

ON *CALLIONYMUS RETICULATUS* C. & V.
AND ITS DISTRIBUTION IN
EUROPEAN SEAS

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(Plates I-III)

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INTRODUCTION

In the course of a study of the age and growth of the Common Dragonet, *Callionymus lyra* L., a number of specimens of another species of *Callionymus* have been collected off Plymouth, differing from both *C. lyra* L. and *C. maculatus* Rafinesque, the only two dragonets previously recorded from the Plymouth area (Mar. Biol. Assoc., 1931), and, indeed, from northern European seas (Andersson, 1942; Day, 1880-84; Duncker, Ehrenbaum, Kyle, Mohr & Schnakenbeck, 1929; Jenkins, 1925; Mohr (in Joubin, 1929-38); Le Danois, 1913; Norman, 1935; Otterstrøm, 1912; Poll, 1947; Redeke, 1941; Sæmundsson, 1949; Smitt, 1892-95).

Through the kindness of Prof. L. Bertin, Muséum National d'Histoire Naturelle, Paris, who gave me full information about the type specimens of both *C. fasciatus* C. & V. and *C. reticulatus* C. & V., this additional species has been identified as *C. reticulatus* Cuvier & Valenciennes (1837).

Specimens in the collections at the Plymouth Laboratory and from other institutions in Great Britain, and other European countries, have yielded some interesting information about this fish.

HISTORICAL REVIEW OF THE EUROPEAN DRAGONETS

Altogether seventeen 'species' of *Callionymus* have been described from European waters. Their names, together with references to the original descriptions, are listed in chronological order below:

<i>C. lyra</i> Linnaeus	1758, p. 249.
<i>C. dracunculus</i> Linnaeus	1758, pp. 249–50.
<i>C. pusillus</i> Delaroche	1809, pp. 330–31; Pl. 25, fig. 16.
<i>C. maculatus</i> Rafinesque	1810, p. 25; Pl. V, fig. 1.
<i>C. festivus</i> Pallas	1811; pp. 146–47.
<i>C. rissoii</i> Lesueur	1814; pp. 5–6; Pl. I, figs. 16, 16a, 16b.
<i>C. elegans</i> Lesueur	1814; p. 6; Pl. I, figs. 17 and 17a.
<i>C. belenus</i> Risso	1826; pp. 263–64.
<i>C. admirabilis</i> Risso	1826; p. 264; Pl. VI, fig. 11.
<i>C. morrissonii</i> Risso	1826; pp. 265–66; Pl. VI, fig. 12.
<i>C. lacerta</i> Cuvier	1829; pp. 247–48.
<i>C. cithara</i> Cuvier	1829; p. 248.
<i>C. reticulatus</i> Cuvier & Valenciennes	1837; Vol. 12, pp. 284–85.
<i>C. fasciatus</i> Cuvier & Valenciennes	1837; Vol. 12, pp. 285–86.
<i>C. sueurii</i> Cuvier & Valenciennes	1837; Vol. 12, pp. 291–93.
<i>C. phaëton</i> Günther	1861; p. 147.
<i>C. parthenopoeus</i> Giglioli	1883; pp. 397–400.

In addition, Ninni (1934) described two forms, *C. maculatus atlanticus* and *C. festivus giglioli* (= *C. parthenopoeus* Giglioli, 1883); and Gonçalves (1942) recorded two unidentified species of *Callionymus* from Portuguese waters.

Comparatively few of the above have been accepted, however, by such authorities as Cuvier & Valenciennes (1837), who recognized only six of the earlier species (including Cuvier's two), while at the same time they described three new ones. In 1861 Günther, who made an exhaustive study of the European dragonets, established one new species, *C. phaëton*, and recognized four other good ones—*C. lyra*, *C. maculatus*, *C. festivus* and *C. belenus*. *C. fasciatus* and *C. reticulatus* were considered by him as doubtful species and all the others as synonyms.

C. fasciatus was described by Cuvier & Valenciennes (1837) from a single type specimen from Sicily. There was no further record of this species until A. P. Ninni (1877–78) had occasion to examine a number of specimens taken near the Istrian coast. He decided that it was definitely a good species, and worked out a key to the European *Callionymus*, which included the five species recognized by Günther, plus *C. fasciatus*. After A. P. Ninni there were further records of *C. fasciatus*, and its distribution, which is confined to the Mediterranean, was given by Carus (1889–93) and by E. Ninni (1934).

Like Günther, Fage (1918, p. 126) was inclined to think that there are only five good European species. In the same paper he pointed out that *C. parthenopoeus* Giglioli (1883) was a synonym of *C. festivus*, which E. Ninni (1934) redescribed as a form of *C. festivus* Pallas.

The type specimen of *C. reticulatus* Cuvier & Valenciennes (1837) was from Malaga. This species has not been reported since, and has been confused with *C. maculatus* in a number of ways. It was considered as a synonym of *C. maculatus* by Steindachner (1868), Day (1880-84), Carus (1889-93), Smitt (1892-95) and Mohr (in Joubin 1929-38); or identified as *C. maculatus* by Bragança (1903) and Nobre (1935). The descriptions of *C. maculatus* by Moreau (1881) and by Day (1880-84) evidently combined the characteristics of both *C. maculatus* and *C. reticulatus*.

The two unidentified species of *Callionymus* recorded by Gonçalves (1942) are of particular interest (see also p. 302). I was fortunate enough to have the opportunity of examining two specimens, one of each species. One male belonging to the first unidentified species was the identical specimen that had been identified as *C. maculatus* by Bragança (1903) and by Nobre (1935). It proved, however, to be in fact a fully mature male of *C. reticulatus*.

The female specimen belonging to the second unidentified species remains undetermined.

DESCRIPTION

Callionymus reticulatus Cuvier & Valenciennes

C. reticulatus Cuvier & Valenciennes, 1837, Vol. 12, pp. 284-85. *C. maculatus* (part.) Moreau, 1881, Vol. 2, pp. 164, 169-70¹. *C. maculatus* (part.) Day, 1880-84, Vol. 1, pp. 177-78¹. *C. maculatus* (nec Raf.) Bragança, 1903, p. 35. *C. maculatus* (nec Raf.) Nobre, 1935, pp. 505-6. *C. sp.* Gonçalves, 1942, p. 80 (fish no. 273, third specimen, male 8·3-11·0 cm.).

