

REVIEW OF THE LANTERNFISH GENUS *LAMPADENA* WITH A DESCRIPTION OF A NEW SPECIES

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ABSTRACT: The genus *Lampadena*, family Myctophidae, includes seven known species, one of which, occurring in the southern hemisphere, is here described as new. We consider *L. nitida* to be conspecific with *L. luminosa* and do not recognize the subgenus *Lychnophora*. The otoliths of the species in the genus show interspecific differences, and thus are of taxonomic value. The distribution of each species is plotted and tentative conclusions concerning relationships within the genus are presented.

INTRODUCTION

In spite of the considerable amount of work which has been done on the family Myctophidae, many groups within the family need to be reworked. There are three reasons for this: (a) inadequate original and subsequent descriptions, including, as Bolin (1959) has emphasized, extremely general statements concerning the distribution of individual species; (b) addition of new species; and (c) the potential for more critical comparative studies due to the increase in the number and size of collections.

Prior to Bolin's work (1959) the genus *Lampadena* comprised a total of nine described species assigned by Fraser-Brunner (1949) to two subgenera, *Lampadena* and *Lychnophora*. Two of these nine species were placed by Bolin in a separate genus, *Taaningichthys*. Further, the same author placed *Lampadena braueri* Zugmayer in the synonymy of *L. speculigera* Goode and Bean. Paxton (1963) described a new species, *L. urophaos*, from the eastern north Pacific, and placed it in the subgenus *Lychnophora*. At that point the composition of the two subgenera was as follows: subgenus *Lampadena*—*L. speculigera*, *L. dea*, *L. chavesi*, *L. anomala*; subgenus *Lychnophora*—*L. luminosa*, *L. nitida*, *L. urophaos*.

The two main purposes of the present work are (a) to bring "under one roof" detailed descriptions of all the species of the genus found scattered in the literature, and (b) to present a survey of those species which occur in the southern oceans. The genus as a whole is rather uncommon. Examination of many more collections around the world will probably result in an increase in the number of known species in the genus and further elucidate individual patterns of distribution. With representatives of all currently known species

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available to us, we thought it advisable to redescribe them in as much detail as possible, thus hoping to minimize confusion in future investigations.

MATERIALS AND METHODS

The ultimate rays of the dorsal and anal fins are double, but they have here been considered as single. Only the well-developed gill rakers of the first gill arch (one side) have been counted. In the method of taking measurements and presenting data we follow Bolin (1939). A few modifications and additions were made, however. These are as follows: depth of body—the vertical through the upper end of the base of the pectoral fin; caudal peduncle length—the distance from the base of the last anal ray to the end of the hypural plate; caudal gland length—the greatest extent of the luminous tissue, not always a midline measurement. Most measurements and proportionality data have proven unsatisfactory for the elucidation of differences between species of the genus *Lampadena*. Rather than present what we consider meaningless data under each species description, those measurements which have proven useful are summarized in Table 1. Certain proportions, notably the lengths of the dorsal and anal fin bases, have been utilized in the past to characterize genera. To enable a future comparison of the genus *Lampadena* with other myctophid genera, those measurements, expressed as per cent of standard length (SL), which are not useful at the specific level, are summarized for all species (except *L. anomala*) as follows: length of head, 28.4-36.6; depth of head, 18.2-23.3; length of upper jaw, 19.1-26.9; depth of body, 18.3-23.8; predorsal distance, 44.3-50.0; prepectoral distance, 28.9-37.4; preventral distance, 40.9-50.5; preadipose distance, 69.2-78.8; length of base of dorsal fin, 12.6-20.7; length of base of anal fin, 11.8-16.7. A list of individual measurements and calculated percentages of standard lengths for all specimens is available on request. Vertebral counts and structure were determined from X-rays.

Under the description of each species, locality data are presented for all specimens examined and ranges of standard lengths are given. Coordinates for the starting position only of each trawl are included. All time is in local time. All captures were made with a 10' Isaacs-Kidd Midwater Trawl (IKMT), unless otherwise indicated. For open IKMT captures, the depth sampled is recorded from the surface to maximum depth reached by the gear. For captures with an IKMT equipped with a closing device, the discrete depth sampled is indicated.

The terminology of body photophores is that of Bolin (1939). Consistent within all specimens examined, and indeed in the entire family, is the presence of three Br photophores on the branchiostegal membranes under the ventral sheet of the dentaries. Since they are invariably present, their occurrence is omitted from the species descriptions.

Otoliths were measured with an ocular micrometer, then lightly smeared

with graphite to bring out details in their sculpture and photographed. The entire series of otoliths is deposited in the extensive collection established by John Fitch of the California Fish and Game at Terminal Island and supported by a National Science Foundation Grant. The terminology on otoliths follows that of Frizzell and Dante (1965).

KEY TO THE SPECIES OF THE GENUS *Lampadena*

- 1a. None of the PO abruptly and highly elevated..... 2
- 1b. PO₄ abruptly and highly elevated, about over PO₃.....
.....*L. luminosa* (Garman, 1899)
- 2a. VO plus SAO 7-9; AOa 5-7; Pol immediately below or very close to lateral line 3
- 2b. VO plus SAO 5-6; AOa 3-4; distance between Pol and lateral line about half as great as that between Pol and ventral contour of caudal peduncle
.....*L. anomala* Parr, 1928
- 3a. Prc₁-Prc₂ interspace equal to, or greater than, three times the diameter of a photophore of this series..... 4
- 3b. Prc₁-Prc₂ interspace much shorter than three times the diameter of a photophore of this series..... 5
- 4a. Last two (sometimes three) AOa entirely behind base of anal fin; two AOp; infracaudal luminous gland very long, at least 1.5 times as long as least depth of caudal peduncle, almost twice as long as diameter of eye; crescent-shaped patch of whitish tissue on iris above pupil; pterotic spine directed posteriorly.....*L. chavesi* Collett, 1905
- 4b. No AOa behind base of anal fin; four to five AOp (rarely three); infracaudal luminous gland shorter than 1.5 times the least depth of caudal peduncle and about 1.5 times as long as diameter of eye; no crescent-shaped patch of whitish tissue on iris above pupil; pterotic spine directed downward and forward (in specimens longer than about 30 mm).....
.....*L. dea* Fraser-Brunner, 1949
- 5a. Gill rakers 6-8+1+12-17; supracaudal gland shorter than infracaudal gland; mesopterygoid teeth uniformly small..... 6
- 5b. Gill rakers 3-5+1+8-10; supracaudal gland equal in length to or somewhat longer than infracaudal gland; posterior mesopterygoid teeth noticeably enlarged.....*L. urophaos* Paxton, 1963
- 6a. Distance between posterior end of base of anal fin and anterior margin of infracaudal gland equal to, or slightly greater than, length of this gland; photophores small, in specimens smaller than 30 mm AOa about two organ diameters apart from each other; first and usually second AOp in front of infracaudal gland; AOa level; gill rakers 6-7+1+12-14, total

- 19-22.....*L. speculigera* Goode & Bean, 1896
- 6b. Distance between posterior end of base of anal fin and anterior margin of infra-caudal gland equal to about one-fourth of length of this gland; photophores large, in specimens smaller than 30 mm AOa less than one organ diameter apart from each other; all AOp well over infra-caudal gland; last AOa usually distinctly raised above level of rest of organs of same series; gill rakers 7-8+1+16-17, total 24-26.....*L. notialis* sp. n.

Lampadena luminosa (Garman, 1899)

Fig. 1

R/V ANTON BRUUN, cruise III, sta. 147, 06°54'N, 59°55'E, 16 August 1963, 1845-2213 hrs, depth sampled 0-750 m, bottom depth 1775-3015 m, one specimen, 31.0 mm; sta. 151, 04°52'S, 60°02'E, 23 August 1963, 0625-1350 hrs, depth sampled 0-2030 m, bottom depth 3895 m, two specimens, 67.5-86.0 mm.

R/V ANTON BRUUN, cruise VI, sta. 334A, 06°01'N, 64°59'E, 24 May 1964, 1912-2345 hrs, depth sampled 0-700 m, bottom depth 4663 m, one specimen, 53.0 mm; sta. 335B, 03°46'N, 65°05'E, 26 May 1964, 0100-0850 hrs, depth sampled 0-275 m, bottom depth 2926 m, two specimens, 39.5-49.0 mm; sta. 341B, 07°56'S, 65°14'E, 1-2 June 1964, 2200-0300 hrs, depth sampled 0-504 m, bottom depth 4200 m, one specimen, 22.0 mm; sta. 342A, 09°57'S, 64°55'E, 2 June 1964, 1755-2250 hrs, depth sampled 0-525 m, bottom depth 3200 m, 12 specimens, 16.5-29.0 mm; sta. 343A, 12°10'S, 64°54'E, 4 June 1964, 0020-0510 hrs, depth sampled 0-798 m, bottom depth 3200 m, one specimen, 20.0 mm; sta. 345E, 17°58'S, 65°34'E, 7 June 1964, 2130-2400 hrs, depth sampled 0-120 m, bottom depth 3000 m, five specimens, 17.0-22.0 mm.

Scripps Institute of Oceanography, SIO 60-239-25H, 04°56'N, 142°54'W, 6 July 1960, one specimen, 22.5 mm.

