has persisted without such conspicuous modifications in the other parts of its range.

Alosa has a much more restricted distribution than *Sardina*, as it occurs only in the North Atlantic and the Mediterranean. Southwards it extends a short distance into the Tropical Zone and northwards it ranges in the summer months well into the Subarctic Zone.

The more restricted distribution and the greater tendency to form local races of *Alosa* as compared with *Sardina* are no doubt correlated with the biological difference between the two genera, that the shads breed in fresh water and the young live in the rivers for a year or two before migrating to the sea, whilst the pilchards are strictly marine and have pelagic eggs and young. The local forms with a most restricted distribution are, of course, the non-migratory lacustrine colonies, such as the shads of Killarney or of Lake Garda.

Clupea harengus of the North Atlantic is closely related to *C. pallasii* of the North Pacific. Both species extend into the Arctic Zone, but neither is found on the northern coasts of Asia or America; southwards they range throughout the Subarctic Zone, and somewhat overstep its southern boundary. There can be little doubt that under somewhat milder climatic conditions the ancestral herring ranged along the whole northern coast of Eurasia and, perhaps, of America; it is not surprising that the herrings, belonging to the colder northern seas, are not represented in the Southern Hemisphere.

Clupea sprattus, of Western and Southern Europe, has a more southerly distribution than *C. harengus*, but does not

range so far south as *Sardina pilchardus*; it is not represented on the Atlantic coast of North America nor in the North Pacific, but it is represented on the coasts of Patagonia, Tasmania, and Stewart Island respectively by three species that are more closely related to each other than either is to *C. sprattus*. The greater distinctness of the northern and southern species, as compared with *Sardina*, may be correlated with their greater remoteness and colder habitat.

III. BIOLOGY AND ECONOMICS.

Owing to their economic value the life-history of the European Clupeidæ has been extensively studied, especially in the North Sea. One need only mention the researches of Hjort and Lea on the herring, Sund on the sprat, and Hoek on the shads. But a fact that may, perhaps, be emphasized is that the exotic species of *Sardina* resemble the European pilchard, not only in the structure of the adult fish, but in that of the eggs and larvæ, and also in their biology—growth, food, migrations, etc.,—and that the Australian and South African species could certainly be made use of in the same way as the European one.

I have examined the scales of a considerable number of specimens, with a view to testing whether their structure agrees with what is known as to the rate of growth; a complete examination of the scales of all the pilchards in the British Museum collection would not be worth the time expended on it, for to get a clear idea of the growth and age of the species in any one locality it would be necessary to examine large samples taken from different shoals throughout the year*.

Marion (Ann. Mus. Marseilles, iv. 1891, fasc. 1, pp. 99–108, fasc. 2, pp. 66–72) has shown that in the Mediterranean *Sardina pilchardus sardina* breeds from January to May, and that the earliest fry, hatched in March, may attain a length of as much as 120–140 mm. by the end of the year, whilst those hatched in June reach only 80–90 mm. in December. Scales of specimens from Trieste, Dalmatia, Barcelona, and Madeira bear this out, the first winter ring corresponding to a length of 100–140 mm. (Pl. III. figs. 1, 3, 7); the largest examples, 180 mm., have from 3 to 5 winter rings. A few examples from Constantinople indicate that the average rate

* In a recent paper (Arch. Zool. lii. 1913, pp. 305–341) Fage has published the results of investigations on the biology and scales of *S. pilchardus*.

of growth in the Black Sea may be slower and that a greater age may be attained; they measure 135–155 mm. in length, and their scales have 3 to 6 winter rings (Pl. III. figs. 8, 9).

According to Cunningham ('Marketable Marine Fishes,' p. 168) *Sardina pilchardus* breeds at the mouth of the Channel from June to October. It might, therefore, be expected that the first winter ring would be formed at a smaller size than in the Mediterranean race, and this proves to be the case; in the scales that I have seen it corresponds to a length of 90 to 110 mm. (Pl. III. figs. 2, 6); specimens 200–220 mm. long have from 5 to 8 winter rings. Scales of *S. pilchardus* from Santander and Coruña (Pl. III. figs. 4, 5) are essentially similar to those from Cornwall.