Diagnostic Characters

(1) The preopercular spine is tricuspid, but occasionally carries a very rudimentary basal spine. (2) The second dorsal fin always consists of ten rays, of which the last is branched. (3) In the second dorsal fin of the adult male there are eight vertical or oblique rows of dark spots. In between these rows of spots there are dark-margined, bluish, tortuous lines and spots. In the anal fin there exist four or five rows of parallel, but discontinuous, dark-margined bluish lines.

The Plymouth Specimens (Pl. I, figs. 1-4; Pl. II, figs. 1, 4 and 5; Pl. III, figs. 1-4).

The following description is based on the twenty-one males (40-108 mm.)² and fifteen females (30-65 mm.) collected in the Plymouth area during a period

¹ The descriptions combine the characteristics of both *C. maculatus* and *C. reticulatus*.

² The length of the specimens referred to in this paper is total length; except when specific mention is made of standard length.

of 18 months, from December 1948 to May 1950; and a mature male (the caudal fin had broken, 70 mm. in standard length) collected on 1 August 1900, near Mewstone, Plymouth.

General features. Body of typical dragonet-shape, smooth, devoid of scales and depressed throughout; deepest and broadest in opercular region. Head large, much depressed, and flat on ventral side, contained about 3·2 to 3·6 times (in male) and 3·3 to 3·7 times (in female) in standard length; its width, in opercular region, varying from 1·7 to 2·0 times its depth. Snout spatulate, nearly equal in length to long diameter of eye in females and immature males, but much elongated in mature males. Eyes very prominent, of medium size and closely set on dorsal side; interorbital space very narrow, less than one-half of vertical diameter of eye. Opercular bone very thin; gill opening reduced to foramen; lateral line single, extending to middle of caudal fin, with short branches on trunk and connection with that on opposite side through common dorsal branch near base of caudal fin.

Fin-rays. D₁, IV; D₂, 10; A, 9-10; V, 1, 5; C, 12. First dorsal fin with four flexible spines; second dorsal fin with ten rays, of which first nine are simple but last one is branched twice. Anal fin with nine to ten rays, last ray also branched. Number of fin-rays in dorsal fin very constant.

Preopercular spines. The preopercular bone ends posteriorly in three small recurved spines. The anterior and the middle ones are rather stout and curved upwards. The posterior one, which is directed backwards, is much smaller than the other two. It is always less than one-half of the middle one, both in length and in thickness. Among the thirty-seven specimens examined, thirty-four have no free basal spine (i.e. there is no fourth preopercular spine projecting forwards). In the other three, however, the basal spine is distinct but very rudimentary; one has a spine on both sides and the other two have one on the left side only.

Coloration. In females and young males the ground colour on the dorsal side varies from orange-brown to orange-red, passing into white or creamy beneath. There are many very light bluish spots scattered over the dorsal side of the body, and six dark orange-red patches along the dorsal median line.

These bluish spots are relatively much larger than those of *C. lyra*, *C. maculatus* and *C. fasciatus*. The six dark, dorsal patches are very similar to those of *C. lyra* and *C. fasciatus*; but in *C. reticulatus* they are very hard in outline, especially the fourth patch which is very characteristic as it has two waves anteriorly and is smooth and rounded posteriorly. On the lateral side of the body there is a series of seven or eight irregular dark spots.

Sexual dimorphism. As in many other dragonets, the male secondary sexual characters develop gradually into a state which makes the fully mature male entirely different from the female and the young male in external features. The largest male examined was 108 mm. long, while no mature female exceeded 65 mm.

In the female the first and second dorsal fins are only as high as, or slightly higher than, the body below them, but in the fully mature male they extend to

more than three times the body depth. The anal fin, which is less than the body depth in the females, may be nearly twice as high as the body in old males. The lower portion of the caudal fin in the mature male is much longer than the upper portion.

On the second dorsal fin of the male there appear gradually three dark spots, of which the uppermost is always very faint, on the membrane between the consecutive rays. As the spots immediately posterior to the odd-numbered rays are arranged somewhat on the same level, and those posterior to the rays of even number on another level, they form eight oblique or vertical rows crossing the rays diagonally, instead of rows running parallel with the dorsal outline as in the male *C. maculatus* (compare Pl. I, figs. 1 and 3 with Smitt, 1892–95, Pl. XV, fig. 1, reproduced in Pl. 36 of Jenkins (1925) and later editions). In between these rows of dark spots, there are eight rows of dark-margined, bluish, tortuous lines and irregular spots. These lines and spots are more or less continuous in young males. On the anal fin of mature males there are four or five parallel rows of dark-margined, discontinuous bluish lines, which turn obliquely downwards on the membrane between the branches of the last ray. The ventral fin of the mature male becomes very dark and the caudal fin bears many dark-margined, bluish spots and lines. In old males, the ground colour between the spots and lines on all median fins is bright yellow.

Other Channel Specimens

Two young specimens, 31 and 34 mm. long (British Museum Fish nos. 1951.2.19.51 and 52), were collected by the *Manihine* in the English Channel at position $50^{\circ} 35' 45''$ N., $1^{\circ} 20' 40''$ E., on 28 August 1949. The smaller of these specimens has a rudimentary basal spine on the preoperculum of the right side.

A North Sea Specimen

One adult male (British Museum Fish no. 1950.11.11.1), 74 mm. long, was contained in a bottle labelled 'Mouth of Thames, Mus. Leach'. William Elford Leach, M.D. (1790–1836), was naturalist assistant librarian, and later assistant keeper, at the British Museum, 1813–21. It would thus appear that this specimen was extant before the species was described as new.

A Portuguese Specimen

Dr H. Vilela, Estação de Biologia Marítima, Lisbon, kindly lent me ten valuable specimens¹ of *Callionymus* collected off the Portuguese coast. One of the specimens, a mature male, 110 mm. long, was identified as *C. reticulatus*

¹ A female specimen, 57 mm. long, was collected at the same time and from the same locality as the above male (Gonçalves, 1942, p. 81, Fish no. 274, *Callionymus* sp.). This is a very interesting specimen because the preoperculum has four recurved spines. Like *C. reticulatus*, its second dorsal fin consists of ten rays and there is no basal spine. As none of the European dragonets has four recurved spines, I am uncertain whether this is an abnormality. This specimen remains unidentified. The other eight specimens are all *C. lyra* L.

C. & V., Pl. II, fig. 8. Its colour has been lost; the second dorsal fin consists of ten rays; the preopercular bone has only three recurved spines and no basal spines; the male secondary sexual characters other than coloration are the same as those of the Plymouth specimens. Dr Vilela also informed me that it was collected by Don Carlos de Bragança, the King of Portugal, near Sezimbra (between Cape Espichel and mouth of River Sado), by trawl-net, 110 m. depth, year 1897, and that it is the identical specimen referred to by Bragança (1903, p. 35), Nobre (1935, pp. 505-6) and Gonçalves (1942, p. 80, no. 273, *Callionymus* sp., the third specimen).