R/V ATLANTIS II, cruise 13, sta. RHB 1005, 41°26'N, 59°01'W, 4 September 1964, 1045-1410 hrs, depth sampled 0-555 m, one specimen, 28.0 mm; sta. RHB 1013, 41°36'N, 52°21'W, 6 September 1964, 1940-2320 hrs, depth sampled 0-65 m, one specimen, 23.5 mm.

R/V CHAIN, cruise 17, sta. RHB 801, 00°15'S, 18°40'W, 26 April 1961, 0250-0605 hrs, depth sampled 0-85 m, one specimen, 49.0 mm.

R/V CHAIN, cruise 35, sta. RHB 960, 07°39'N, 45°14'W, 11 February 1963, 2005-2350 hrs, depth sampled 0-60 m, one specimen, 27.0 mm; sta. RHB 966, 01°13'S, 34°35'W, 17 February 1963, 0335-0605 hrs, depth sampled 0-102 m, four specimens, 23.0-33.0 mm.

R/V CHAIN, cruise 60, sta. RHB 1252, 16°45'N, 64°18'W, 24 May 1966, 2015-2335 hrs, depth sampled 0-84 m, 12 specimens, 19.0-33.0 mm; sta. RHB 1253, 16°38'N, 64°27'W, 25 May 1966, 0046-0400 hrs, depth sampled

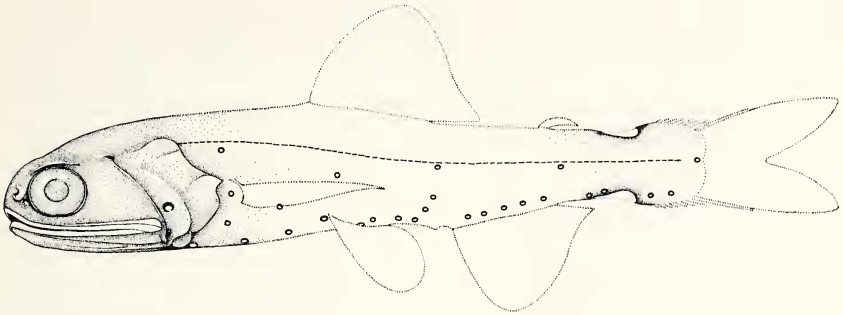


Figure 1. *Lampadena luminosa*, 67.4 mm in standard length; 04° 52' S, 60° 02' E.

0-133 m, two specimens, 20.0-27.0 mm; sta. RHB 1258, 13°32'N, 71°24'W, 27 May 1966, 2030-2300 hrs, depth sampled 0-210 m, one specimen, 19.0 mm; sta. RHB 1261, 13°04'N, 73°12'W, 28 May 1966, 1628-1955 hrs, depth sampled 0-300 m, four specimens, 29.0-66.0 mm; sta. RHB 1263, 12°58'N, 73°34'W, 29 May 1966, 0040-0450 hrs, depth sampled 0-120 m, nine specimens, 27.0-69.0 mm; sta. RHB 1286, 19°46'N, 83°07'W, 10 June 1966, 0020-0505 hrs, depth sampled 0-86 m, nine specimens, 17.0-51.0 mm; sta. RHB 1289, 21°11'N, 85°12'W, 10 June 1966, 2010-2320 hrs, depth sampled 0-170 m, two specimens, 41.5-64.0 mm; sta. RHB 1290, 21°17'N, 85°22'W, 11 June 1966, 0030-0400 hrs, depth sampled 0-124 m, eight specimens, 17.0-71.0 mm (otolith of 71.0 mm specimen photographed, Fig. 10); sta. RHB 1307, 27°01' N, 90°02'W, 22 June 1966, 0007-0400 hrs, depth sampled 0-95 m, six specimens 39.0-67.5 mm; sta. RHB 1315, 25°46'N, 79°47'W, 25-26 June 1966, 0002-0400 hrs, depth sampled 0-71 m, 41 specimens, 18.0-26.0 mm.

D. 15; A. 14(13-15); P. 16(15-17); V. 8; gill rakers 4+1+9(8-10), total 14(13-15); PO 5; VO 4-5; AOa 5-6 (rarely 7); AOp 2; Prc 2+1; lateral line scales 35-37; vert. 36(37), 8 x-rayed specimens. Of 16 specimens counted, only one had P. 17.

A relatively large myctophid fish; snout obtuse and round; mouth large, terminal, its cleft somewhat oblique; eye of moderate size, its diameter 3.7 to 4.3 in length of head; opercular margin concave posterodorsally, convex posteroventrally, tapering into a rather sharp point located above PVO₂ and with a distinct indentation at about level of same organ; pterotic spine strong and directed posteriorly.

Origin of dorsal fin distinctly in advance of vertical through base of outermost ray of ventral fin; origin of anal fin well behind vertical through end of base of dorsal fin; base of adipose fin somewhat in advance of vertical through end of base of anal fin; pectoral fin long, extending to level of second or third VO; ventral fin reaching anus.

A small, roundish Vn posteroventrad to nasal apparatus, capped by crescent-shaped, darkly pigmented tissue; a narrow strand of black tissue extending along entire anterior margin of orbit. A very small, deeply embedded Op_1 close behind angle of mouth; Op_2 larger than general body photophores, directly over or slightly posterior to Op_1 and about at level of ventral margin of orbit.

PLO in advance of base of pectoral fin and 1.5 to 2 times its own diameter below lateral line. PVO_1 at about level of posterior end of maxillary and somewhat in advance of vertical through PVO_2 ; PVO_2 somewhat behind straight line connecting PLO with PVO_1 , distinctly above level of Op_2 and in front of middle of base of pectoral fin. First PO interspace 1.2 to 1.4 times as wide as second, which is equal to or somewhat narrower than that between PO_3 and PO_5 ; PO_5 displaced laterally, situated about its own diameter in front of and anteromesad to base of outermost ray of ventral fin; PO_4 highly and abruptly elevated, over, slightly anterior or slightly posterior to vertical through PO_3 and on same level with, or somewhat higher than, PVO_1 . VLO distinctly behind vertical through base of outermost ray of ventral fin and somewhat nearer to lateral line than to base of ventral fin. VO series forming a gentle arc; VO_1 posteromesad to base of inner ray of ventral fin. SAO slightly angular, with last VO, SAO_1 and SAO_2 equidistant and on straight, steeply ascending line; SAO_2 - SAO_3 interspace about twice as wide as SAO_1 - SAO_2 interspace; SAO_3 on or slightly posterior to vertical through SAO_2 and immediately below lateral line. AOa level and usually evenly spaced. Pol behind vertical through last AOa and immediately below lateral line. AOp_1 slightly in front of, or directly over anterior end of infracaudal luminous gland and separated from AOp_2 by a distance about 1.5 times the diameter of these organs. Prc_1 and Prc_2 on horizontal line, space between them varying from 1 to 2.5 times the diameter of these organs; Prc_3 at base of middle rays of caudal fin, on level of lateral line and well behind vertical through Prc_2 .

Supra- and infracaudal luminous glands of about equal length, somewhat shorter than diameter of eye; distance between anterior end of infracaudal gland and posterior end of base of anal fin about equal to or slightly less than length of gland.

Several series of needlelike teeth on both jaws, those of inner series distinctly larger and more widely spaced; four to five large, recurved teeth directed anteriorly at posterior end of dentary; one to two large teeth hooked forward in inner dentary row near symphysis (these peculiar teeth are undifferentiated in young specimens and often missing in large ones); anteriormost premaxillary teeth in outer row very slightly hooked. Palatines with a narrow band of small teeth. A small patch of similar teeth on distal end of each limb of vomer. Mesopterygoid teeth in large patch with medial series greatly enlarged in maturing fish (about 65 mm), undifferentiated in size in young individuals; last few teeth on posterolateral margin of patch also enlarged. Quite often, in

the fish examined, several specimens of comparable size from the same haul showed marked differences in the development of the medial series of mesopterygoid teeth.

Neural arches of anterior vertebrae not greatly expanded.

A direct comparison of the type specimens of *Lampadena luminosa* and *L. nitida* (Tåning, 1928) revealed no differences. Tåning, it seems, established his subspecies *L. luminosa nitida* mainly on the basis of the division of the VO series into two groups (Bolin, pers. comm.). A grouping of the VO into 1+1+3 is clearly visible in Garman's type. Furthermore, examination of several specimens, from both the Atlantic and Indian Oceans, shows that irregularities in the spacing of both the VO and the AOa series are not uncommon within a given population. Some specimens have five VO evenly spaced, others, from the same station, have the same number of VO but the series is divided into two groups (2+3). Still others possess only four VO either evenly spaced or with the VO₂-VO₃ interspace distinctly wider than the other interspaces in the series. Finally, in some cases where there are five VO, the third is markedly reduced in size. With these differences appearing to be a simple expression of intra-specific variation and with no other differences sharp enough to justify the establishment of two species, or even subspecies, we place Tåning's *L. luminosa nitida* in the synonymy of *L. luminosa* Garman.

It should also be added here that among the Indian Ocean specimens two trends involving the numbers and arrangement of the VO, AOa and Prc can be discerned. Specimens with four VO usually, but not invariably, have five AOa. The Prc₁ and Prc₂ in these specimens are separated by a distance equal to 2 to 2.5 times the diameter of a body photophore. On the other hand, specimens with five VO tend to have six AOa. The Prc₁-Prc₂ interspace in the latter individuals is equal to 1 to 1.5 times the diameter of a body photophore. Intermediates between the two patterns are not uncommon and the differences in the three characters mentioned seem to intergrade.