Kishinouye has given a most interesting account of the biology of the Japanese pilchard (*S. sagax*). According to him the breeding-season is from February to May, and the young fish may attain a length of more than 120 mm. by the end of the year and 150 mm. in the second year; this is confirmed by the scales that I have examined (Pl. III. figs. 10, 11), but not his conclusion that the maximum size of 250 mm. may be reached in four or five years. In other parts of its range the growth of *S. sagax* appears to be much the same as in Japan, and *S. neopilchardus* (Pl. III. fig. 12) is essentially similar.

The fact that the structure of the scales conforms so well to what is known of the rate of growth of the species may be regarded as confirming, if any confirmation were necessary, the soundness and accuracy of the methods used by Lea in his researches on the herring.

The fishes of the genus *Sardina* are of great economic value. *Sardina pilchardus* is the basis of the sardine industries of France and Portugal and the pilchard fishery of Cornwall. The Japanese, who rival the Norwegians in their utilization of the resources of the sea, regard *Sardina sagax* as their most important fish. According to Kishinouye it is appreciated as a nutritious and palatable food, and enormous quantities are pressed for oil or dried for manure; also the immature fish are tinned in oil and exported as "Japanese sardines." In California the same species is canned and sold as "Californian pilchards."

Hitherto very little use appears to have been made of the pilchards of South Africa, Australia, and New Zealand, although they are very abundant; perhaps in the future sardine industries will become established in those parts of the British Empire.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. *Sardina sagax*, S. Africa, 210 mm.

Fig. 2. *Sardina neopilchardus*, New Zealand, 230 mm.

PLATE II.

Distribution of *Sardina*. The mean annual surface-isotherms of 6°, 12°, and 20° C. are shown. // // // //, *S. pilchardus*; \ \ \ \ \, *S. pilchardus sardina*; ≡, *S. sagax*; |||||, *S. neopilchardus*.

PLATE III.

Diagrams of scales of *Sardina*.

Fig. 1. *S. pilchardus sardina*, Barcelona, 140 mm.

Fig. 2. *S. pilchardus*, Cornwall, 200 mm. (specimen figured by Day, P. Z. S. 1887, pl. xv.).

Fig. 3. *S. pilchardus sardina*, Trieste, 140 mm.

Fig. 4. *S. pilchardus*, Santander, 175 mm.

Fig. 5. *S. pilchardus*, Coruña, 160 mm.

Fig. 6. *S. pilchardus*, Cornwall, 210 mm.

Fig. 7. *S. pilchardus sardina*, Madeira, 180 mm.

Figs. 8, 9. *S. pilchardus sardina*, Constantinople, 140 mm.

Figs. 10, 11. *S. sagax*, Japan, 200 and 190 mm.

Fig. 12. *S. neopilchardus*, Wellington, N.Z., 230 mm.

II.—*Rhynchotal Notes*.—LX. By W. L. DISTANT.

HOMOPTERA.

Fam. Membracidæ (continued from vol. xvii. p. 330).

Oxyrhachis tenebrosus.

Centrotus tenebrosus, Walk. List Hom. ii. p. 623 (1851).

Hab. Sierra Leone.

Oxyrhachis lamborni, sp. n.

Body and legs piceous brown; tibiæ brownish ochraceous; pronotal carinations paler, more than apical half of posterior pronotal process blackish; membrane subhyaline, the base and costal margin brownish ochraceous, remaining venation and a small spot at posterior angle of inner tegminal margin piceous; pronotum thickly finely punctate, centrally carinate, the lateral processes broad, obtusely acute, a little upwardly



Regan, C. Tate. 1916. "The British fishes of the sub-family Clupeinae and related species in other seas." *The Annals and magazine of natural history; zoology, botany, and geology* 18, 1–19.

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