The Type Specimen

Prof. L. Bertin has kindly given me the following information about the type specimen of *C. reticulatus* C. & V.:

Nous avons eu le désagrément de constater qu'il est en très mauvais état. Ses nageoires et sa coloration ne peuvent être connues.

Nous pouvons seulement vous dire que le préopercule comporte seulement 3 épines dirigées vers l'arrière et dont le plus ventrale est presque rudimentaire. Il n'y a pas de 4-ème épine dirigée vers l'avant. C'est à peu près la disposition de votre photographie No. 2 de votre lettre du 9 août.

Dans ces conditions, nous sommes très perplexes au sujet de vos spécimens de Plymouth. Êtes-vous sûr que ce ne sont pas des *C. fasciatus*.—Le type de cette espèce, nous vous le répétons, a 4 épines operculaires.

Fage, dans son travail de 1918, ne parle pas de *C. reticulatus*.

The original description of *C. reticulatus* by Cuvier & Valenciennes (1837) is reproduced here for reference.

Le Callionyme réticulé.

(*Callionymus reticulatus*, nob.)

Elle nous a été donnée par M. Baillon, qui l'a reçue de Malaga. Son museau est un peu plus long et plus pointu que dans le *Callionymus cithara*: il a aussi trois rayons à la pointe du préopercule. Le premier rayon dorsal s'allonge en fil d'un peu plus du quart de la longueur totale. La seconde dorsale n'a pas trois fois la hauteur du corps, et l'anale est de moitié moindre, en sorte que l'une et l'autre est plus basse que dans le *C. cithara*. La deuxième dorsale a un rayon de plus.

D. 4-10. A. 8, etc.

Il y a sur la seconde dorsale trois rangées de taches brunes semblables à celles du *C. cithara*; mais les intervalles sont remplis de cercles et de rubans ondulés, blancs, avec un liséré mince, brun et blanc; d'où résulte un ensemble très-agréable à l'oeil. La première a deux ou trois de ces rubans ondulés et à double lisérés, et deux ou trois taches noires. Quatre lignes semblables, mais plus étroites, parcourent parallèlement toute la longueur de l'anale, dont le bord est noirâtre. Sur l'anale, entre les rayons supérieurs, sont des traits obliques; entre les autres des longitudinaux, tous blancs, lisérés de brun. On voit aussi quelques taches semblables sur la joue et à la base de la ventrale.

La longueur de notre individu est de trois pouces et demi.

In studying all the material mentioned above, I have found that the specimens from different localities are identical with the original description of

C. reticulatus C. & V. and Prof. Bertin's information about the type, except in one minor point, which is that there are only eight rays in the anal fin in the type. This is probably due to variation. Different from all other European dragonets, *C. reticulatus* is definitely a good species. The details will be discussed under the heading 'Comparison with other European species'.

DISTRIBUTION

If the above information concerning *C. reticulatus* be accepted it is clear that this species is present in the western portion of the Mediterranean in Spanish waters off Malaga, and in coastal areas off Portugal, and extends into the English Channel and southern North Sea. Recently there have been reports of the spread of southern forms, notably fish and certain algae, into the northern waters of the European seas and into the Northern Atlantic (Cotton, 1935; Fridriksson, 1949; Lund, 1945; Parke, 1948; Tåning, 1949). It appeared at first that the presence of *C. reticulatus* in the Plymouth area might be yet another example of immigration from the south. It now seems more likely that this species has been overlooked and that it may therefore long have been even more widely distributed in European waters than the above records would suggest.

ECOLOGICAL NOTES

The catches of *Callionymus* in the Plymouth area during a period of 18 months, from December 1948 to May 1949 inclusive, indicate the great scarcity of *C. reticulatus* as compared with the other two dragonets. Altogether thirty-six specimens of *C. reticulatus* have been caught (30–108 mm. long); but the total number of *C. lyra* (30–300 mm. long) amounts to over four thousand, and that of *C. maculatus* (30–109 mm.) to 149. The nets used were (a) the ordinary otter trawl, (b) ordinary otter trawl with small-mesh cod-end, (c) fine-meshed Agassiz trawl, and (d) small beam trawl (shrimp netting). Owing to their small size¹ *C. reticulatus* and *C. maculatus* would not normally be expected in an ordinary trawl catch, and in fact most of the specimens of these two species were caught in the Agassiz trawl and in the small-mesh cod-end of the otter trawl. The relative abundance of *C. lyra* in the catches is therefore probably due to its presence in greater numbers and to the retention of this large species in the ordinary otter trawl. It is interesting to note, however, that on 18 January 1950, ten specimens of *C. reticulatus* were caught in the Agassiz trawl off Whitsand Bay, and at the entrance of Plymouth Sound, from off Wembury Bay and the Mewstone to Whitsand Bay and Cawsand Bay. This represents a total of about 3 hr. trawling by this net, and indicates considerable numbers of this species on these grounds.

¹ In the Plymouth area *C. reticulatus* reaches at least 108 mm. Although my largest specimen of *C. maculatus* is 109 mm. a preserved specimen of 124 mm. is present in an old collection in the Laboratory of the Marine Biological Association.

Although *C. lyra*, *C. maculatus* and *C. reticulatus* may be trawled from the same grounds in the Plymouth area, it seems that they have their own habitat preferences. *C. lyra*, one of the commonest fishes in this locality, has a very wide distribution. The adults inhabit all the offshore waters off Plymouth. The young fish usually spend the first year very close to the shore and may go as far as 3 or 4 miles up the River Tamar. *C. maculatus*, very scarce inside Plymouth Sound, is sparsely but fairly generally distributed on the trawling grounds off Plymouth. *C. reticulatus*, on the contrary, seems to have a definitely localized distribution in this area. Out of the thirty-six specimens obtained, twenty-seven were caught in or near the entrance to Plymouth Sound, from Wembury Bay to Whitsand Bay, and four from the *Amphioxus* grounds near the Eddystone. Two of the remaining five specimens were obtained from the stomach of a gurnard (*Trigla* sp.). Furthermore, this species does not frequent brackish water as does the young *Callionymus lyra*, and it is very rare in the offshore water on the trawling ground off Plymouth, where *C. maculatus* is common and the adults of *C. lyra* are plentiful.