Lampadena luminosa appears to be a tropical species, found mainly in equatorial waters of all three oceans, between 20°N and 20°S (Fig. 8). Its occurrence in the Gulf of Mexico, Straits of Florida and high latitudes in the western north Atlantic is probably due to the influence of the Gulf Stream. Individuals of many tropical myctophid species have often been taken all along the path of this current as far as 42°N in the western half of the north Atlantic (O'Day and Nafpaktitis, 1967). It is reasonable to suspect a similar situation in the western north Pacific. For instance, Matsubara (1952) reports, under the name *L. nitida*, a specimen 150 mm (SL) taken by commercial fishermen off Owase, Mie Prefecture, Japan.

***Lampadena urophaos* Paxton, 1963**

Fig. 2

Most of the examined specimens are from the southern California off-

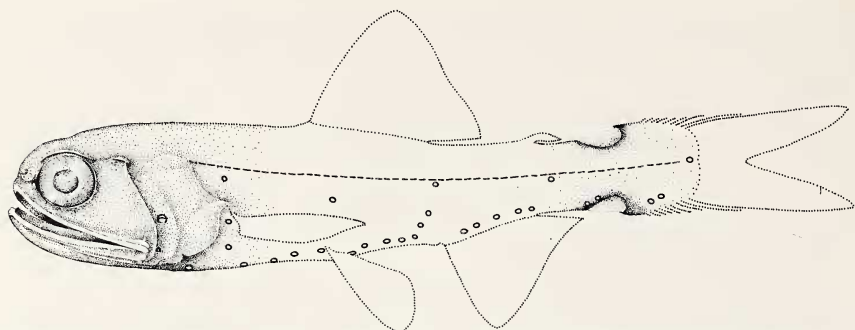


Figure 2. *Lampadena urophaos*, 56.0 mm in standard length; San Nicolas basin, California.

shore waters, and only a few localities were plotted (Fig. 9). Station data for the Pacific localities are from Berry and Perkins (1966), Paxton (1963), and Percy (pers. comm.); coordinates for the latter are $34^{\circ}49'N$, $160^{\circ}19'W$, and $42^{\circ}00'N$, $126^{\circ}59'W$. The following Atlantic specimens were also examined: CAP'N BILL III, sta. RHB 910, $38^{\circ}24'N$, $71^{\circ}08'W$, 12 October 1962, 1330-1830 hrs, 0-713 m, 64' midwater trawl, one specimen, 73.6 mm; R/V CHAIN, cruise 49, sta. RHB 1111, $21^{\circ}33'N$, $70^{\circ}12'W$, 17 June 1965, 1520-1940 hrs, 612-668 m, two specimens, 19.0-22.7 mm.

D. 15(14-16); A. 14(13); P. 16(15-17); V. 8; gill rakers 4(3-5)+1+8-9(10), total 13-14(16); PO 5; VO 5(4-6); AOa 5(6); AOp 2(3); Prc 2+1; lateral line scale pockets 37; vert. 36(35), 6 x-rayed specimens. Of 22 specimens examined, the following counts were observed only once: D. 16; P. 17; gill rakers 3+1+9, 5+1+10; VO 6; AOa 6; AOp 3.

Snout bluntly rounded; mouth large, terminal, its cleft slightly oblique; eye moderate in size, its diameter 3.5 to 4.1 in length of head; posterior opercular margin produced into a point situated above PVO_2 ; pterotic spine strong, directed posteriorly and slightly ventrally.

Origin of dorsal fin distinctly anterior to origin of ventral fin; origin of anal fin behind vertical through end of base of dorsal fin; base of adipose fin somewhat in advance of vertical through end of base of anal fin; pectoral rays extending about to level of VO_2 ; ventral rays almost reaching origin of anal fin.

V_n small, posterior and ventral to nasal organ; anterior margin of orbit, from below V_n to above nasal organ, lined with black tissue. Op_1 small and difficult to discern, situated about on same level as and close behind posterior end of maxillary; Op_2 larger than body photophores, located about at level of ventral margin of orbit, slightly behind vertical through Op_1 .

PLO one to three photophore diameters below lateral line and anterior to PVO_2 . PVO_2 slightly anterior to upper half of base of pectoral fin; PVO_1 about on level of posterior end of mouth, slightly anterior to or under PVO_2 in

Pacific specimens and under or slightly posterior to PVO_2 in Atlantic specimens. First PO interspace about twice as wide as others; PO_2 to PO_5 evenly spaced or PO_4 - PO_5 interspace slightly larger; PO_1 to PO_3 in a horizontal line, with PO_4 and PO_5 diverging posteriorly; PO_4 somewhat closer to level of PO_5 than to that of PO_3 ; PO_5 slightly anteromesad to base of outermost ray of ventral fin. VLO distinctly behind vertical through base of outermost ray of ventral fin, closer to lateral line than to base of ventral fin. VO_1 slightly postero-mesad to base of innermost ray of ventral fin; rest of VO somewhat higher, the entire series forming a gentle arc, with the organs evenly spaced or with VO_2 - VO_3 interspace largest, particularly if only four VO present. Last VO, SAO_1 and SAO_2 evenly spaced and in a straight line; SAO_3 over or slightly posterior to SAO_2 , about under base of last dorsal ray and immediately below lateral line; SAO_2 - SAO_3 interspace about twice as wide as others in series. AOa in a straight line, evenly spaced or noticeably grouped (2+1+2); last AOa directly over or slightly anterior to base of last anal ray. Pol behind last AOa, immediately below lateral line. AOP_1 over anterior margin of infracaudal gland, separated from AOP_2 by 1 to 1.5 photophore diameters (in the one specimen with three AOp, the third is half the size of other body photophores). Prc_1 over second or third ventral procurrent spine, one to two photophore diameters anterior to Prc_2 ; Prc_3 at base of middle rays of caudal fin and slightly above level of lateral line.

In small specimens, supra- and infracaudal luminous glands are about equal in length; in all large Pacific specimens (over 50 mm), the supracaudal gland is somewhat longer, while they are of equal length in the large Atlantic specimen; distance from base of last anal ray to anterior margin of infracaudal gland two-thirds to one times the length of infracaudal gland.

Premaxillary and dentary with wide band of conical, closely-set teeth; entire inner row of dentary composed of larger, more widely-spaced conical teeth; three to five large, recurved teeth directed anteriorly at posterior end of dentary; inner row of premaxillary teeth only slightly enlarged; dentigerous portion of premaxillary, near symphysis, somewhat widened to form an approximately triangular area, with an upper (outer) row of three to five large, recurved teeth directed posteroventrally. A narrow band of small teeth along length of palatine. A small patch of teeth on distal ends of vomer. Very small mesopterygoid teeth in an elongated, oval-shaped patch; posterolateral margin of patch with row of six to ten moderate-size teeth.

Neural arches of anterior vertebrae not greatly expanded.

A number of errors were made in the original description (Paxton, 1963), which are corrected in the above description. The antorbital organ, which is difficult to discern in adult specimens and is obscured by the black tissue at the anterior portion of the orbit, is definitely ventral to the nasal organ. Thus, *L. urophaos* agrees with all of its congeners in the presence of a small Vn. The ventral ray count for the species is eight, plus a small accessory splint on the

base of the first ray. With very few exceptions (notably species in the genera *Gonichthys* and *Notolychnus*), eight ventral rays plus an accessory splint is constant for the family Myctophidae. The PO_4 and PO_5 , while slightly raised out of the line of PO_1 - PO_3 , are not as highly elevated as is the PO_4 in *L. luminosa*. *L. urophaos* can therefore be referred to the subgenus *Lampadena*, as defined by Fraser-Brunner (1949). The status of the subgenus *Lychnophora* will be discussed after the species descriptions.

Lampadena urophaos occurs between 25°N and 42°N in the central and eastern Pacific and between 21°N and 38°N in the western Atlantic (Fig. 9). The minor differences noted between the Pacific and Atlantic populations, namely the position of the PVO_1 and the relative sizes of the caudal glands, may be expected in widely allopatric populations. A more complete comparison of the populations must await the collection of additional large Atlantic specimens.

***Lampadena speculigera* Goode and Bean, 1896**

Fig. 3

USNS ELTANIN, cruise 15, sta. 1402, 39°15'S, 179°35'W, 30 November to 1 December 1964, 2353-0600 hrs, depth sampled 0-2489 m, bottom depth 2946-3514 m, one specimen, 20.0 mm.

USNS ELTANIN, cruise 23, sta. 1710, 41°44'S, 178°18'W, 25 May 1966, 1658-1956 hrs, depth sampled 0-900 m, bottom depth 2641 m, one specimen, 66.0 mm (otolith photographed, Fig. 10).

USNS ELTANIN, cruise 26, sta. 1820, 40°22'S, 168°25'E, 2 December 1966, 2000-2319 hrs, depth sampled 0-750 m, bottom depth 920-1028 m, one specimen 109.0 mm.

R/V ANTON BRUUN, cruise III, sta. 157, 32°11'S, 59°30'E, 8 September 1963, 1510-1835 hrs, depth sampled 150-750 m, bottom depth 4389 m, four specimens, 21.0-24.0 mm.

