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Distribution and ecological aspects of leptocephali collected 1979–1994 in North- and Central Atlantic. I. Congridae

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ABSTRACT: This is the first report on the leptocephalus catches made during the last 15 years in North- and Central Atlantic during the course of 19 cruises of five different ships from Germany and one from Poland. This report comprises identification, geographical occurrence and abundance and in some cases depth preference, migratory routes and spawning area of Congridae in the North Atlantic. The largest part of this collection consists of 876 *Conger conger* larvae. The likelihood that this species spawns in the Mediterranean is again confirmed. Decreasing density as well as increasing size from Gibraltar west- and north westward showed migration to be occurring in that direction. Age was determined by counting "daily rings" on the otoliths of up to 120-mm long larvae. It is suggested to be more than 300 days and is calculated to be $1^1/_4$ years for the largest larvae (TL = 140–160 mm). Some 126 specimens of three other *Conger* species, i.e. *C. oceanicus, C. triporiceps, C. esculentus,* were identified in the collection. The major part originated from the western North Atlantic. The most numerous larvae, belonging to another genus of Congridae, were *Ariosoma balearicum* (n = 265). They showed, also in consideration of other studies, quite a wide range in number of myomeres. Their systematic status is therefore uncertain, as is also the status of those known from the NW Indian Ocean and the NW Pacific. One larva, probably of *Ariosoma selenops*, of unusually large size (TL = 467 mm) and captured in the Iberian Basin is described and compared with specimens known from the literature. Two larvae of unknown identity were captured off NW Africa; they resembled *A. balearicum* but had too high a number of myomeres. The identity of most of the *Gnathophis* larvae caught in the East Atlantic is uncertain. Leptocephali of *Paraconger notialis* in the East Atlantic, up to the area north of New Guinea, exhibited a higher number of myomeres than those known from the West Atlantic. Larvae of *Xenomystax congroides* (n = 29), belonging to a population with a relatively high number of myomeres, were captured in the Sargasso Sea.

INTRODUCTION

Larvae of the Anguilliformes leptocephali collected during 19 cruises of five German and one Polish research vessels are evaluated. One part of the material was obtained during general fishery biological and oceanographical cruises in the East Atlantic. A first evaluation of the leptocephali of that material was made in the thesis of Strehlow (1992). The other part of the collection is based on cruises designated mainly for the study

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of the oceanic life of the North Atlantic *Anguilla* species (e.g. Tesch, 1982; Tesch & Wegner, 1990) and, in addition, for monitoring the density of *Anguilla* larvae stocks arriving annually at the European continental slope (e. g. Tesch, 1980; Tesch & Niermann, 1992).

This comparatively large amount of material contributes substantially to our knowledge on the occurrence, migration and spawning areas of several anguilliform species in the North Atlantic. It comprises more than 30 species and a total number of about 4000 specimens. A systematic presentation of this material by taxonomic order alone, to supplement the ecological view, is beyond the scope of this paper. The taxonomic information is therefore combined with geographical and regional aspects. The first paper includes species which occur and spawn mainly in the East Atlantic, although West Atlantic occurrence is also described. Congridae, like *Conger conger, Ariosoma* and *Gnathophis* species are included in this first presentation. *Conger conger* is of special interest because its collection is the most substantial of this section and comprises catches obtained from 1979 to 1994. Species of other families are considered in later papers.

MATERIAL AND METHODS

The study material of eel larvae was collected during 20 expeditions of six research vessels between 1979 and 1994. The cruises were conducted by the Biologische Anstalt Helgoland (R. V. "F. Heincke", R. V. "A. Dohrn"), by the former Institut für Hochseefischerei, Rostock in cooperation with the Marine Institut, Gdynia (R. V. "A. v. Humboldt", R. V. "Prof. Siedlecki") and by the Institut für Meereskunde, Kiel (R. V. "Poseidon") (Table 1). Because the program of some cruises was not especially designed for catching eels and eel larvae and due to the different catching methods and gear, calculations and comparison of mean abundances were not possible. After capture, the leptocephali were preserved in seawater formalin (4 %) or ethanol (70 %). Measurements were made to nearest 0.1 mm, counts and identification under magnifications of 125 and 500, partly on board and partly in the laboratory. A screening of all available samples was necessary. As some specimens were loaned or in bad condition due to preservation for a long period, the identity of some species could not be confirmed. Specimens of *Bathycongrus* (formerly *Rhechias*) and *Hildebrandia* especially could only be identified to genus level.

The following abbreviations are used: n – number of specimens, ∅ – mean value, s. d. – standard deviation, TL – total length, preAL – preanal length, preDL – predorsal length, LO – length to the opisthonephric blood vessel, LH – length of the head, D – greatest depth of the body, TNM – total number of myomeres, MP – number of myomeres to the pronephric blood vessel, MO – number of myomeres to the opisthonephric blood vessel, MA – number of myomeres to the origin of the anal fin, MD – number of myomeres to the origin of the dorsal fin, FC – number of fin rays in the caudal fin.

RESULTS AND DISCUSSION

Conger conger

Morphometry and meristics

The *Conger* larvae were differentiated mainly by counting myomeres. The 876 *Conger* larvae, which were collected in the NE-Atlantic and Mediterranean during