Unfortunately, no full information about the breeding season has been obtained, but some indications can be derived from the time at which the mature specimens were caught. Among the males there are two specimens with fully developed secondary sexual characters. The first, 72 mm. long, was obtained in May of 1949, and the other, 108 mm. long, collected in 1950, was also obtained in the month of May. Altogether there were four females which could be considered as mature as they contained very large eggs. In the first, 59 mm. long, caught in March 1949, the ova measured up to 0.5 mm. in diameter. The second, 60 mm. long, was obtained in May of 1949, and contained ova measuring up to 0.7 mm., and the third one, 63 mm. long, trawled in May of 1950, contained ova up to 0.5 mm. In another, caught in June of 1949, the ova measured up to 0.4 mm. Several eggs, found lying free in the body cavity of the second mature female, had very large hexagonal reticulations on the vitelline membrane; these reticulations varied from 18 to 26 μ across. It is obvious from the above that the breeding season of *C. reticulatus* in the Plymouth area extends at any rate from March to June.

COMPARISON WITH OTHER EUROPEAN SPECIES

As *C. reticulatus* C. & V. shares many important characteristics common to *C. lyra*, *C. maculatus* and *C. fasciatus*, with any one of which it may easily be confused, I examined the most important characters of a number of specimens of these three species from different localities. The details are described below and shown in Table I.

C. fasciatus C. & V. Prof. L. Bertin has provided the following information about the type specimen:

J'ai examiné le type *Callionymus fasciatus* C. & V. Il possède à chaque préopercule 3 épines dirigées en arrière et une épine dirigée en avant, selon le schéma ci-dessous, et

TABLE I. COMPARISON OF THE FREQUENCIES OF THE NUMBERS OF PREOPERCULAR SPINES, AND THE NUMBERS OF RAYS IN THE DORSAL AND ANAL FINS OF *CALLIONYMUS RETICULATUS*, *C. FASCIATUS*, *C. MACULATUS* AND *C. LYRA* EXAMINED FROM DIFFERENT LOCALITIES

	<i>C. reticulatus</i> C. & V.					<i>C. fasciatus</i> C. & V.			<i>C. maculatus</i> Rafinesque				<i>C. lyra</i> L.			
	Malaga (Type)	Plymouth	English Channel	Southern North Sea	Portugal	Sicily (Type)	Genoa	Istria	Port Vendres	Vendres	Plymouth	Port Erin	Mill- port	Port Plymouth	Port Erin	Portugal
No. of rays in the dorsal fins	{ IV + 8 IV + 9 IV + 10	.. .. I	.. .. 37	.. .. 2	.. .. I	.. .. I	.. .. 2	.. .. 2	.. 4 ..	.. 107 2	.. 5 I	.. 6 ..	4 277 I	.. 39 ..	.. 8 ..
No. of rays in the anal fin	{ 8 9 10	I .. ..	.. 36 I	.. 2 ..	.. I ..	.. I ..	.. 2 ..	.. 2 ..	.. 4 ..	.. 105 2	.. 6 ..	.. 6 ..	4 278 ..	I 38 ..	.. 8 ..
Preoperculum with three recurved spines and	A basal spine No basal spine	{ Well-de- veloped Rudi- mentary	.. 34	.. I	.. I	.. I	I ..	2 ..	2 ..	4 ..	109 ..	6 ..	6 ..	282 ..	39 ..	8 ..

répondant à peu près à la disposition de votre *C. maculatus* (Photo N. 3). La 3^e épine est cependant un peu plus courte et la 4^e est moins détachée de l'os préoperculaire.

La coloration de la seconde dorsale—il s'agit d'un mâle—est différente de celle de votre photographie No. I. Il y a en effet 3 ou 4 taches noires dans chaque espace interradiaire, au lieu de 2 ou 3. Le nombre des rangées de ces taches est donc plus élevé que sur votre photo et rappelle la disposition du *C. maculatus* dessiné par Erna Mohr dans la fiche de la Faune ichthyologique de l'Atlantique Nord.

Sur la première dorsale, il n'y a pas de tache prédominante, mais la disposition figurée ci-dessous :

Je ne connais pas le fig. 2. pl. 40 dont parlent Cuvier et Valenciennes.

C. fasciatus me semble tomber en synonymie avec *C. maculatus*. C'est d'ailleurs l'opinion déjà soutenue par Fage, dans un très important travail que vous semblez ignorer: Shore-Fishes, dans Report Danish Oceanogr. Exped. Medit. Adj. Seas-Vol. II- Biology-A. 3. paru en 1918.

Reste à savoir ce que sont vos spécimens ayant seulement 3 épines préoperculaires (et quelquefois 4).

D'après Fage et les auteurs consultés il n'existe dans la Manche et l'Atlantique que *C. lyra* et *C. maculatus* (*fasciatus*) qui ont toutes deux 4 épines.

Les espèces à 3 épines n'existent qu'en Méditerranée.

Il y a donc là un point à éclaircir, mais sur lequel je ne puis vous rendre aucun service à distance.

The four specimens of *C. fasciatus* belonging to the 'Museo Civico de Storia Naturale, Genova', comprise three mature males and one female. The first male was from 'Golfo di Genova' (71¹) mm. long; the second and third males were from 'Istria', 83 (66¹) mm. and 90 (71¹) mm. long respectively (Fish nos. 265A, 468a); and the female, from 'Golfo di Genova', was 55 (44) mm. long (Fish nos. 265, 486). D 1, IV; D 2, 10; A, 9; V, 1, 5. The last rays of both the second dorsal and the anal fin are branched. The preopercular bone has always three recurved spines and a very prominent basal spine (Pl. II, figs. 6, 7). There are four dark spots on the membrane between consecutive rays in the second dorsal fin, and the spots on the fin are also arranged in oblique or vertical rows across the fin as in *C. reticulatus*. There are six to eight rows of dark-margined, bluish parallel lines in the anal fin of the male.

C. lyra. Altogether 329 specimens were examined, the length of the specimens varying from 40 mm. to about 300 mm. They all have four very prominent preopercular spines, three recurved spines and a basal spine. The number of the second dorsal fin-rays varies from eight to ten (Pl. I, fig. 5; Pl. II, fig. 3).

C. maculatus. I have examined 125 specimens from different localities. The preopercular bone has constantly four spines. On the second dorsal fin of the males there are four horizontal rows of dark spots; sometimes there are similar numbers of light round spots lying immediately behind the dark spots. There are no parallel lines on the anal fin such as are found in *C. fasciatus* and

¹ The figures in brackets are standard length. The total length of one of the specimens is not known as the tail has been damaged.