R/V ANTON BRUUN, cruise VI, sta. 352B, 34°14'S, 64°58'E, 30 June 1964, 1420-2000 hrs, depth sampled 350-750 m, bottom depth 2700 m, two specimens, 20.0-20.5 mm.

R/V ANTON BRUUN, cruise XIII, coll. 54, 33°42'S, 73°35'W, 2 February 1966, 0320-0920 hrs, depth sampled 0-500 m, one specimen, 70.5 mm.

R/V CAP'N BILL III, sta. RHB 913, 39°26'N, 71°00'W, 13 October 1962, 1020-1505 hrs, depth sampled 0-715 m, 64' midwater trawl, one specimen, 128.0 mm; sta. RHB 914, 39°32'N, 71°00'W, 13 October 1962, 1545-2025 hrs, depth sampled 0-715 m, 64' midwater trawl, one specimen, 130.0 mm; sta. RHB 915, 39°36'N, 71°12'W, 13 October 1962, 2105-0025 hrs, depth sampled 0-550 m, 64' midwater trawl, one specimen, 126.0 mm (otolith photographed, Fig. 4).

R/V ATLANTIS II, cruise 13, sta. RHB 1023, 43°16'N, 45°03'W, 10

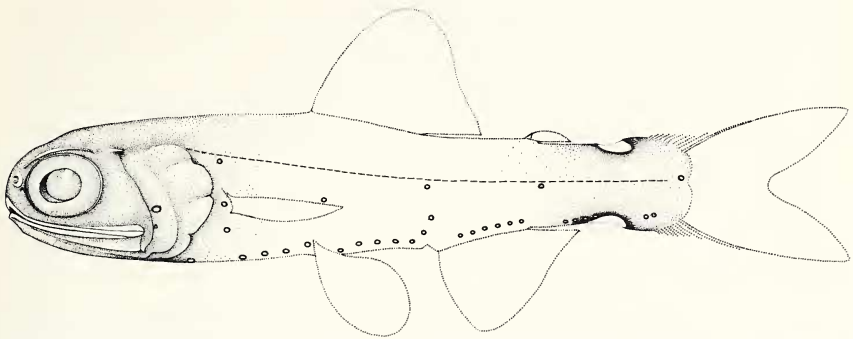


Figure 3. *Lampadena speculigera*, 66.0 mm in standard length; 41° 44' S, 178° 18' W.

September 1964, 0855-1230 hrs, depth sampled 0-700 m, two specimens, 33.0 mm; sta. RHB 1006, 41°16'N, 57°37'W, 4 September 1964, 1947-2330 hrs, depth sampled 0-85 m, four specimens, 29.0-36.0 mm; sta. RHB 1003, 41° 36'N, 60°30'W, 3 September 1964, 2021-2345 hrs, depth sampled 0-60 m, one specimen, 28.0 mm.

D. 14(13-15); A. 14(15); P. 14(15); V. 8; gill rakers 6-7+1+12-14, total 19-22; PO 5(6); VO 5(4-6); AOa 6-7; AOp 3-4(5); Prc 2+1; lateral line scales 39-41; vert. 38-39(40), 5 x-rayed specimens. Of 15 specimens examined, the following counts were found only once: D. 13; PO 6; VO 4; AOp 5.

Snout bluntly rounded; mouth large, barely subterminal, its cleft very slightly oblique; eye large, its diameter 2.7 to 3.2 in length of head; opercular margin not pointed, but with a shallow indentation about on level of upper end of pectoral base; pterotic spine strong, straight, directed posterolaterally.

Origin of dorsal fin on or slightly behind vertical through base of outermost ray of ventral fin; origin of anal fin behind vertical through end of base of dorsal fin; base of adipose fin over end of base of anal fin; pectoral fin extending to about level of first VO; ventral fin reaching origin of anal fin.

A small Vn, immediately posteroventrad to nasal apparatus and directed ventrally; anterior third of orbital margin lined with black tissue. Op₁ small, immediately behind lower preopercular margin and opposite posterior end of mouth; Op₂ markedly larger than general body photophores, at least one times its own diameter above level of ventral margin of orbit and about 2.5 times its own diameter above and slightly behind Op₁.

PLO distinctly in advance of vertical through base of uppermost ray of pectoral fin and about one photophore diameter below lateral line; PVO₁ somewhat above level of posterior end of maxillary, slightly behind vertical through PVO₂, which is situated in front of lower half of base of pectoral fin and on a straight line connecting PLO with PVO₁. PO₁-PO₂ interspace about

twice as wide as PO_4 - PO_5 interspace, which is equal to or slightly wider than rest; PO_1 - PO_3 in a horizontal line; PO_5 situated about its own diameter in front of, and slightly mesad to, base of outermost ray of ventral fin; PO_4 much closer to horizontal level of PO_3 than to that of PO_5 . VLO distinctly behind vertical through base of outermost ray of ventral fin and somewhat closer to lateral line than to base of ventral fin; VO more or less level and evenly spaced, sometimes last VO slightly raised; VO_1 posteromesad to base of innermost ray of ventral fin. SAO forming a wide angle; SAO_1 above and behind last VO; SAO_2 above and behind SAO_1 ; SAO_2 - SAO_3 interspace about 2.5 times as wide as SAO_1 - SAO_2 interspace, which is equal to that of VO_5 - SAO_1 ; SAO_3 slightly in advance of vertical through SAO_2 and its own diameter, or less, below lateral line. AO small, especially in young specimens; AOa level, evenly spaced, about one photophore diameter (one to two diameters in fishes less than 30 mm) apart from each other. Pol behind last AOa and about its own diameter below lateral line; AOp evenly spaced, on a straight, gently ascending line; AOp_1 and usually AOp_2 in front of anterior end of infracaudal luminous gland. Prc_1 and Prc_2 horizontal or Prc_2 slightly raised, the two photophores being only one organ diameter apart from each other; Prc_3 at base of middle rays of caudal fin and very slightly above level of lateral line.

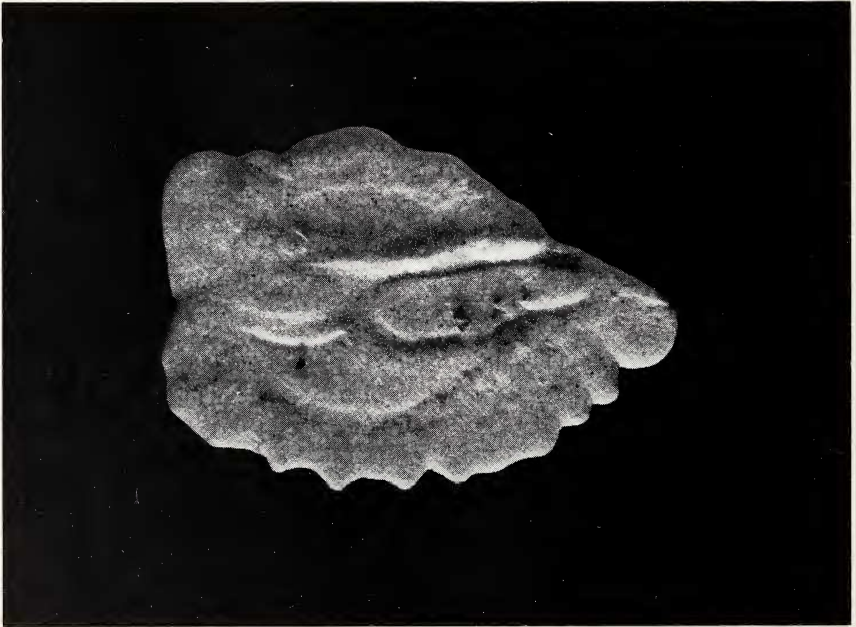


Figure 4. *Lampadena speculigera*, medial view of left otolith, 4.9 mm long, 3.5 mm high, belonging to an 126 mm specimen from the north Atlantic.

Length of supracaudal gland one-half to two-thirds that of infracaudal; posterior margin of both glands at about same vertical; posterior margin of supracaudal gland distinctly emarginate; distance between posterior end of base of anal fin and anterior margin of infracaudal luminous gland 1 to 1.5 times as great as length of this gland.

Premaxillary and especially dentary with bands of small, needlelike teeth; an inner series of 10 to 15 enlarged, broad-based, recurved teeth directed anteriorly on posterior dentary; two to five large, anteriorly directed, recurved teeth on inner margin of dentary close to symphysis (more prominent in large specimens, 80 mm or more); anterior end of premaxillary broadened, forming a roughly triangular dentigerous area outside the mouth; teeth of outer row of this area enlarged, recurved, directed posteroventrally. Palatine with long, narrow band of small teeth. Few minute teeth on each distal end of vomer. Mesopterygoid with large, roughly oval, patch of uniformly small teeth.

Neural arches of anterior vertebrae greatly expanded to form an almost closed tube above vertebrae.

Two trends can be distinguished between specimens from the two hemispheres. These involve AO and gill-raker counts. Individuals from the southern oceans tend to have 6+4 AO and 7+1+13-14 gill rakers, whereas in those from the north Atlantic, 7+3 AO and 6+1+12-13 gill rakers are the most frequent counts. In addition, John Fitch called our attention to the fact that the otoliths from a specimen 126 mm long taken in the north Atlantic (Fig. 4), were distinctly different from those of specimens from the southern hemisphere (Fig. 10 (4)). Some changes in size and shape, depending on the size of the specimens and the length of time of preservation, are to be expected. However, the differences in the present case are strong enough to warrant an examination of larger material, especially from the north Atlantic. Until this is done we prefer to consider the two populations as conspecific.