Table 1. Sources of examined leptocephali material from the North Atlantic

Exp. Nr.	Date	Research vessel	Catching area	Gill	Mesh size (µm)
1.	12. 02.–09. 05. 1979	"F. Heincke" "A. Dohrn"	Bay of Biscay, Sargasso Sea	IKMT MOC	500, 850 335
2.	14. 08.–01. 09. 1980	"W. Herwig"	North Atlantic near the northern European coast	?	?
3.	17. 08.–23. 08. 1980	"F. Heincke"	North Atlantic west of Ireland	IKMT	1000
4.	18. 02.–23. 04. 1981	"F. Heincke"	Bay of Biscay, western North Atlantic	IKMT	500, 850, 1800
5.	28. 10.–21. 11. 1982	"F. Heincke"	Bay of Biscay, Gibraltar	IKMT	1800
6.	16. 03.–10. 04. 1983	"A. v. Humboldt"	Central North Atlantic near the coast of NW-Africa	PT	4000
7.	10. 11.–11. 12. 1983	"F. Heincke"	Bay of Biscay, Mediterranean	IKMT	1800
8.	16. 07.–12. 10. 1984	"Prof. Siedlecki"	Iberian Basin	PT	4500
9.	15. 11.–13. 12. 1984	"F. Heincke"	Bay of Biscay, Gibraltar	IKMT	1800
10.	31. 03.–18. 04. 1985	"Prof. Siedlecki"	Central North Atlantic	PT	6000
11.	11. 11.–14. 11. 1985	"F. Heincke"	Bay of Biscay	IKMT	1800
12.	31. 10.–08. 11. 1986	"F. Heincke"	Bay of Biscay, Coast of Portugal	IKMT	1800
13.	06. 11.–15. 11. 1987	"F. Heincke"	Bay of Biscay, Coast of Portugal	IKMT	1800
14.	12. 11.–20. 11. 1988	"F. Heincke"	Bay of Biscay, Coast of Portugal	IKMT	1800
15.	25. 05.–01. 06. 1989	"F. Heincke"	Bay of Biscay, Coast of Portugal	IKMT	1800
16.	13. 07.–07. 10. 1989	"A. v. Humboldt"	Central North Atlantic near the coast of NW-Africa	Bongo	315, 400
17.	23. 10.–28. 10. 1991	"F. Heincke"	Bay of Biscay, Coast of Portugal	IKMT	1800 ?
18.	15. 02.–05. 04. 1993	„Poseidon"	Bay of Biscay, Sargasso Sea	IKMT Bongo MOC	300, 4000 500 50
19.	30. 05.–22. 06. 1994	"Poseidon"	Coast of Portugal	IKMT Bongo MOC PT	4000 335, 500 335 10.000

IKMT – Isaacs-Kidd Midwater Trawl
MOC – (MOCNESS) Multiple Opening Closing Net Environmental Sensing System
PT – Pelagic Fishery Trawl

1979–1994, were all *Conger conger* (number of expeditions: 1, 2, 3, 4, 5, 7, 8, 9, 10, 13, 14, 17, 18, 19 - Table 1). The total number of myomeres of *C. conger* leptocephali varies between 154 and 162 (Table 2). Four other *Conger* species which, up to now, are known from the NW-Atlantic were also present in the collection, i. e. *C. oceanicus* with 140–148 myomeres, *C. esculentus* with 133–135 myomeres, *C. triporiceps* with 150–158 myomeres and leptocephali of Congridae genus A species A with 130 myomeres (Smith, 1989). The larvae of *C. conger* and *C. triporiceps* are very similar in number of myomeres. Until now they were distinguished only by their catch position either in the East- or in the West-Atlantic. In contrast to the larvae, the adults of both species differ distinctly with regard to the number of their pores and in their dentition. *C. conger* occurs only in the East-Atlantic, Mediterranean and Black Sea and in depths up to 500 m. *C. triporiceps* occurs only in the tropical West-Atlantic, frequently near coral reefs and in surface waters (Smith, 1981, 1989; Böhlke & Chaplin, 1968). The number of myomeres of *C. conger* leptocephali, as well as other characters such as body shape, pigmentation and dental patterns agree well with the corresponding data found by other authors (Table 3).

Table 2. Comparison of morphometric and meristic characters of *Conger conger* larvae in the NE-Atlantic and Mediterranean

Parameter	Present studies	D'Ancona (1931)	Schmidt (1931)	Castle (1970)
n	355*	?**	201	2
TL (mm)	32–165	8–150	–	91.5–127
		Proportions (% of TL)		
preAL	73.4–88.8	84–88	–	–
preDL	55.1–78.5	–	–	–
LBO	45.3–51.0	–	–	–
LH	4.0–7.1	–	–	–
D	7.3–10.8	7–8	–	–
		Meristic values		
TNM	154–162	148–155	154–163	154–159
MP	14–21	–	–	–
MO	56–61	–	–	58–59
MA	119–128	93***	–	120–123
MD	72–91	–	–	–
FC	9–10	–	–	9–10

* n = 355 for TNM-values, for other parameters n = 65–70
** number of specimens uncertain
*** one specimen of 8 mm

There is little information about the development of morphometric body proportions of *C. conger* leptocephali, but we were able to analyse our material of large premetamorphic larvae for this character. The anus does not begin to move to a distinctly more anterior position until specimens have attained a total length of 150 mm. Preanal, predorsal and head length, as well as body height increases in relation to the total length. The total length and the number of myomeres are not correlated (Fig. 1). Of importance,

Table 3. Frequency distribution of different numbers of myomeres of *Conger Conger* larvae caught in the NE-Atlantic during 1979–1994

Parameter	Frequency distribution														n	Ø	s.d.
TNM	154	155	156	157	158	159	160	161	162								
n	2	6	30	92	104	98	15	7	1						355	157.93	1.23
MP	14	15	16	17	18	19	20	21									
n	3	2	5	15	23	14	2	1							65	17.66	1.39
MO	56	57	58	59	60	61											
n	1	7	26	16	13	3									66	58.64	1.10
MA	119	120	121	122	123	124	125	126	127	128							
n	3	1	9	15	14	14	5	1	3	2					67	122.96	1.85
MD	72		78	79	80	81	82	83	84	85	86		90	91			
n	1		1	3	2	6	12	11	18	6	4		1	1	66	82.98	2.60

and very similar to *Conger*, is the genus *Gnathophis*; but species of this genus have a higher count of myomeres, a shorter and rounder snout, a shorter preanal length and sparser postanal pigmentation.