C. reticulatus. Dark round spots are present on the sides of the body (Pl. I, fig. 6; Pl. II, fig. 2).

C. reticulatus C. & V. can therefore be distinguished from *C. lyra*, *C. maculatus* and *C. fasciatus* by the following characteristics:

(1) The preopercular spines are the most reliable characteristic. In *C. reticulatus* there are three recurved spines, which project upwards or backwards; but the basal spine, which projects forwards, is normally absent. If present, it is very rudimentary (Pl. II, figs. 4, 5) and is usually on one side only (p. 300). In the other three species, however, there are also three recurved spines, but the basal spine is always present and very prominent (Pl. II, figs. 2, 3, 6 and 7).

(2) The number of the fin-rays in the second dorsal fin is constantly ten in *C. reticulatus* and in *C. fasciatus*; in *C. lyra* and *C. maculatus*, however, there are normally nine rays, but occasionally eight or ten rays. The last rays of the second dorsal fin of all these four species are branched.

(3) The colour patterns on the body of *C. reticulatus* are very similar to those of *C. fasciatus* and of the young *C. lyra*. Nevertheless, in the first species the light bluish spots are much larger than those in the latter two species, in specimens of similar size. As a rule the dorsal patches of *C. maculatus* and *C. lyra* have irregular margins, whereas those of *C. reticulatus* have always very well-defined entire margins, especially the fourth which is very characteristic (Pl. I, figs. 2 and 4–6). As *C. maculatus* has dark spots on the sides of the body, there can be no difficulty in distinguishing it from the other three species, so long as these spots have not been lost in preservation.

(4) The male secondary sexual characters are very different in the mature adults of these four species. There can be no difficulty in distinguishing them when the specimens are fresh, or in preserved material, if the coloration has not been lost completely. The smallest mature male of *C. lyra* is about 180 mm. long. Its greatly elongated first dorsal fin may extend to the base of the caudal fin or beyond it. There are no dark spots on the first and the second dorsal nor on the anal fin (Couch, 1863, pl. CIII; Holt, 1898, pl. XXVI; Jenkins, 1925, pl. 34; Smitt, 1892–95, tab. XIV). The mature males of *C. maculatus*, *C. fasciatus* and *C. reticulatus* are much smaller in size (see pp. 299 and 306). On the second dorsal fin of these three species there are dark spots on the membrane between consecutive rays—four spots in *C. maculatus*, four (the uppermost very faint) in *C. fasciatus*, and three (the uppermost also very faint) in *C. reticulatus*. In *C. maculatus*, these dark spots are arranged in more or less horizontal rows (Smitt, 1892–95, tab. XV, fig. 1; Günther, 1867, pl. V, fig. A; E. Ninni, 1934, tab. II and III, fig. 1). In *C. fasciatus* and *C. reticulatus* these spots are arranged in oblique or vertical rows (Guérin-Meneville, 1829–44, pl. 40, no. 2; E. Ninni, 1934, pl. III, fig. 2; and Pl. I, figs. 1 and 3 in this paper). Furthermore, in both *C. fasciatus* and *C. reticulatus* there are rows of bluish dark-margined, tortuous lines or spots on the second dorsal fin; and

dark-margined bluish parallel lines on the anal fin. In the former there are six to eight lines; while in the latter there are only four or five lines.

As regards the other three European dragonets, *C. phaeon* has two recurved spines, but *C. festivus* and *C. belenus*, like *C. reticulatus*, also have only three recurved spines. Nevertheless, the dorsal fins of *C. belenus* and *C. festivus* have fewer rays than *C. reticulatus*. The fin formula is D₁, IV and D₂, 6-7 in *C. festivus*; and D₁, III, and D₂, 8, in *C. belenus*.

Thus *C. reticulatus* is well distinguished from all other European species, with the possible exception of *C. fasciatus*. These two species present the following incomplete contrasts:

- C. reticulatus*: preoperculum with three recurved spines; rarely a fourth (basal) spine on one or both sides.
- C. fasciatus*: preoperculum with three recurved spines and a strong basal spine.
- C. reticulatus*: mature males with three dark spots on an inter-radial membrane of D₂ and four or five horizontal bands on the anal.
- C. fasciatus*: mature males with four dark spots on an inter-radial membrane of D₂ and six to eight horizontal bands on the anal.
- C. reticulatus*: distributed from Malaga to the North Sea.
- C. fasciatus*: not known outside the Mediterranean.

The only well-authenticated specimen of *C. reticulatus* from the Mediterranean is the type, but its colour is not known.

The question of geographical variation arises. Fishes with rows of spots on the fins increase the number of rows as the fish grows. The number of mature males of these two species examined by me is too small to admit of generalization, but those named *fasciatus* are not all larger than those assigned to *reticulatus*. In some other species of the northern hemisphere, however, the northern members are known to grow larger and to mature later than the southern, and it is possible that we have here a difference associated with rate of growth. This could hardly account, however, for the presence in one and rarity in the other of a basal spine on the preoperculum; until, therefore, the Mediterranean populations are better known it seems wise to recognize both *C. reticulatus* and *C. fasciatus* as distinct species.

SUMMARY

Three species of *Callionymus* are recognized as occurring in British waters, *C. lyra* L., *C. maculatus* Raf. and *C. reticulatus* C. & V.

The third is here recognized for the first time and is described from an abundant material.

Both *C. reticulatus* and *C. fasciatus* C. & V. in the past have been confused with *C. maculatus*. They are here shown to be quite distinct from that species.

C. reticulatus is closely related to *C. fasciatus*. The value of the characters used to distinguish them is discussed.

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REFERENCES

- ALLEN, E. J., 1899. On the fauna and bottom-deposits near the thirty-fathom line from the Eddystone grounds to Start Point. *Journ. Mar. Biol. Assoc.*, Vol. 5, pp. 365-542.
ANDERSSON, K. A., 1942. *Fiskar och Fiske i Norden*. Vol. 1. Stockholm.
BLEGVAD, H. & LØPPENTHIN, B., 1944. Fishes of the Iranian Gulf. *Danish Scientific Investigations in Iran*, Pt. III, pp. 1-247. Copenhagen.