Our material from the southern hemisphere indicates that *Lampadena speculigera* is a subtropical-temperate form, ranging, in the Indian and Pacific Oceans, between the latitudes of approximately 30°S and 45°S. It is considered relatively common in the north Atlantic (Bolin, 1959). On the basis of material from the collections of the Woods Hole Oceanographic Institution, this species appears to range between the latitudes of approximately 35°N and 45°N in the north Atlantic (Fig. 9). Further study of large collections is necessary before its apparent absence from the south Atlantic can be ascertained.

***Lampadena notialis*, new species**

Fig. 5

Holotype: LACM 11321-1; immature specimen, 66.3 mm, USNS ELTANIN, cruise 26, sta. 1830, 42°00'S, 160°11'E to 42°08'S, 160°05'E, 8

December 1966, 0839-1140 hrs, depth sampled 0-800 m, bottom depth 4895 m (otolith photographed, Fig. 10).

Paratypes: LACM 11331-1; a male specimen, 105.0 mm, USNS EL-TANIN, cruise 26, sta. 1841, 47°20'S, 161°54'E to 47°28'S, 161°52'E, 12-13 December 1966, 2334-0221 hrs, depth sampled 0-800 m, bottom depth 4648 m. MCZ 45892; one specimen, 25.2 mm; R/V ANTON BRUUN, cruise VI, sta. 354A, 40°48'S, 65°03'E, 4 July 1964, 0915-1510 hrs, depth sampled 0-1650 m, bottom depth 4600 m.

D. 14; A. 14; P. 14; V. 8; gill rakers 7-8+1+16-17, total 24-26; PO 5; VO 5(6); AOa 6; AOp 3; Prc 2+1; lateral line scales 38-39; vert. 37-38, 2 x-rayed specimens.

A relatively large myctophid fish; body rather robust, gently tapering from vertical through base of pectoral fin to a deep caudal peduncle; dorsal and ventral contours anterior to pectoral fin evenly curved; snout rather high and bluntly rounded; mouth large, slightly subterminal, its cleft moderately oblique; eye large, its diameter 2.8 to 3.0 in length of head; posterior opercular margin produced into two rounded lobes separated by a triangular indentation located at about level of PVO₂; pterotic spine directed posterolaterally in younger specimen (holotype) and posteroventrally in mature specimen (paratype).

Origin of dorsal fin distinctly in advance of vertical through base of outermost ray of ventral fin; origin of anal fin behind vertical through end of base of dorsal fin; base of adipose fin about over end of base of anal fin; rays of pectoral fin extending slightly beyond base of ventral fin; rays of ventral fin reaching first or second ray of anal fin.

Vn well developed, immediately posteroventral to nasal apparatus, roundish, directed ventrally and framed dorsally and laterally by darkly pigmented tissue; a narrow strand of black tissue along entire anterior margin of orbit,

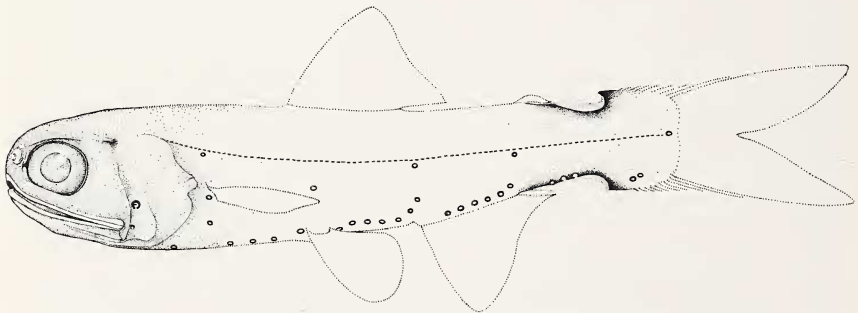


Figure 5. *Lampadena notialis*, new species, holotype, 66.3 mm in standard length; 42° 00' S, 160° 11' E; LACM 11321-1.

extending ventrally and posteriorly up to about vertical through center of pupil; suborbital region with numerous pores, each with a raised, darkly-pigmented ridge. Op_1 small, immediately behind preopercular margin and directly opposite or slightly below level of posterior end of maxillary, often masked by whitish tissue of adjacent neuromasts; Op_2 larger than general body photophores, at about level of ventral margin of orbit, slightly posterior to vertical through Op_1 and separated from latter by a distance about twice as large as its own diameter.

PLO slightly in advance of vertical through upper end of base of pectoral fin and 1.5 to 2 times its own diameter below lateral line. PVO_1 at about level of posterior end of mouth, directly under or slightly posterior to PVO_2 , which is about its own diameter in front of ventral half of base of pectoral fin. PO series forming gently diverging lines; first PO interspace 2 to 2.5 times as wide as spaces between rest of organs of same series; PO_5 about its own diameter from, and slightly mesad to, base of outermost ray of ventral fin. VLO slightly behind vertical through base of outermost ray of ventral fin and somewhat closer to lateral line than to base of ventral fin. LACM paratype with five VO distinctly divided into two groups (2+3) on the left side and six evenly spaced VO on the right side; holotype and smaller paratype with five evenly spaced VO on both sides, the organs forming a gentle arch; VO_1 posteromesad to base of innermost ray of ventral fin. SAO slightly angular; SAO_1 about its own diameter behind and above last VO; SAO_2 (not developed on left side of larger paratype) about its own diameter above, but only slightly behind SAO_1 ; SAO_3 directly over or slightly behind SAO_2 , its own diameter or less below lateral line and separated from SAO_2 by a distance 2 to 3 times as wide as that between SAO_1 and SAO_2 . AOa evenly spaced, interspaces about 1.5 times the diameter of an organ of same series (less than the diameter of a photophore in fishes less than 30 mm); all but last AOa level, latter distinctly raised, its ventral margin touching tangent to dorsal border of preceding organ. Pol behind last AOa and less than its own diameter below lateral line; all three AOp on anterior, ascending dorsal contour of infracaudal luminous gland; AOp interspaces equal to one diameter of an organ of same series, or less; Prc_1 - Prc_2 interspace equal to about half the diameter of an organ of same series; Prc_2 slightly raised; Prc_3 at base of middle rays of caudal fin and slightly above level of lateral line.

Supra- and infracaudal luminous glands very well developed; length of supracaudal gland about three-fourths that of infracaudal gland; length of infracaudal gland equal to (in small specimens) or greater than (in large specimens) diameter of eye; distance between posterior end of base of anal fin and anterior end of infracaudal gland equal to about one-fourth of length of that gland.

Premaxillary and dentary studded with small, villiform teeth; an inner series of eight to nine large, recurved forward, very broad-based teeth at

posterior end of dentary (particularly large in medium-sized fish—*i.e.*, size of holotype); an inner series of widely spaced, large teeth hooked forward along anterior end of dentary (best developed in large individuals); anterior denticerous ends of premaxillaries broadened near symphysis, forming a triangular area with an outer row of enlarged teeth recurved anteroventrally. Palatine teeth very small, papilliform, arranged in a long and narrow band. A small patch of minute teeth on distal end of each limb of vomer. A large, roughly oval patch of somewhat larger teeth on each mesopterygoid.

Neural arches of anterior vertebrae not greatly expanded.

The specific name comes from the Greek *notia*, which means southern, in reference to the occurrence of the species in high southern latitudes (Fig. 8).

Lampadena dea Fraser-Brunner, 1949

Fig. 6

R/V ANTON BRUUN, cruise III, sta. 156, 28°54'S, 60°01'E, 6-7 September 1963, 2155-0240 hrs, depth sampled 0-275 m, bottom depth 4114 m, one specimen, 23.0 mm; sta. 156, 29°13'S, 60°05'E, 7 September 1963, 0245-0620 hrs, depth sampled 0-150 m, bottom depth 4114 m, two specimens, 21.0 mm.

R/V ANTON BRUUN, cruise VI, sta. 352B, 34°14'S, 64°58'E, 30 June 1964, 1420-2000 hrs, depth sampled 350-750 m, bottom depth 2700 m, one specimen, 37.0 mm; sta. 353A, 37°59'S, 64°56'E, 2 July 1964, 1115-1925 hrs, depth sampled 350-2390 m, bottom depth 4400-4600 m, one specimen, 63.5 mm.

R/V ANTON BRUUN, cruise XIII, coll. 22, 33°51'S, 87°49'W, 18 January 1966, 0013-0530 hrs, depth sampled 0-375 m, bottom depth 3550-3900 m, one specimen, 45.5 mm; coll. 28, 30°45'S, 92°34'W, 22 January 1966, 0045-0650 hrs, depth sampled 0-320 m, bottom depth 3450-3710 m, two specimens, 35.0-39.5 mm; coll. 30, 31°07'S, 89°29'W, 24 January 1966, 0025-0350 hrs, depth sampled 0-410 m, bottom depth 3550-3950, two specimens, 27.0-40.0 mm.