Horizontal and vertical distribution

The total number of *C. conger* leptocephali and their average total length in different subareas of the NE-Atlantic are presented in Figure 2. SW of Gibraltar only very few larvae were caught; in the neighbourhood NW of Gibraltar far more larvae were collected

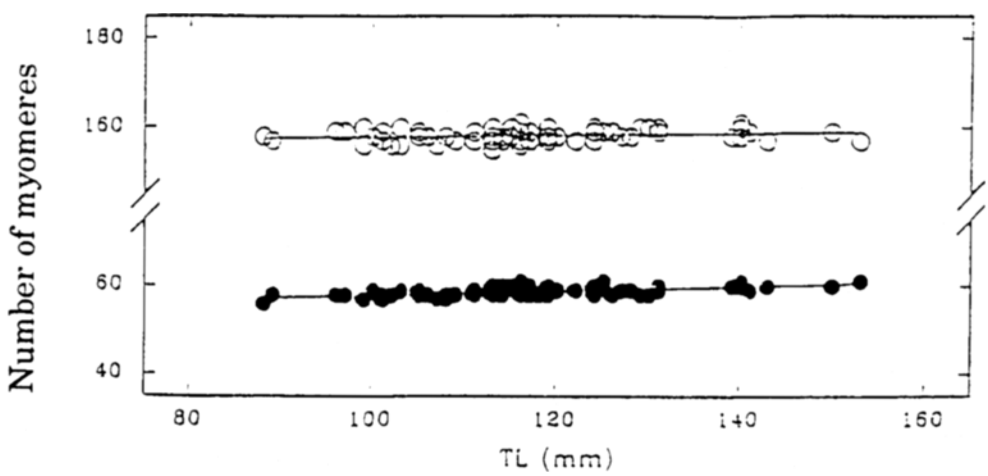

Fig. 1. Regression lines of the total number of myomeres (○) and the number of myomeres to the opisthonephric blood vessel (●) according to the total length for *C. conger* larvae;
TNM = 0.023 TL + 155.51
MO = 0.051 TL + 52.77

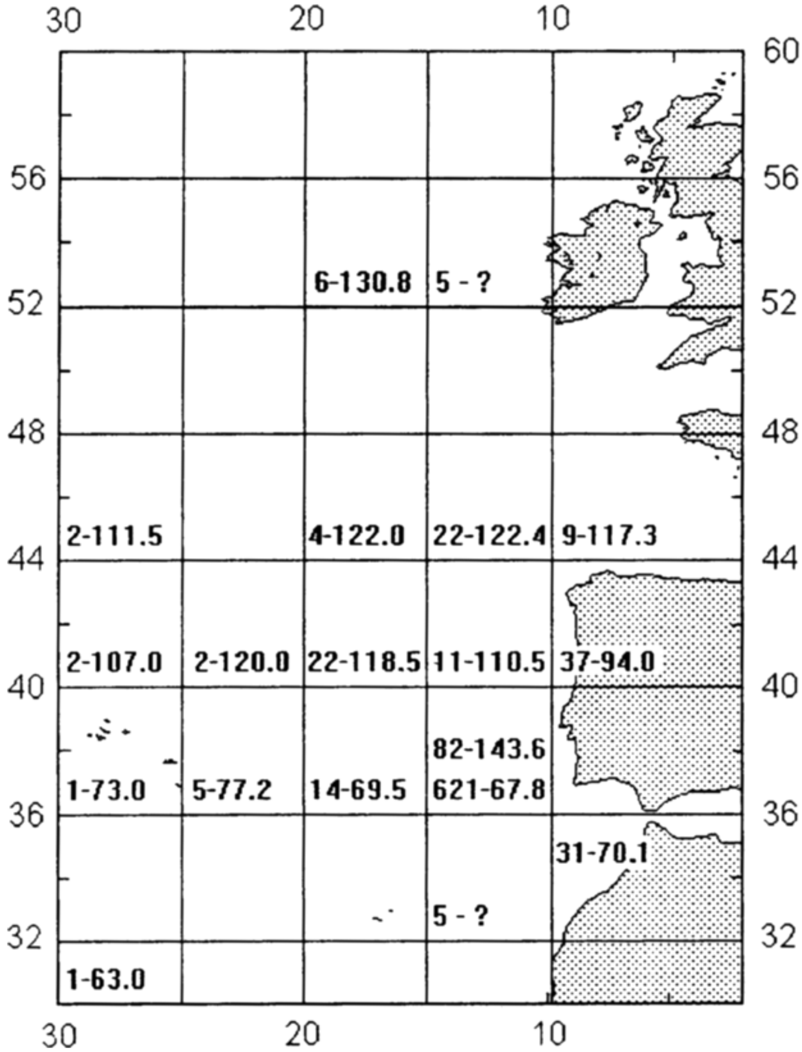

Fig. 2. Horizontal distribution of the mean lengths of *C. conger* larvae from different areas of the NE-Atlantic. First values: number of individuals; second values: mean length (mm) of larvae caught in the subarea; upper values: data of summer cruise of "Poseidon", 1994

by the same catching methods. A decrease of abundance to the west is especially shown by one cruise in 1982 with successive samples from east to west (Fig. 3). The increase of mean total length in the subareas from south to north as well as a decreasing frequency in the directions north and west suggests a migration to the NW which extends comparatively far to the East and Central Atlantic. This cruise and the sampling technique were especially designed to catch *Anguilla* larvae. That the technique was also effective for leptocephali of *C. conger* was shown by MOCNESS samples studying depth occurrence of leptocephali in the area west of Gibraltar. The other anguilliform larvae, mainly re-