- BRAGANÇA, D. CARLOS DE, 1903. *Catalogo das collecções expostas (Palacio de Cristal Portuense)*, p. 15. Lisboa.
- BUEN, F. DE, 1935-36. Fauna ictiológica. *Notas y Resúmenes*, Ser. II, núm. 88 (1935), pp. 1-90; núm. 89 (1935), pp. 91-150; núm. 94 (1936), pp. 151-73. Madrid.
- CARUS, J. V., 1889-93. *Prodromus Faunae Mediterraneae*, Vol. 2, pp. 686-8. Stuttgart.
- COTTON, A. D., 1935. Changes in the British fauna and flora during the past fifty years. (5) Marine Algae. *Proc. Linn. Soc. London*, 1935, pp. 45-9.
- COUCH, J., 1863. *A History of the Fishes of the British Islands*, Vol. 2. London.
- CUVIER, G., 1829. *Le Règne Animal*, Tome 2. Paris.
- CUVIER, G. & VALENCIENNES, A., 1837. *Histoire Naturelle des Poissons*, Vol. 12. Paris.
- DAY, F., 1880-84. *The Fishes of Great Britain and Ireland*, Vol. 1. London.
- DELAROCHE, F. E., 1809. Observations sur des poissons recueillis dans un voyage aux îles Baléares et Pythiuses. *Ann. Mus. Hist. Nat. Paris*, Tome 13, pp. 98-122, 313-61.
- DUNCKER, G., 1939. *Die Fische der Nordmark*, Lief. 5, pp. 209-12. Kiel.
- DUNCKER, G., EHRENBAUM, E., KYLE, H. M., MOHR, E. W. & SCHNAKENBECK, W., 1929. *Die Fische der Nord- und Ostsee*. Leipzig.
- FAGE, L., 1918. Shore-fishes. *Rep. Danish Oceanogr. Exped. Medit. 1908-10*. Vol. 2 (Biology), A3, 154 pp.
- FOWLER, H. W., 1936. The marine fishes of West Africa, based on the collection of the American Museum Congo Expedition, 1909-15. *Bull. Amer. Mus. Nat. Hist.*, Vol. 70, 2 parts, pp. 1-1493.
- 1941. New fishes of the family Callionymidae, mostly Philippine, obtained by the United States Bureau of Fisheries steamer *Albatross*. *Proc. U.S. Nat. Mus.*, Vol. 90, No. 3106, pp. 1-31.
- FRIDRIKSSON, ÁRNI, 1949. Boreo-tended changes in the marine vertebrate fauna of Iceland during the last 25 years. *Cons. Internat. Explor. Mer, Rapp. et Proc.-Verb.*, Vol. 125, pp. 30-2.
- GIGLIOLI, E. H., 1883. Intorno a due nuovi pesci dal golfo di Napoli. *Zool. Anz.*, Bd. 6, pp. 397-400.
- GILL, T. N., 1860. On the genus of *Callionymus* of authors. *Proc. Acad. Nat. Sci. Philad.*, 1859 (1860), pp. 128-30.
- GONÇALVES, B. C., 1942. Colecção Oceanográfica de D. Carlos I: Catálogo dos peixes. *Trav. Stat. Biol. Mar. Lisboa*, No. 46, pp. 1-108.
- GUÉRIN-MENEVILLE, F. E., 1829-1844. *Iconographie du Règne Animal de G. Cuvier*, Tome 4. Poissons, Pl. 40, no. 2. Paris and London.
- GÜNTHER, A., 1861. *Catalogue of the Fishes in the British Museum*, Vol. 3. London.
- 1867. Additions to the British fauna. *Ann. Mag. Nat. Hist.*, 3rd Series, Vol. 20, pp. 288-91.
- HOLT, E. W. L., 1898. On the breeding of the dragonet (*Callionymus lyra*) in the Marine Biological Association's Aquarium at Plymouth. *Proc. Zool. Soc. London*, 1898, Vol. 1, pp. 281-315, pl. XXVI.
- HUBBS, C. L. & SCHULTZ, L. P., 1929. The northward occurrence of southern forms of marine life along the Pacific coast in 1926. *Calif. Fish. Game*, Vol. 15, No. 3, pp. 234-41.
- JENKINS, J. T., 1925. *The Fishes of the British Isles*. London and New York.
- JORDAN, D. S. & FOWLER, H. W., 1903. A review of the dragonets (Callionymidae) and related fishes of the waters of Japan. *Proc. U.S. Nat. Mus.*, Vol. 25, No. 1305, pp. 939-59.
- JOUBIN, M., 1929-38. *Faune ichthyologique de l'Atlantique Nord*. 23 pp. Éditée par le Cons. Perm. Intern. pour Explor. de la Mer.