USNS ELTANIN, cruise 24, sta. 1739, 40°15'S, 144°45'W, 26 July 1966, 0204-0530 hrs, depth sampled 0-1125 m, bottom depth 5325 m, one specimen, 59.0 mm (otolith photographed, Fig. 10).

D. 14; A. 14(15); P. 14(15); V. 8; gill rakers 6(7)+1+14(15), total 21(22-23); PO 5; VO 5(4-6); AOa 6-7(5); AOp 4-5(3); Prc 2+1; lateral line scales 37-38; vert. 38, 3 x-rayed specimens. Of ten specimens examined, the following counts occurred only once: A. 15; gill rakers 7+1+14, 7+1+15; VO 4, 6; AOp 3.

The 11 specimens in the collection yielded 22 AO counts, as follows: 5+4(4), 6+3(1), 6+4(6), 6+5(6), 7+4(4), and 7+5(1).

Snout bluntly rounded; mouth large, slightly subterminal, its cleft some-

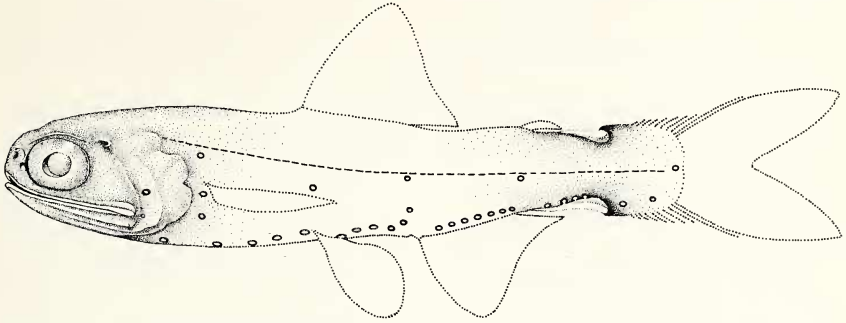


Figure 6. *Lampadena dea*, 59.0 mm in standard length; 40° 15' S, 144° 45' W.

what oblique; eye large, its diameter 2.9 to 3.3 in length of head; opercular margin with a very distinct triangular indentation at about level of upper half of base of pectoral fin; pterotic spine very strong, curved downward and forward in larger specimens, posterolaterally in smaller specimens.

Origin of dorsal fin over or slightly in advance of vertical through base of outermost ray of ventral fin; origin of anal fin behind vertical through end of base of dorsal fin; base of adipose fin somewhat behind vertical through end of base of anal fin; pectoral fin extending to about level of second VO; ventral fin reaching base of second or third anal ray.

Vn present, posteroventral to nasal apparatus, directed ventrally; anterior third of orbital margin lined with black tissue. A small Op_1 , difficult to see, close to and directly behind posterior end of maxillary; Op_2 distinctly larger than general body photophores, about on level of ventral margin of orbit and slightly behind vertical through Op_1 .

PLO slightly in advance of vertical through upper end of base of pectoral fin and about its own diameter below lateral line. PVO_1 at about level of posterior end of mouth, directly under or slightly in advance of vertical through PVO_2 , which is found in front of middle of base of pectoral fin and slightly behind straight line connecting PLO with PVO_1 . PO series forming posteriorly diverging lines, with PO_5 situated about its own diameter in front of, and slightly mesad to, base of outermost ray of ventral fin; first PO interspace about 1.5 times as wide as others; PO_4 closer to horizontal level of PO_3 than to that of PO_5 . VLO directly over or slightly in advance of vertical through base of outermost ray of ventral fin and markedly closer to lateral line than to base of ventral fin. VO equally spaced or distinctly grouped (2+3), the entire series on a gently arched line; VO_1 posteromesad to base of innermost ray of ventral fin. SAO forming a wide angle; SAO_1 above and behind last VO; SAO_2 above and behind SAO_1 ; SAO_2 - SAO_3 interspace 2 to 2.5 times as wide as SAO_1 SAO_2 interspace, which is equal to that of VO_5 - SAO_1 ; SAO_3 directly over,

slightly anterior, or immediately posterior to SAO_2 , and 0.5 to 1 time its own diameter below lateral line. AOa level and usually evenly spaced. Pol behind vertical through last AOa and less than one times its own diameter below lateral line. AOp evenly or irregularly spaced, but all organs over anterior two-thirds of infracaudal gland. Prc_1 anterior to first ventral procurrent spine; Prc_1 and Prc_2 on same horizontal level or Prc_2 slightly raised, the two organs separated by a distance equal to at least three photophore diameters; Prc_3 at base of middle rays of caudal fin, and slightly above level of lateral line.

Supra- and infracaudal luminous glands well developed; length of supra-caudal gland about two-thirds length of infracaudal gland; posterior margin of both glands on same vertical; posterior margin of supracaudal gland slightly or distinctly emarginate; distance between anterior end of infracaudal gland and posterior end of base of anal fin less than one-fourth the length of infracaudal gland.

Premaxillary and dentary with a band of small, conical teeth; inner series of 6-8 large, broad-based, widely-spaced, recurved teeth directed anteriorly on posterior third of dentary; two or three larger inner teeth on anterior dentary near symphysis, but these are not recurved; anterior dentigerous portion of premaxillary near symphysis slightly widened, with curved teeth. Narrow band of small teeth on palatine. No teeth evident on vomer. Elongated oval patch of small, uniformly-sized teeth on mesopterygoid.

Neural arches of anterior vertebrae greatly expanded to form an almost closed tube above centra.

Lampadena dea occurs in the southern parts of all three oceans, between the latitudes of approximately 20°S and 50°S (Fig. 9).

Lampadena chavesi Collett, 1905

Fig. 7

R/V ANTON BRUUN, cruise VI, sta. 351D, 31°45'S, 65°08'E, 29 June 1964, 0359-1507 hrs, depth sampled 350-1786 m, bottom depth 4480 m, one specimen, 54.5 mm.

R/V ANTON BRUUN, cruise XIII, coll. 26, 31°16'S, 92°28'W, 20-21 January 1966, 2014-0138 hrs, depth sampled 0-380 m, bottom depth 3300-3700 m, one specimen, 60.0 mm; coll. 30, 31°07'S, 89°29'W, 24 January 1966, 0025-0350 hrs, depth sampled 0-410 m, bottom depth 3550-3950 m, two specimens, 36.0-38.0 mm (otolith of 36.0 mm specimen photographed, Fig. 10).

R/V ATLANTIS II, cruise 13, sta. RHB 1014, 41°34'N, 52°15'W, 7 September 1964, 0115-0500 hrs, depth sampled 0-85 m, one specimen, 19.0 mm; sta. RHB 1022, 42°35'N, 45°56'W, 10 September 1964, 0135-0505 hrs, depth sampled 0-50 m, two specimens, 22.0-24.0 mm; sta. RHB 1044, 39°37'N, 31°10'W, 26 September 1964, 0050-0535 hrs, depth sampled 0-475 m, one

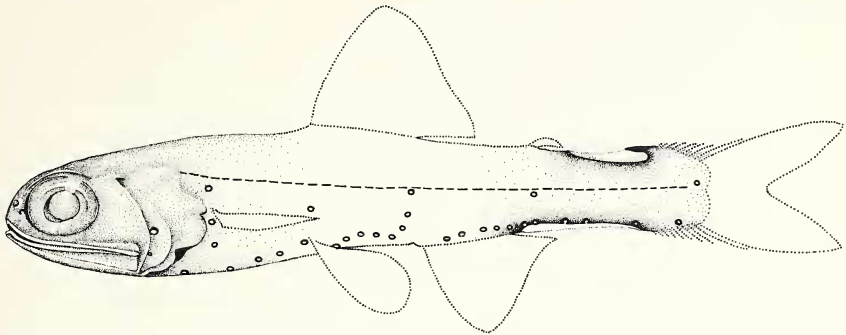


Figure 7. *Lampadena chavesi*, 54.5 mm in standard length; 31° 45' S, 65° 08' E.

specimen, 35.0 mm; sta. RHB 1047, 39°25'N, 36°56'W, 27 September 1964, 2030-2250 hrs, depth sampled 0-52 m, one specimen, 21.0 mm.

R/V CHAIN, cruise 49, sta. RHB 1127, 31°28'N, 70°25'W, 22 June 1965, 0035-0330 hrs, depth sampled 0-83 m, two specimens, 22.0-25.0 mm; sta. RHB 1129, 34°12'N, 70°21'W, 22 June 1965, 2145-2355 hrs, depth sampled 0-80 m, one specimen, 27.0 mm.

D. 14; A. 13-14(12); P. 16-17; V. 8; gill rakers 6-7+1+13, total 20-21; PO 5; VO 5(6); AOa 7(8); AO_p 2; Prc 2+1; lateral line scales 38(39); vert. 37-38, 2 x-rayed specimens.

Snout rounded; mouth large and terminal, its cleft very slightly oblique; maxillary somewhat expanded posteriorly; eye large, its diameter 2.6 to 3.3 times in length of head; opercular margin with slight indentation opposite level of middle of pectoral base; pterotic spine strong, directed posteriorly.

Origin of dorsal fin over or slightly behind vertical through base of outermost ray of ventral fin; origin of anal fin behind vertical through end of base of dorsal fin; base of adipose fin markedly behind vertical through end of base of anal fin; pectoral fin reaching base of ventral fin; ventral fin extending to origin of anal fin.