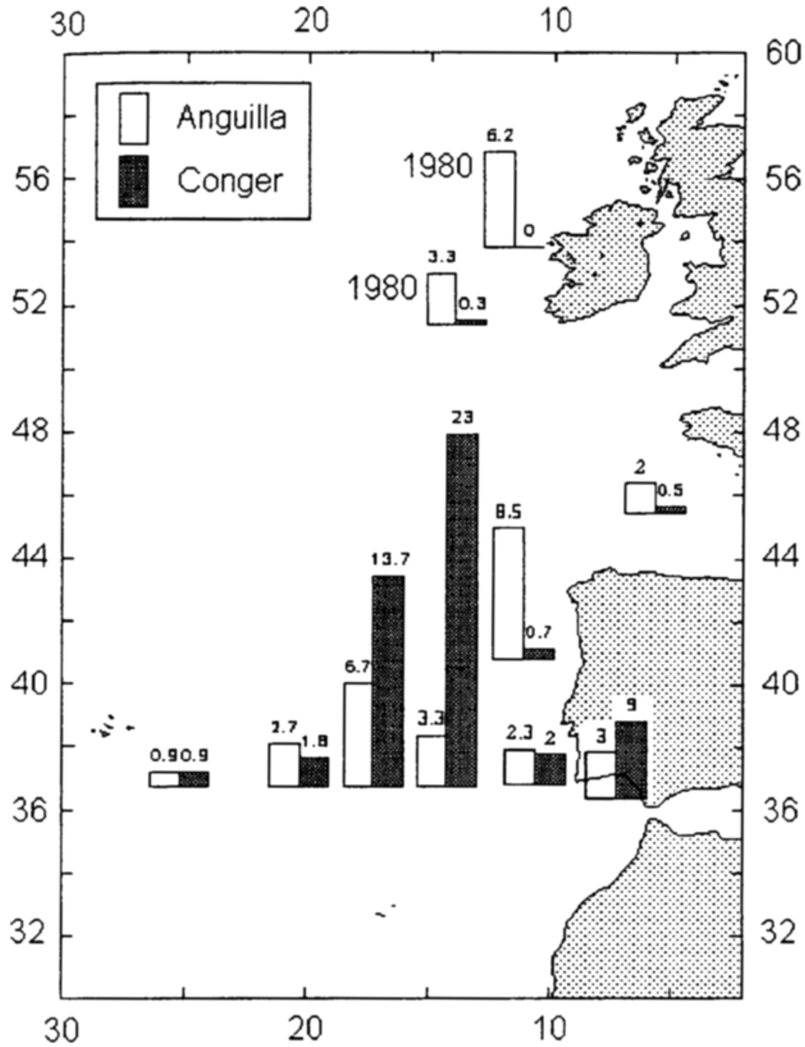

Fig. 3. Abundances of *C. conger* and *A. anguilla* larvae caught during the cruises of R. V. "F. Heincke" 1980 and 1982 (values - larvae per hour)

presented by *C. conger,* occurred during the night presumably between 0 and 200 m, whilst *A. anguilla* larvae preferred a depth of 0–150 m (Tesch et al., 1986).

The described tendency of a NW increase in the length of *C. conger* leptocephali was found exclusively in catches from August to May. In contrast, one summer cruise ("Poseidon" 1994), end of May to June, provided not too far west of Gibralta, much larger sizes of *C. conger* larvae than did the winter catches (Fig. 2). These specimens were perhaps one year old, and were larvae that had not moved too far away from Gibraltar to the NW, or could have been returning from the NW.

That the spawning place is not somewhere in the East Atlantic is demonstrated by the fact that our samples did not contain any larva below 30 mm TL. The only season when we captured the smallest larvae of 35–75 mm TL was early winter (Nov./Dec. – Table 4). We agree therefore with Schmidt (1913) that spawning in the Mediterranean takes place in August (July to September). The assumption of Schmidt (1931) that *Conger* spawns in the Mediterranean is based on his catches of small, 9- to 20-mm long, larvae in that area. Schmidt's assumption that Atlantic *C. conger* could spawn, like *A. anguilla*, in the Western Sargasso Sea is based on the fact that he captured small *Conger* larvae in the Sargasso Sea. But this conclusion is now no longer valid. These small *Conger* larvae from the Sargasso Sea with a relatively high number of myomeres in relation to other *Conger* species of the western Atlantic have to belong to *C. triporiceps* (McCleave & Miller, 1994). The two species are separated by a line which runs from the Canary Isles in a NW direction and to the area west of the Azores. *C. conger* larvae occur only in the East- and Central Atlantic.

Table 4. The total length of *Conger conger* larvae caught in the NE-Atlantic in relation to time of sampling

Parameter	Nov.–Jan.	Febr.–April	May–July	Aug.–Sept.
Minimum TL (mm)	32	79	93	81
Maximum TL (mm)	145	143	165	150
Mean TL (mm)	67.61	106.39	135.16	106.44
s.d.	16.91	15.74	18.09	22.68
n	673	38	116	48

On the basis of Figures 2 and 4 we further hypothesise that, from November on, there is sufficient time for the more than 30-mm long young larvae to leave the Mediterranean in the direction of the Atlantic and to attain the small size that we have found repeatedly south of Portugal/Spain. They then grow, until the early summer, to a TL of 130–150 mm (up to 165 mm). From their wide distribution area in the Eastern Atlantic some return for metamorphosis to the coastal waters of the continental slope and to the Mediterranean. This is suggested by the mixed occurrence of small and large larvae observed from November to January west of Gibraltar (see also Schmidt, 1931). The length interval of caught larvae and the standard deviation is here double that of other seasons and areas (Table 4). This may show that here emigrating and immigrating larvae are crossing their migratory paths. Nothing is known on location and time of metamorphosis.

Age determination by daily rings

The possible ages of 21 *C. conger* larvae caught in October 1991 by R. V. "F. Heincke" were determined by counting the so-called daily rings in the otoliths. The method was the same as that used for larvae and glass eels of *A. anguilla* (Antunes, 1994; Antunes & Tesch, 1997). Considering the area of capture, the investigations showed an increase of size and age from south to north. Larvae of about 90 mm are 8 months old and a larva with a total length of 116 mm is about 10 months old (Table 5).