- LE DANOIS, ED., 1913. Contribution à l'étude systématique et biologique des poissons de la Manche occidentale. *Ann. Instit. Ocean. Monaco*, Tome 5, Fasc. 5, pp. 1-214.
- LESUEUR, C. A., 1814. Note sur deux poissons non encore décrits du genre *Callionymus* et de l'ordre des Jugulaires. *Bull. Sci. Soc. Philom. Paris*, 1814, pp. 5-6, Pl. I, figs. 16, 16a, 16b, 17 and 17a.
- LINNAEUS, C., 1758. *Systema Naturae*, Tome I. Regnum Animale. (pp. 249-50.)
- LOZANO REY, L., 1919. Los peces de la fauna ibérica en la colección del museo. *Trab. Mus. Ci. Nat.*, Ser. Zoologica, Núm. 39, pp. 1-112. Madrid.
- LUND, S., 1945. On *Colpomenia peregrina* Sauv. and its occurrence in Danish waters. *Rep. Danish Biol. Stat.*, 1942, No. XLVII, pp. 3-16.
- MARINE BIOLOGICAL ASSOCIATION, 1931. *Plymouth Marine Fauna*. 2nd ed.
- MCINTOSH, W. C. & PRINCE, E. E., 1889. On the development and life-histories of the teleostean food and other fishes. *Trans. Royal Soc. Edinb.*, Vol. 35, Pt. 3, No. 19, pp. 665-944.
- MOREAU, É., 1881. *Histoire naturelle des poissons de la France*, Tome 2, 572 pp. Paris.
- NAVARRO, F. DE P., 1928. Un pez nuevo en la fauna balear *Callionymus phaëton* Günther. *Boletín de Pescas*, Madrid, Núm. 142, pp. 165-8.
- NINNI, A. P., 1877-78. Materiali per la fauna veneta. II. Genere *Callionymus*. *Atti. Ist. Veneto. Sci.*, Ser. V, Tome 4, pp. 1043-57.
- NINNI, E., 1934. *Callionymus dei mari d'Europa*. *Notas y Resúmenes*, núm. 85, pp. 1-59. Madrid.
- NOBRE, A., 1935. *Fauna marinha de Portugal*. I. *Vertebrados*, pp. 153-6; 505-6. Pôrto.
- NORMAN, J. R., 1935. *List of British Vertebrates*. London.
- OTTERSTRÖM, C. V., 1912. *Danmarks Fauna VI. Fisk I. Pigfinnefisk*, pp. 168-72. Kjøbenhavn.
- PALLAS, P. S., 1811. *Zoographia Rosso-Asiatica*, Vol. 3, pp. 146-7. Petropoli.
- PARKE, M., 1948. *Laminaria ochroleuca* De La Pylaie growing on the coast of Britain. *Nature*, Vol. 162, pp. 295-6.
- PERRIER, R., 1924. *La faune de France en tableaux synoptiques illustres*. IO. *Vertebres Poissons*. Paris.
- POLL, M., 1947. *Faune de Belgique. Poissons marins*. 452 pp. Bruxelles.
- RAFINESQUE SCHMALTZ, C. S., 1810. *Caratteri di alcuni nuovi generi e nuove specie di animali e piante della Sicilia, con varie osservazioni sopra i medismi*. 105 pp. Palermo.
- REDEKE, H. C., 1941. *De visschen van Nederland*. 331 pp. Leiden.
- RISSO, A., 1810. *Ichthyologie de Nice*, pp. 103-6. Paris.
- 1826. *Histoire naturelle de l'Europe Méridionale*, Tome 3, pp. 262-6. Paris.
- SÆMUNDSSON, B., 1949. *Marine Pisces. Zool. Iceland*, Vol. 4, Pt. 72, pp. 1-150. Copenhagen and Reykjavík.
- SMITH, J. L. B., 1949. *The Sea Fishes of Southern Africa*. 550 pp. Cape Town.
- SMITT, F. A., 1892-95. *A History of Scandinavian Fishes*, by B. Fries, C.U. Ekström, & C. Sundevall, 2nd ed., Pts I and II. Stockholm.
- ŠOLJAN, T., 1948. *Fauna i flora Jadrana. Knjiga I. Ribe Jadrana*. (Fishes of the Adriatic). Split.
- STEINDACHNER, F., 1868. Ichthyologischer Bericht über eine nach Spanien und Portugal unternommene Reise. V. *Sitzber. Akad. Wiss. Wien*, Vol. 57, 1868, pp. 351-424.
- TÅNING, A. V., 1949. On changes in the marine fauna of the north-western Atlantic area, with special reference to Greenland. *Cons. Internat. Explor. Mer, Rapp. et Proc.-Verb.*, Vol. 125, pp. 27-9.
- TORTONESE, E. & TROTTI, L., 1949. Catalogo dei pesci del Mare Ligure. *Atti. Accad. Ligure Sci. Lett.*, Vol. 6, pp. 1-118.

- VINCIGUERRA, D., 1885. Appunti ittiologici sulle collezioni del Museo Civico di Genova. VII. Spora alcuni pesci nuovi del Golfo di Genova. *Ann. Mus. Civ. Storia Nat.*, Vol. 22, pp. 446-75. Genova.
 YARRELL, W., 1859. *A History of British Fishes*, Vol. 2. 3rd ed. London.

EXPLANATION OF PLATES

PLATE I, photographs of *Callionymus*, $\times \frac{2}{3}$

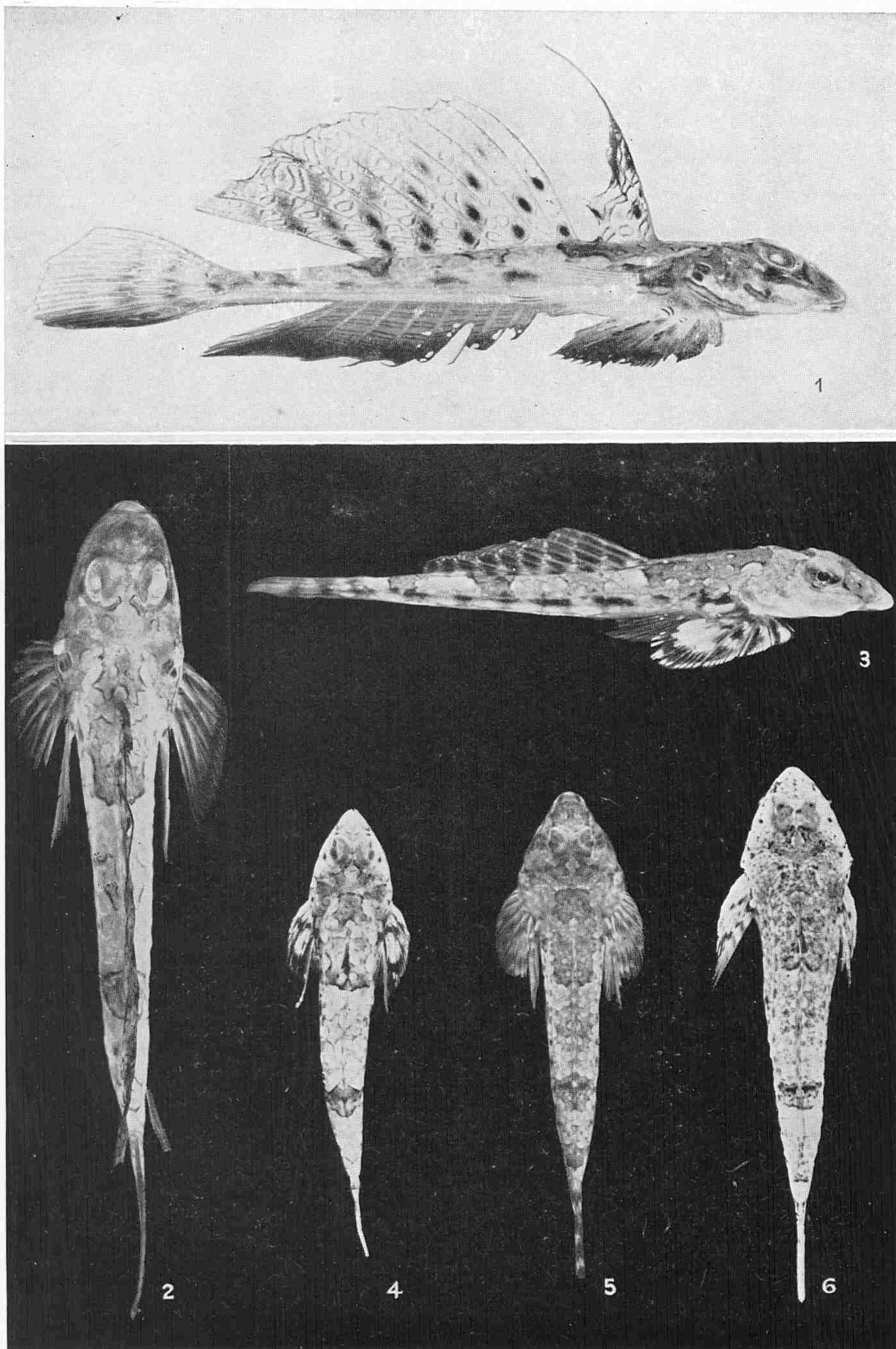
- Fig. 1. *C. reticulatus* C. & V., mature male, lateral view of a preserved specimen collected in May 1950, Plymouth.
 Fig. 2. Same as fig. 1, dorsal view.
 Fig. 3. *C. reticulatus* C. & V., male, lateral view of a living specimen collected in November 1949. Plymouth.
 Fig. 4. *C. reticulatus* C. & V., mature female, dorsal view of a fresh specimen collected in July 1950, Plymouth.
 Fig. 5. *C. lyra* L., young female, dorsal view of a fresh specimen collected in September 1950, Plymouth.
 Fig. 6. *C. maculatus* (Rafinesque), mature female, dorsal view of a fresh specimen collected in May 1950, Plymouth.