A small, roundish V_n immediately posteroventrad to nasal apparatus; anterior third of orbital margin lined with black tissue; a conspicuous, crescent-shaped strip of whitish (luminous?) tissue on iris dorsal to pupil, which is somewhat elliptical; distinct aphakic space anteroventrad to lens. Op₁ small, immediately behind preopercular margin and about opposite posterior end of mouth; Op₂ distinctly larger than general body photophores, at about level of ventral margin of pupil, separated from Op₁ by a distance about three times as wide as its own diameter.

PLO slightly in advance of vertical through base of uppermost ray of pectoral fin and 1 to 1.5 times its own diameter below lateral line. PVO₁ at about level of posterior end of mouth, slightly posterior to vertical through

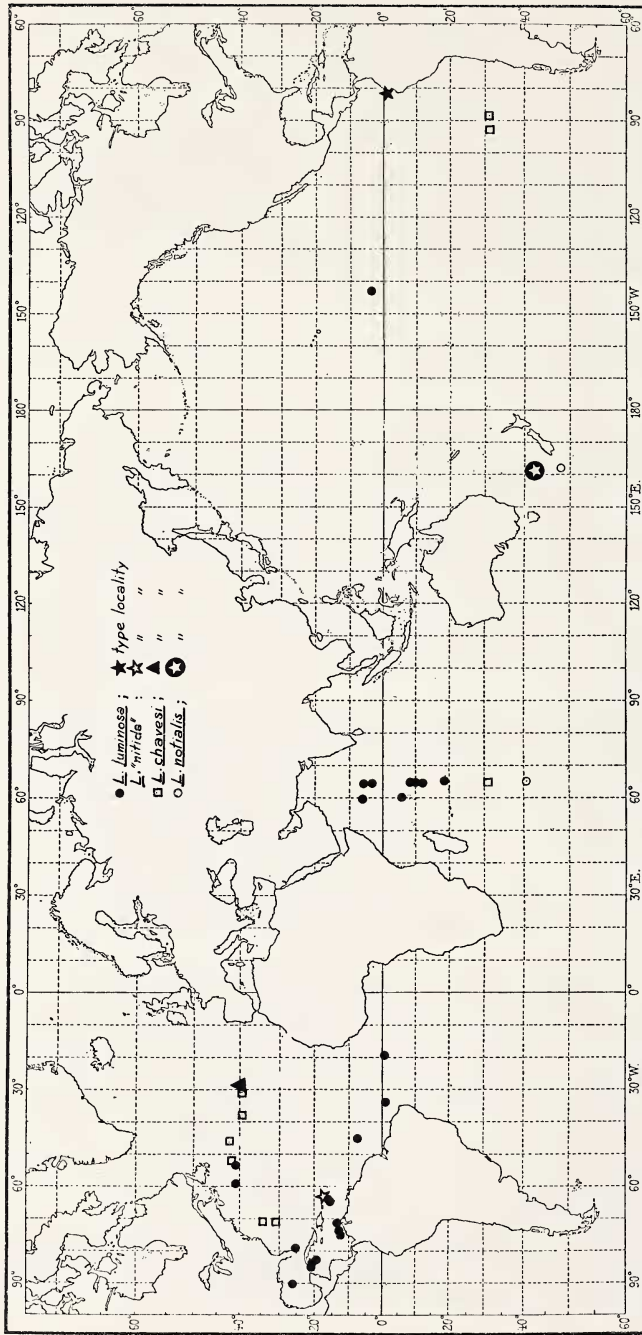


Figure 8. Chart showing stations which yielded material examined in the present study (the type locality of *L. chavesi* was added from the literature).

PVO₂, which is situated in front of middle of base of pectoral fin and on a straight line connecting PLO with PVO₁. PO₁ and PO₂ on a straight, horizontal line; PO₂ through PO₅ in straight, diverging lines, with PO₅ situated about 1.5 times its own diameter in front of and slightly mesad to base of outermost ray of ventral fin; first PO interspace 1.5 to 2 times as wide as last, which is somewhat wider than PO₂-PO₃ and PO₃-PO₄ interspaces; VLO over base of outermost ray of ventral fin and midway between latter and lateral line. VO evenly spaced or distinctly grouped (2+3) forming a markedly arched line; VO₁ directly mesad, or slightly anterior, to base of innermost ray of ventral fin. SAO series very slightly angular; SAO₁ above and behind VO₅; SAO₂ above and behind SAO₁; SAO₃ directly over, slightly anterior, or immediately posterior to vertical through center of SAO₂ and about its own diameter below lateral line; distance between SAO₃ and SAO₂ about twice as wide as distance between SAO₂ and SAO₁, the latter being equal to that between SAO₁ and VO₅. First and second AOa somewhat depressed; space between AOa₂ and AOa₃ usually distinctly wider than other AOa interspaces; last two to three AOa entirely behind base of anal fin; at least one and usually two AOa over infracaudal luminous gland. Pol over or slightly posterior to last AOa and about its own diameter below lateral line. AOp widely spaced, about over middle of, and in contact with, infracaudal gland. Prc₁ over posterior end of infracaudal gland; Prc₁ and Prc₂ horizontally arranged and very widely spaced, distance between them equal to, or somewhat smaller than, distance between Prc₂ and Prc₃, which is posterior to Prc₂ and slightly above level of lateral line.

Caudal luminous gland largest in genus, their posterior borders on same vertical; supracaudal gland bifurcating posteriorly; infracaudal gland flat in cross section, limited to ventral area of caudal peduncle and not conspicuous laterally, tapering posteriorly rather than anteriorly (in contrast to all other species of the genus); distance between end of base of anal fin and anterior margin of infracaudal gland very short, about twice the diameter of a photophore.

Premaxillary and dentary with band of small, needlelike teeth; six to eight large, recurved, broad-based teeth directed anteriorly on posterior part of dentary; three to four inner, moderately large teeth hooked forward on anterior portion of dentary near symphysis; premaxillary slightly broadened near symphysis, with outer row of large, recurved teeth. Palatine with long, narrow band of minute teeth. A small patch of minute teeth on each limb of vomer. Large, oval patch of similar teeth on mesopterygoid.

Neural arches of anterior vertebrae greatly expanded to form an almost closed tube above centra.

Bolin (1959) states that "*Lampadena chavesi* appears to occur throughout the Atlantic between the latitudes of approximately 38°N and 33°S." Our data suggest that this species occurs in the North Atlantic between the latitudes of about 30°N and 45°N and in both the Indian and Pacific Oceans between

the latitudes of approximately 30°S and 40°S (Fig. 8). An antitropical distribution is indicated.

Lampadena anomala Parr, 1928

R/V PAWNEE, sta. 58B, 32°24'N, 64°29'W, 20 March 1927, depth sampled 0-ca. 2000 m, 14-foot Ring Net, one specimen (holotype), ca. 48 mm, BOC 2272.

R/V CHAIN, cruise 60, sta. RHB 1260, 13°12'N, 72°47'W, 28 May 1966, 1050-1400 hrs, depth sampled 0-890 m, Marinovich Trawl, one specimen, about 48 mm (otolith photographed, Fig. 10).

Parr (1928) described this species on the basis of a single 48 mm specimen. Because of the poor condition of the fish, Parr was unable to take accurate measurements. Unfortunately, the only specimen from the Woods Hole collection is in equally poor, if not poorer, condition. However, direct comparison with Parr's type left us with no doubt that it belongs to *L. anomala*. The following description is based on the characters which we have been able to positively locate, identify, and count in the Woods Hole specimen.

D. 16; A. 13; P. 16; V. 8; gill rakers 5+1+11; VO 3; SAO 3; AOa 3 on left side, 4 on right; AOp 2; Prc 2+1; vert. 36.

Photophores small, more so than in any other species of the genus; two Op (Parr's ". . . a series of six small organs . . .", mistaken for photophores, are nothing but a series of neuromasts immediately behind the preopercular margin, found in all myctophids); PLO in advance of vertical through upper end of base of pectoral fin, about twice its own diameter below lateral line. PVO₁ slightly behind vertical through center of PVO₂, which is immediately in front of middle of base of pectoral fin. VLO slightly nearer lateral line than base of ventral fin; three VO widely spaced. SAO₃ about over origin of anal fin and about its own diameter below lateral line. AOa level, widely spaced; last AOa well in advance of end of base of anal fin. Pol behind end of base of anal fin, about twice its own diameter below lateral line. AOp₁ in advance of anterior margin of infracaudal luminous gland; AOp₂ over same gland; AOp₁-AOp₂ interspace about twice the diameter of an organ; Prc₁ and Prc₂ horizontal and about one organ diameter apart from each other; Prc₃ near base of middle rays of caudal fin and slightly above level of lateral line.

Supracaudal luminous gland slightly shorter than infracaudal, the length of the latter being equal to distance between end of base of anal fin and anterior margin of infracaudal gland.