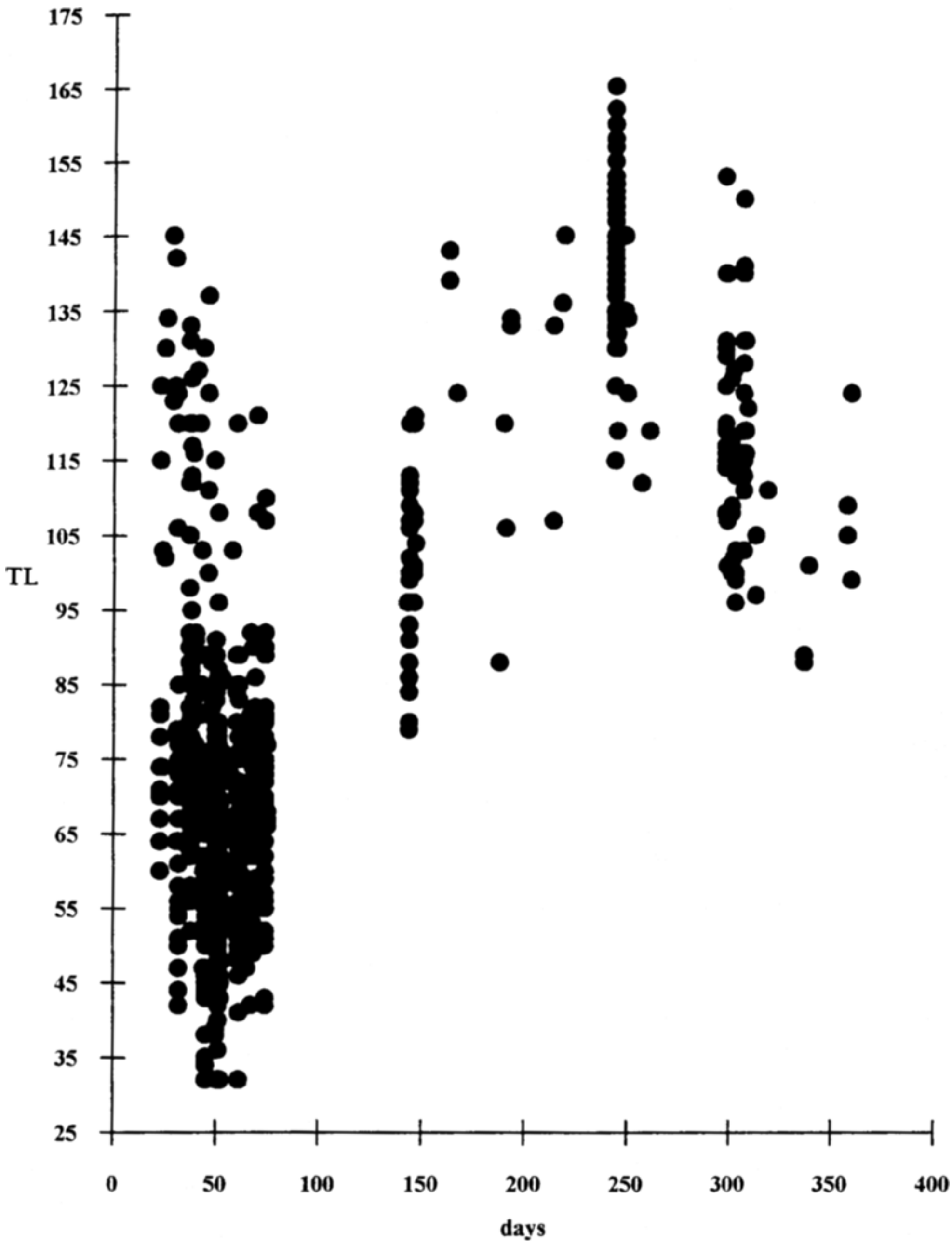

Fig. 4. Total length (mm) of *C. conger* larvae in relation to day of the year when collected (first day on the left is November 1st)

Table 5. Age determination by daily rings and diameter of otoliths of *Conger conger* larvae caught in the East-Atlantic in spring 1989

Area	n	Ø TL (mm)	Ø radius of otoliths (µm)	Ø diameter of otoliths (µm)	Ø number of daily rings
Bay of Biscay	7	116	160 (s.d. = 28)	243 (s.d. = 47)	306 (s.d. = 44)
North coast of Portugal	11	108	154 (s.d. = 26)	241 (s.d. = 51)	292 (s.d. = 43)
Northern Iberian Basin	3	91	130	190	234

Based on the age determination according to the "daily rings" of the otoliths, an age of 8 to 10 months is likely. Spawning therefore must have taken place between July and September i.e. in agreement with the assumption of Schmidt (1913) obtained from his catch of the smallest larvae in the Mediterranean. Thus, the very large larvae of 140 to 160 mm caught during the "Poseidon" cruise of the early summer 1994 could, by extrapolation, be nearly 1 $^1/_4$ years old (400–425 rings). The calculated age is in accordance with the hypothetical age of the larval phase of *C. conger* described above.

Conger oceanicus, Conger esculentus, Conger triporiceps

The catch of 126 larvae enabled three other species of the genus *Conger*, apart from the leptocephali of *C. conger*, to be investigated. They originated from the expeditions Nr. 1, 4 and 18 (Table 1). Most were captured in the western region of the North-Atlantic and in none of the samples were two different *Conger* species caught. The results are shown in Table 6. We only considered those individuals for which exact catch and identification data or the preserved samples were provided. Some specimens were measured fresh on board. The others were measured after fixation for several years. After several years in formalin the total length had shrunk by up to 10 %. Therefore body length is not comparable and an evaluation of horizontal size distribution is not possible.

Table 6. *Conger* larvae caught in the western North Atlantic during February–April 1979, 1981 and 1993

Species	n	TL (mm)	TNM	Ø TNM	s.d.
C. oceanicus	44	19–104	139–151	144.7	2.30
C. triporiceps *	41	24–129	150–160	155.8	1.83
C. esculentus	2	36–100	133–135	134.0	–

* Four larvae were metamorphosing

The total number of larvae of *C. triporiceps* caught was 80, but their condition was too poor for examination. Four larvae with TL from 95 to 129 mm were metamorphosing (catching dates: 15. 4. 1979; 35° 51'N, 6° 58'W). Concerning *C. esculentus* leptocephali, besides uncertain identity, the condition of pigmentation was such as to preclude identification of the stage of development. This question was also left open by Smith (1989).

Ariosoma balearicum

Leptocephali of *Ariosoma* are easy to identify by their slender shape, their long and simple intestine, their very short dorsal fin and their characteristic rows of short pigment series along the myosepta. The larvae of *Ariosoma balearicum* can be differentiated distinctly from the other species of this genus by counting the TNM and by the single pigment series below the midlateral level. *A. balearicum* is one of the most frequently caught larval species in tropical and subtropical latitudes of the Atlantic, and several other descriptions are therefore available (Table 7).