PLATE II, photographs of *Callionymus*, figs. 1-7, $\times 6\cdot7$; fig. 7, $\times \frac{2}{3}$.

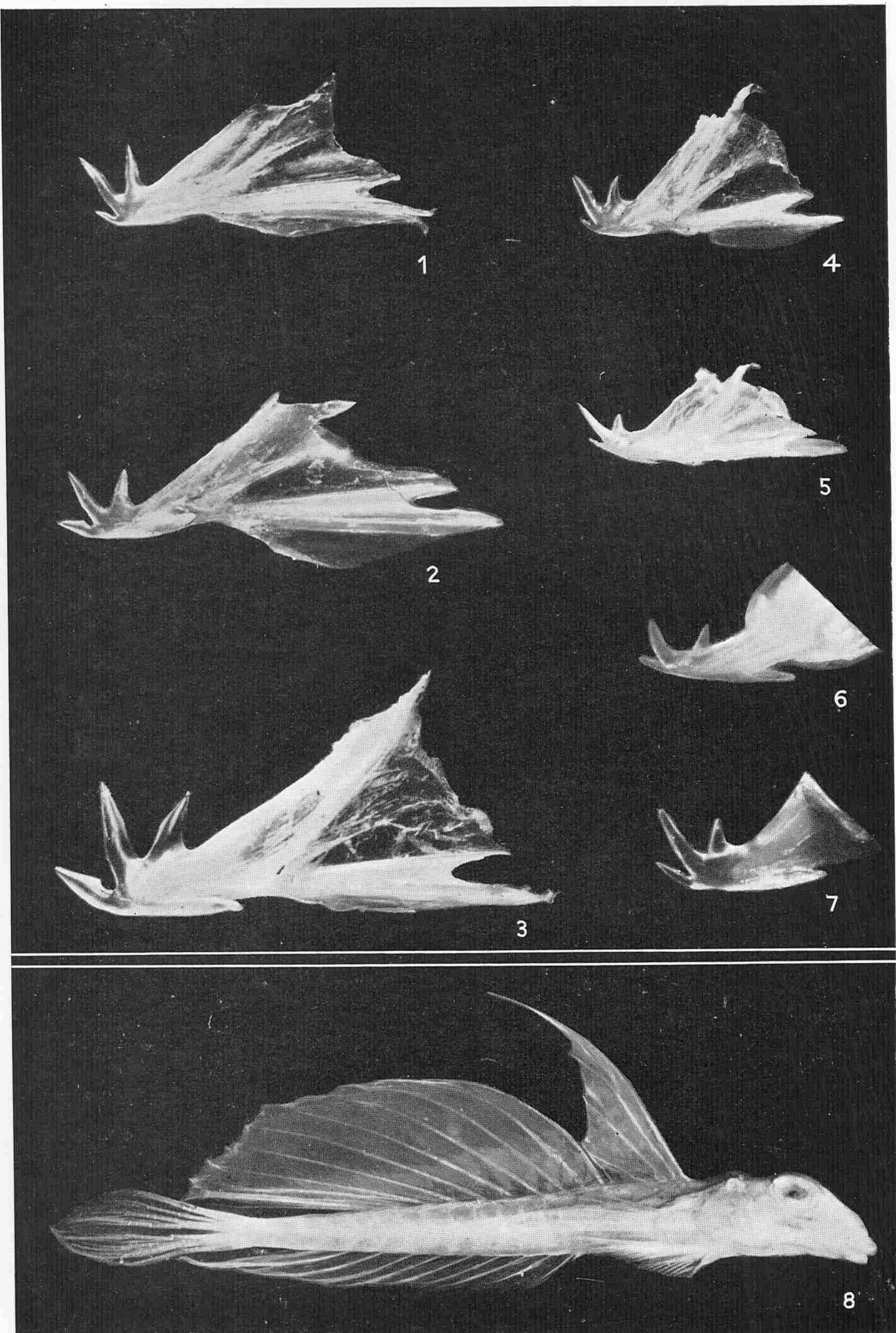
- Fig. 1. The right preopercular bone, lateral view, of a male *C. reticulatus*, 86 mm. long, Plymouth, bearing three recurved spines only.
 Fig. 2. The right preopercular bone, lateral view, of a male *C. maculatus*, 86 mm. long, Plymouth, showing three recurved spines and one basal spine.
 Fig. 3. The right preopercular bone, lateral view, of a female *C. lyra*, 86 mm. long, Plymouth, showing three recurved spines and one basal spine.
 Fig. 4. The right preopercular bone, lateral view, of a male *C. reticulatus*, 60 mm. long, Plymouth, bearing three recurved spines and one rudimentary basal spine.
 Fig. 5. Same as the above specimen, dorsal view to show three recurved spines and the rudimentary basal spine.
 Fig. 6. A portion of the right preopercular bone, dorsal view, of a male *C. fasciatus*, 71 mm. in standard length, Genoa, showing the well-developed basal spine.
 Fig. 7. Same as above, lateral view.
 Fig. 8. *C. reticulatus* C. & V., lateral view, mature male, 110 mm. in total length, Portugal.

PLATE III, *Callionymus reticulatus* C. & V.

- Figs. 1, 1a, male; Figs. 2, 2a, female. Fig. 1 is a specimen 108 mm. long caught off Plymouth on 11 May 1950. (From original coloured drawing by A. Fraser Brunner.)



Figs. 1-6.



Figs. 1-8.