Premaxillary and dentary with band of small, needlelike teeth, the inner series distinctly enlarged; five broad-based, strongly recurved teeth directed anteriorly on posterior part of dentary; no evidence of enlarged teeth on anterior part of dentary or premaxillary near symphysis. Palatine with what appears to be a single, long row of relatively large, sharp teeth. One or two



Figure 10. Medial views of left otoliths, anterior end to the right. (1) *Lampadena luminosa*, otolith 5.4 mm long, specimen 71 mm; (2) *L. urophaos*, otolith 7.6 mm long, specimen probably about 80 mm; (3) *L. species A*, otolith 9.2 mm long; (4) *L. speculigera*, otolith 3.8 mm long, specimen 66 mm; (5) *L. notialis*, otolith 3.9 mm long, specimen 66.3 mm; (6) *L. dea*, otolith 3.4 mm long, specimen 59 mm; (7) *L. chavesi*, otolith 1.7 mm long, specimen 36 mm; (8) *L. anomala*, otolith 1.8 mm long, specimen about 48 mm; (9) *Taaningichthys bathyphilus*, otolith 1.9 mm long, specimen probably about 50 mm.

teeth at each distal end of vomer. A large, roughly oval-shaped patch of similar teeth on mesopterygoid, with posterior ones somewhat enlarged.

Neural arches of anterior vertebrae not greatly expanded.

Inadequate data preclude any statement concerning the horizontal distribution of *L. anomala* (Fig. 9). However, this fish appears to occur at greater depths than the rest of its congeners.

OTOLITHS

Sagittae of the species of the genus *Lampadena* display three main patterns (Fig. 10). *L. luminosa* and *L. urophaos* have large otoliths, considerably longer than high, with a length to height ratio of 1.7:1 to 1.8:1. The posterodorsal angle is conspicuously notched and the ventral margin is not smooth. A distinct rostrum and small antirostrum are present. The lateral face is slightly rounded and weakly sculptured. The posterior angle of the dorsal margin is pronounced (broken off in the photographed specimen of *L. luminosa*). The ventral margin of *L. urophaos* is scalloped or finely serrate, while that of *L. luminosa* has more distinct spinous processes. The collum divides the sulcus into two unequal sections in *L. urophaos*, whereas the collum is about in the middle of the sulcus in *L. luminosa*. *L. speculigera*, *L. notialis*, *L. dea* and *L. chavesi* have more oval-shaped otoliths, with length to height ratios varying between 1.3:1 and 1.5:1. The posterodorsal notch is slight or absent, the collum is about in the middle of the sulcus, the ventral margin has small but distinct spines, and the lateral face is slightly rounded and weakly sculptured. A distinct rostrum and antirostrum are present in *L. dea* and *L. chavesi*, while these structures are less conspicuous in *L. speculigera* and *L. notialis*. The posterodorsal angle is slightly indented in *L. chavesi* and essentially unnotched in the other three species. The anterior region of the dorsal margin is distinctly scalloped in *L. notialis*, while that of *L. speculigera* is almost smooth. *L. anomala* has a small otolith with a length to height ratio of 1.2:1, no posterodorsal notch, a smooth ventral margin, a greatly developed rostrum, and a distinctly rounded lateral surface. The otolith of *Taaningichthys bathyphilus* is small and nearly round, with a length to height ratio of 1.0:1, no posterodorsal notch, a smooth ventral margin, a slight to moderate rostrum, and a rounded lateral surface. Although otoliths from fishes of comparable sizes were not available, a difference in relative sizes is suggested. The ratios of standard length of specimen to otolith length are as follows: *L. luminosa*—13.1:1; *L. notialis*—16.9:1; *L. speculigera* and *L. dea*—17.4:1; *L. chavesi*—20.6:1; *L. anomala*—26.7:1. Standard lengths for the other species are not available; however, *L. urophaos*, like *L. luminosa*, has a large otolith, whereas *Taaningichthys bathyphilus*, like *L. chavesi*, has a small one.

DISCUSSION

Fraser-Brunner (1949) erected the subgenus *Lychnophora* to include the forms *L. luminosa* and *L. nitida*. The distinguishing characters of the subgenus were given as follows: PO_3 (= PO_4) much elevated (versus PO all on same level); diameter of eye more than four times in length of head (versus eye diameter less than four times in head); and inner row of pterygoid teeth conspicuously enlarged (versus pterygoid teeth uniformly small). The present study has revealed that the latter two characters are not diagnostic for the

TABLE 1
Measurements as per cent of standard length for the species of *Lampadena*.

	specimens	standard length	eye diam.	caud. ped. length	caud. ped. depth	preanal	infc. gland	supc. gland
<i>L. luminosa</i>	10	22.0-151.0	7.3- 9.4	19.8-22.9	9.5-10.7	64.3-68.0	6.6- 9.4	7.0- 9.4
<i>L. urophaos</i>	9	19.0- 79.1	8.0- 9.3	21.3-24.3	8.8-11.6	63.3-66.6	6.3- 8.7	6.0-11.2
<i>L. dea</i>	4	22.8- 63.3	10.1-10.6	25.4-25.8	11.5-12.2	60.4-61.6	13.2-15.4	8.6-10.2
<i>L. speculigera</i>	4	23.8-109.2	10.4-10.9	22.7-24.4	11.2-12.9	63.0-63.6	7.3-10.1	5.0- 5.8
<i>L. notialis</i>	3	25.2-105.0	10.5-11.5	24.0-24.2	13.8-14.3	62.6-63.9	11.1-12.8	7.5- 9.8
<i>L. chavesi</i>	5	34.0- 60.0	8.8-11.3	25.8-27.9	9.5-11.5	58.0-60.9	15.1-18.6	about 11

subgenus. The eye diameter in head length for *L. luminosa* varies from 3.7 to 4.3 times, for *L. urophaos* from 3.5 to 4.1 times, and for the other species from 2.6 to 3.3 times. The most posterior mesopterygoid teeth are enlarged in *L. urophaos* and slightly enlarged in *L. anomala*. The subgenus can be defined on the basis of one character only, the elevated PO_4 .

Since *L. nitida* is herein considered conspecific with *L. luminosa*, the subgenus is restricted to one form; its retention suggests that *L. luminosa* stands apart from its congeners. However, *L. urophaos* shares a number of characters with *L. luminosa*. In addition to the two characters noted above, each of these species has a very low gill-raker count, total 13-16, versus 17-26 for the other species, and a distinct similarity in the shape and size of the otolith. Moreover, in *L. urophaos*, the PO_4 , although not as highly elevated as that of *L. luminosa*, is more elevated than the PO_4 of the rest of the species. *L. chavesi*, with extremely long caudal glands, white tissue (possibly luminous) on the iris, and the VO_1 in advance of or directly mesad to the base of the innermost ray of the ventral fin, stands as far from, if not further from, the main *Lampadena* stock as *L. luminosa*. *L. anomala*, as indicated by its otolith size and shape, development and pattern of photophores, etc., appears to be evolving in a different line. At our present state of knowledge, the degree of relationship between the various species of *Lampadena* is not clear and the retention of Fraser-Brunner's subgenera and/or the erection of new ones is, in our opinion, of little value in elucidating evolutionary trends within the genus. Therefore, we do not recognize the subgenus *Lychnophora*.

A tentative interpretation of species relationships is nevertheless possible. *L. luminosa* and *L. urophaos* are clearly related. The relatively low gill-raker count, total 17, and the absence of expanded anterior neural arches in *L. anomala* may indicate derivation from a stock ancestral to these two species. *L. speculigera* has more characters in common with *L. notialis* than with any other species, while *L. dea* appears to be intermediate between the latter two species and *L. chavesi*. *L. speculigera*, *L. dea*, and *L. chavesi* share with the genus *Taaningichthys* the expanded neural arches of the anterior vertebrae. The presence of white tissue on the iris and the restriction of the infracaudal gland to the ventral portion of the caudal peduncle suggest a possible relationship between *L. chavesi* and *Taaningichthys*. Certain measurements (Table 1) will distinguish some of the species. Allometric growth is common for most structures, including the caudal glands.

Knowledge of the biology of most lanternfishes in general, and *Lampadena* in particular, is meager. Many species of the genus are relatively large; specimens of *L. speculigera*, *L. notialis*, and *L. luminosa* attain a standard length of over 100 mm. Most species appear to be among the deepest-dwelling of myctophids; the two known captures of *L. anomala* with open nets have been made below 750 meters. Shallow captures of large specimens during the night, indicative of extensive vertical migration, are known only for *L. lumi-*

nosa and *L. urophaos*. Small (20-35 mm) specimens of *L. speculigera*, *L. dea*, and *L. chavesi* have been taken during the night in the upper 200 meters.

After the manuscript was completed, John Fitch brought to our attention a large series of otoliths recovered in good condition from the stomach contents of a pygmy sperm whale (*Kogia simus*) caught off Taiji, Japan. These otoliths (Fig. 10(3)) belong to a species of the genus *Lampadena*. The new otoliths are large, with posterodorsal angle distinctly notched, ventral margin sculptured, a distinct rostrum and antirostrum, a posteriorly divided sulcus, and with a slightly rounded lateral face. Distinctive differences between these otoliths and those most similar to them, *i.e.* *L. luminosa* and *L. urophaos*, include stronger development of the antirostrum, strong sculpturing of the lateral face, reduction of the area posterior to the sulcus, and a length to height ratio of 1.3:1 to 1.4:1. We have little doubt that the new otoliths belong to a form as yet undescribed. Moreover, we are inclined to believe that this new form, when caught, will prove to be more closely related to *L. urophaos* and *L. luminosa* than to any other species. If we may venture a further prediction, the new species will probably have a small number of gill rakers, unexpanded anterior neural arches, and short caudal luminous glands.

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