Table 7. Comparison of morphometric and meristic characters of *Ariosoma balearicum* larvae in the North Atlantic

Parameter	Present studies	Smith (1971, 1989)	Blache (1977)	Castle (1966)
n	265	3131	175*	155*
TL (mm)	7–173	4–205	8–216	100–209
		Proportions (% of TL)		
preAL	87.4–97.1	87.0–98.0	78.7–97.9	–
preDL	92.6–98.2	–	92.7–96.8	–
LH	2.8–8.6	3.0–12.0	–	–
D	6.8–17.6	8.0–17.0	–	–
		Meristic values		
TNM	124–136	121–136	126–138	123–131
MP	18–26	–	14–16	12–16
MO	56–64	62–72	63–71	65–69
MA	114–124	90–126	–	52–121
MD	115–128	–	–	–
FC	5–7	–	6–8	6–8

* larvae and postlarvae

Larvae caught in the West- as well as in the East-Atlantic display a wide range of TNM. The smallest and greatest known numbers (121 and 138) differ by 18 myomeres. In larvae of other eel species which in addition agree in all essential features and which also can only be identified by myomere count, this difference is less. In *A. anguilla* and in *A. rostrata* leptocephali a comparatively small difference of 7 myomeres is sufficient for differentiation; and in other eel species even less (Castle, pers.comm.; Tesch, 1983).

However, distinct geographical differences of the TNM of *A. balearicum* larvae suggest the existence of several groups characterized by different myomere counts. Smith (1989) describes three populations for adult *A. balearicum* of the Western Atlantic, one northern and one southern population with a high number of vertebrae and one geographical intermediate population with a low number of vertebrae. Clearly, for all adults of the Western Atlantic there is a length frequency distribution with two peaks (125 and 131). These two peaks are also observable in the number of myomeres of the larvae (126 and 132). However, it was not possible to characterize the three different adult populations by larval myomere counts.

Table 8. Total numbers of myomeres of *Ariosoma balearicum* larvae caught in Mediterranean, coastal and oceanic regions of the North Atlantic

n	∅ TNM	s.d.	Area	Author
20	131.95	2.28	Mediterranean	Grassi (1913)
12	126.58	1.16	Iberian Basin	Strehlow (1992)
7	128.14	3.24	NW-Africa	Strehlow (1992)
23	129.39	2.52	Cape Verde Islands	Blache (1977)
115	127.70	1.99	Cape Verde Islands, NW-Africa	Castle (1966)
157	127.88	2.19	Summary of coastal regions	
107	130.44	2.15	Gulf of Guinea	Blache (1977)
81	132.97	1.71	Central East-Atlantic	Lea (1913)
30	133.20	1.69	Central East-Atlantic	Blache (1977)
218	131.76	2.33	Summary of oceanic regions	

The larvae of *A. balearicum* in our study and in other investigations have on average 3–5 myomeres more in the open ocean and in the Mediterranean than in coastal areas (Table 8). Schmidt (1912) mentioned earlier that the larvae of *A. balearicum* from the Mediterranean exhibited 2 to 3 myomeres less than the larvae of the Central Atlantic. Castle (1966) supports this hypothesis by comparing the TNM of the specimens captured in 1964 by "W. Herwig" and those of the "Sars"-Expedition in 1910. These differences in the numbers of myomeres are difficult to explain. The two possible spawning areas of *A. balearicum* in the East-Atlantic, on the basis of the occurrence of very small larvae, are presumably in the Mediterranean (Grassi, 1913) and in the Gulf of Guinea (Blache, 1977). In these two areas leptocephali with high numbers of myomeres were caught. Therefore the hypothesis of different populations of *A. balearicum* with different spawning areas characterized by different myomere numbers is not supported by our larval data. The frequency distribution of the TNM data of all pooled data of *A. balearicum* leptocephali of the East Atlantic and the Mediterranean resembled a plot with two peaks (Fig. 5).

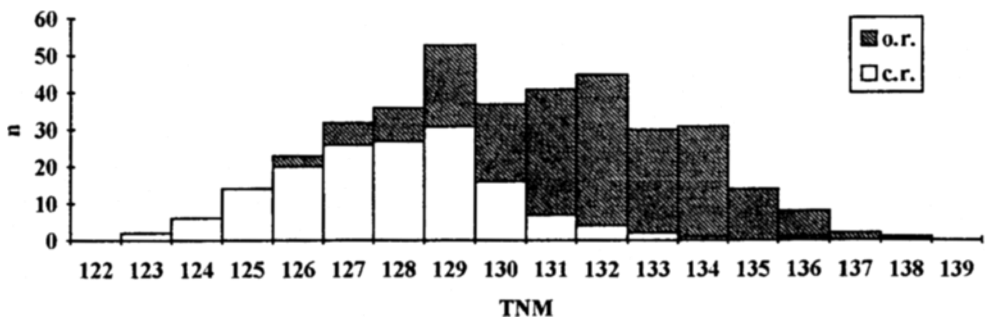

Fig. 5. Frequency distribution of total numbers of myomeres of *A. balearicum* caught in Mediterranean and coastal regions (c. r. – values of Grassi, 1913; Strehlow, 1992; Blache, 1977; Castle, 1966) and oceanic regions of the NE-Atlantic (o. r. – values of Blache, 1977; Lea, 1913)

The occurrence of larvae and adults of *A. balearicum* all over the Atlantic and in the Mediterranean is supplemented by a report of adult specimens in the Red Sea and in the North-West of the Indian Ocean (Blache & Bauchot, 1972). Mochioka et al. (1991) studied 57 larvae of *Ariosoma* (Type II) with a TL between 33 and 210 mm which very well agreed with *A. balearicum*. In agreement with an irregular worldwide occurrence is also the existence of additional spawning areas which very likely are indicated by the catch of very small larvae in the West-Atlantic (Smith, 1989) and in the NW-Pacific south of Okinawa (Mochioka et al., 1991). However, the species structure of *Ariosoma* in the Indo-west Pacific appears to be complex but unresolved (Castle, pers. comm.), and despite the similarity of myomere numbers it would be premature to synonymise the Indo-west Pacific *Ariosoma* with *A. balearicum*.

On the basis of our material, the suggested northern boundary of distribution in the East Atlantic can be moved from 32° N to 48° N. To overcome the unequivocal systematic status of the larvae of *A. balearicum* with different TNM, molecular biological investigations should be applied.

Ariosoma selenops

During the expedition of R. V. "Prof. Siedlecki" 1984 in the Iberian Basin an *Ariosoma* larva of unusual size and high myomere count was caught (48° 52,8'N, 26° 59,8'W). The larva seems to be identical to the larva of *A. selenops* as described by Smith (1989) from the western Atlantic. After examination it was retained in the collection of the "Museum für Naturkunde", Berlin.

The total length of the larva was 467 mm; after being preserved in seawater formalin (4 %) for five years it shrank by 7.9 % to 430 mm. The maximum body depth is directly behind the head; but the last third of the body is much narrower. The small head is characterized by large round eyes (diameter of circular eye 1.7 mm); the mouth cleft (4.8 mm) is in line with the centre of the eye; 21 teeth are in the upper jaw – uniform in shape and size (the lower jaw was somewhat damaged); an oval nasal capsule with two round nostrils is level with the upper half of eyes. The dorsal, caudal and short anal fin combine in a continuous fin and there are two hypurals. The gut is straight without any swellings or arches. The length of the filamentous exterilium was 18.4 mm (4.2 % of TL). In the completely transparent larva some fine irregular pigment in the anterior part of the gut and liver are obvious. Besides lateral pigment on the posterior half of the body, minute melanophores are present on the myosepta below the chorda and form short diagonal lines directed caudally. Details of morphometric and meristic characters in comparison with other known examples of the species are given in Table 9.

Larvae of *A. selenops* are only known from the western and central North Atlantic (Smith, 1989: 29 specimens of 24–344 mm SL; Keller, 1976: 5 specimens of 349–402 mm TL). Van Utrecht (1988) described a giant example of "*Leptocephalus pseudomicrocephalus*" in the Iberian Basin as a new, hitherto undescribed type of congrid larva. A comparison of distinct characters shows that both examples from the eastern Atlantic corresponded with the larvae of *A. selenops* known from the western Atlantic. Mochioka et al. (1982) recorded similar larvae, possibly of more than one species, in the western part of the Pacific Ocean. His *Ariosoma* Typ A4 and A5 larvae corresponded in their high count of myomeres, but larvae of both described species have an arch in the gut and

Table 9. Comparison of morphometric and meristic characters of *Ariosoma selenops* larvae in the North Atlantic and of similar eel larvae from the Western Pacific

Parameter	Strehlow (1992)	Smith (1989)	v. Utrecht (1988)*	Mochioka et al. (1982)**	Mochioka et al. (1982)***
N	1	29	1	6	4
TL (mm)	467	24–344	373	41.8–398	41.5–187
			Proportions (% of TL)		
PreAL⁺	98.6	96–98	–	96.9	95.7
PreDL	98.1	–	–	96.0	95.2
LBO	51.2	–	–	–	–
LH	2.1	4–10	2.1	4.3	3.3
D	8.3	9–14	9.3	8.9	9.9
			Meristic values		
TNM	171	169–174	172	160–173	171–177
MP	30	–	–	20–23	8–14
MO	88	96–103	91	78–91	101–104
MA	167	160–169	170	151–161	159–166
MD	165	–	169	149–157	149–164
FC	9	–	–	9	8

* described as *Leptocephalus pseudomicrocephalus*
** described as *Ariosoma* Type A4
*** described as *Ariosoma* Type A5
⁺ measured to the point where the gut becomes free of body

several dorsal and anal pigments, the outer intestine in *Ariosoma* Typ A5 is longer (77.8 % of TL – Table 9).

The enormous size of the specimens from the Iberian Basin and the presence of smaller larvae of the species in the western part of Atlantic could be indicative of an extended larval phase and a spawning area in the western Atlantic. Adults of *A. selenops*, known only from the western North Atlantic, have total lengths of about 500 mm. The larvae reach much more than half the TL of the largest known adults (>90 %), giving this species one of the largest larva-to-adult size ratios of any eel. The larva of *A. selenops* studied here seems to belong to the longest of all known eel larvae. Only four leptocephali of Anguilliformes and Notacanthiformes with greater TL have been described (Bertin, 1954; Castle, 1959, 1967: *L. giganteus* of 565, 900 and 1800 mm; Castle, 1967: *Ascomana eximia* of 700 mm).

Unidentified *Ariosoma* species

During the expedition of R. V. "Prof. Siedlecki" in 1985 two larvae were captured which resembled *A. balearicum* in shape and pigmentation. However, they had higher numbers of myomeres (151 and 152) than *A. balearicum* (123–138). From the West-Atlantic only one species *(A. anale)* is known that exhibits a high number of myomeres (Smith, 1989: TNM = 147–155; n = 19). Blache (1968, 1977) likewise described a number of *Ariosoma* larvae from the Central Atlantic and from the Gulf of Guinea with a TNM between 141 and 154 (TL = 5.4–275 mm; MO = 60–99; MA = 134–142; n = 56). The larvae were differently described, like *Cynoponticus ferox, Parabathymyrus* sp. and *Ariosoma melissi.* Smith (1989) associated all specimens studied by Blache (1968, 1977) with *Ariosoma anale.* However, the two individuals collected during our expedition could not be *A. anale,* because they exhibit neither the three lateral rows of pigment series nor the exterilium, typical of this size and developmental stage. The few known adult specimens of *A. mellissi* (Blache & Bauchot, 1976; Smith, 1981) showed a number of vertebrae between 140 and 142 which is distinctly below the TNM of two larvae under investigation, making their identity questionable. Confirmed larvae of *A. mellissi* are not known.

In addition to the two sampled larvae, seven further specimens, very similar to *A. balearicum,* stored in the "Museum für Naturkunde" in Berlin, were studied. They were captured by the "E. Haeckel"-Expedition 1968 in the Atlantic Ocean. These leptocephali were 130–255 mm and had 123 to 140 preanal myomeres. The exact TNM could not be counted because of the poor condition of the preserved specimens, but they were distinctly above 138.

Table 10. Comparison of morphometric and meristic characters of leptocephali of *Ariosoma* species in the North Atlantic

Parameter	Strehlow (1992)	Fortuna & Olivar (1986)	Smith (1989)	Mochioka et al. (1991)*
N	2	1	5	783
TL (mm)	117–123	79	20–230	11.9–282.2
		Proportions (% of TL)		
preAL	95.5–95.9	–	94–95	–
LH	3.2–7.1	–	5–9	–
D	6.8–6.9	–	9–13	–
		Meristic values		
TNM	151–152	148	148–149	136–151
MO	70–71	82	76–79	71–80
MA	134–137	138	133	131–142

* described as *Ariosoma* Type III without exterilium

Good agreement in all essential features of the two larvae described was obtained in the description of the following material of *Ariosoma* larvae: Fortuno & Olivar (1986) from the Southeast Atlantic, Smith (1989) from different areas of the West-Atlantic, Mochioka et al. (1982) from the North and Central Pacific (*Ariosoma* Type III, without exterilium – Table 10). Castle (1964) as well described very similar larvae of *A. mauritianum* from the South Pacific showing no exterilium. These larvae exhibited a frequency distribution of 134 to 153 TNM showing probably two maxima at 142 and 151. The larvae with the higher number of myomeres therefore are similar to the studied leptocephali of the genus *Ariosoma.* Nothing is known about the distribution, ecology or relationship to other species of *Ariosoma* of these unidentified species.

Other Congridae

Not all congrid larvae shown in Table 11 could be identified definitely to species level. The identification of the *Gnathophis* larvae has been very difficult up to now. The eight larvae captured in the Iberian Basin exhibited good agreement with *Gnathophis mystax* except that there was no lateral pigment and only very sparse intestinal pigmentation. They also had a distinctly higher number of myomeres (∅ TNM = 144.25; s.d. = 1.49) than *G. mystax* leptocephali (this paper: ∅ TNM = 138.73; n = 15; s.d. = 0.96; Blache, 1977: ∅ TNM = 135.50; n = 12; s.d. = 3.09). Taxonomically they therefore could belong to *G. codoniphorus*. This is a second species of the genus known from this area. But only one juvenile and two post-larvae are reported for this species which agreed in numbers of myomeres and vertebrae of 144 (Maul, 1972). *Gnathophis* larvae with 132–147 TNM from the Central Atlantic were reported by Lea (1913).

Leptocephali of *Paraconger* differ from other congrid leptocephali in having a shorter dorsal fin, blade shaped posterior teeth and no suborbital pigment. Only one species is known in the East-Atlantic which was identified from metamorphic specimens by

Table 11. Leptocephali of other congrid species among the examined material

Species	Exp.-Nr. (Table 1)	n	Catching positions	TL (mm)	∅ TL (mm)
Acromycter perturbator	1	1	?	163	163.0
Gnathophis trios	1	6	57.2–63.2°W; 31.4–33.4°W	55–94	80.6
G. bracheotopos	1	3	64.1°W; 31.4°N	42–61	49.3
G. bathytopos	1	9	64.2°W; 31.4°N	35–62	55.4
Gnathophis sp.	1	109	46.0–66.1°W; 10.4–37.5°N	29–128	70.2
Gnathophis sp.	4	49	9.6–67.1°W; 18.1–37.4°N	17–135	71.6
Gnathophis sp.	5	34	9.4–22.3°W; 36.2–39.2°N	22–134	66.0
Gnathophis sp.	7	33	7.1–9.3°W; 36.2–38.1°N	42–124	74.8
G. mystax	8	15	15.6–29.5°W; 37.0–51.6°N	104–150	122.6
Gnathophis sp.*	8	8	12.0–27.0°W; 37.1–45.6°N	95–137	115.0
Gnathophis sp.	18	5	59.2–62.0°W; 24.5–32.0°N	65–72	69.8
Hildebrandia sp.	1	22	31.4–61.6°W; 25.3–63.2°N	26–123	59.6
Hildebrandia sp.	4	4	66.0°W; 25.5°N	47–134	92.2
Paraconger notialis	9	6	7.0–7.4°W; 35.3–35.4°N	26–59	45.5
Pseudophichthys sp.	1	3	10.6°W; 45.5°N	89–107	95.3
Rhechias sp.	1	14	57.0–67.4°W; 21.0–29.5°N	103–160	135.9
Rhechias sp.	4	1	67.1°W; 24.5°N	64	64.0
Uroconger syringinus	1	3	57.2–61.2°W; 26.5–33.4°N	71–118	89.0
Xenomystax congroides	1	25	55.3–64.0°W; 19.5–33.4°N	91–212	152.8
X. congroides	4	2	66.0–66.1°W; 25.5–26.4°N	91–145	118.0
X. congroides	18	2	62.0–63.0°W; 24.5–26.0°N	154–175	164.5

* *Gnathophis codoniphorus?*

Blache (1977). The East-Atlantic larvae of *Paraconger notialis* all have higher numbers of myomeres (this paper: TNM = 133–136; n = 7; Blache, 1977: TNM = 132–144; n = 122) than the species known from the West-Atlantic (Smith, 1989: TNM = 119–131; n = 133). The collection of *Paraconger notialis* in 1984 in the area of Gibraltar shows that this species occurs also in the East-Atlantic.

All 29 larvae of *Xenomystax congroides* were caught in the Sargasso Sea during spring. The number of myomeres varies between 203 and 212 (n = 12) and supports the hypothesis of Smith (1989) of four distinct Atlantic populations which can be identified by number of myomeres or vertebrae. Leptocephali of the Caribbean population and from the area near Bermuda have the highest numbers of myomeres (Smith, 1989: TNM = 200–212; Keller, 1976: TNM = 221).

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