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ASCARIDOID NEMATODES OF TELEOSTEAN FISHES FROM THE EASTERN NORTH ATLANTIC AND SEAS OF THE NORTH OF EUROPE

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Summary :

Ascarid parasites of Teleostean fishes from the North Eastern Atlantic and seas of the North of Europe deposited in the collections of the "Museum National d'Histoire Naturelle de Paris" are studied. The ratios oesophagus length/width of cervical alae and ventricular appendage length/width of cervical alae allow *Hysterothylacium aduncum* to be divided into two subspecies : *H. aduncum aduncum* was found in *Alosa fallax, A. alosa, Belone belone, Psetta maxima, Lophius piscatorius, Trachurus trachurus, Merluccius merluccius* and *Trisopterus luscus* whereas *H. aduncum gadi* was found in *Pollachius pollachius, P. virens, Gadus morhua, Merlangus merlangus, Scomber scombrus* and *Salmo salar*. *Hysterothylacium cornutum, H. rigidum* and *Maricostula incurva* are recorded respectively from *Thunnus germo alalonga, Lophius piscatorius* and *Xiphias gladius*. The following species are described : *Hysterothylacium reliquens* from *Pagellus acarne* and *Microchirus azevia, Hysterothylacium* sp. from *Callionymus lyra* and *Goezia* sp. from *Trisopterus luscus*. A key is presented for the species of Raphidascaridinae parasites of Teleostean fishes from North Eastern Atlantic and seas of the North of Europe.

KEY WORDS : nematoda. Ascaridoidea. teleostean fish. North Eastern Atlantic. seas of the North of Europe. systematics.

Résumé *: ASCARIDES PARASITES DE POISSONS TÉLÉOSTÉENS DE L'ATLANTIQUE NORD-ORIENTAL ET DES MERS DU NORD DE L'EUROPE*

Les espèces d'Ascarides parasites de Poissons Téléostéens de l'Atlantique Nord-oriental et des mers du Nord de l'Europe présentes dans les collections du Museum National d'Histoire Naturelle de Paris sont étudiées. Les mesures relatives, longueur de l'oesophage/largeur des ailes cervicales et longueur de l'appendice oesophagien/largeur des ailes cervicales, permettent de distinguer deux sous-espèces chez Hysterothylacium aduncum *: H. aduncum aduncum est présente chez* Alosa fallax, A. alosa, Belone belone, Psetta maxima, Lophius piscatorius, Trachurus trachurus, Merluccius merluccius *et* Trisopterus luscus *; H. aduncum gadi est présente chez* Pollachius pollachius, P. virens, Gadus morhua, Merlangius merlangus, Scomber scombrus *et* Salmo salar. Hysterothylacium cornutum, H. rigidum *et* Maricostula incurva *sont signalés respectivement chez* Thunnus (Germo) alalunga, Lophius piscatorius *et* Xiphias gladius *;* Hysterothylacium reliquens *est redécrit chez* Pagellus acarne *et* Microchirus azevia *;* Hysterothylacium *sp. et* Goezia *sp. sont décrits respectivement chez* Callionymus lyra *et* Trisopterus luscus. *Une clef dichotomique des espèces de Raphidascaridinae parasites de Poissons Téléostéens de l'Atlantique Nord-oriental et des mers du Nord de l'Europe est donnée.*

MOTS CLES : *nematodes. Ascaridoidea. poissons téléostéens. Atlantique nord-oriental. mers du nord de l'Europe. systématique.*

INTRODUCTION

The ascarid fauna of Teleostean fishes of North Eastern Atlantic and Seas of the North of Europe has been studied by many authors and is relatively well known. Excluding the species insufficiently described, seven species are known : *Hysterothylacium aduncum, H. gadi, H. auctum, H. rigidum, H. cornutum, Maricostula incurva* and *Goezia sigalasi*. However, the validities of *Hysterothylacium gadi* and *H. auctum* are under discussion, these species being considered as junior synonyms of *H. aduncum* by many authors.

This paper gives the results of the study of Ascarids from these seas deposited in the collections of the Museum National d'Histoire Naturelle de Paris (MNHN). A morphological and biometrical study was performed for specimens from various hosts and localities referred to *Hysterothylacium aduncum* and *H. gadi*, in order to discover if the two species could be distinguished. Six other species were present, including *H. reliquens*, which is recorded for the first time in the North Eastern Atlantic.

MATERIALS AND METHODS

Specimens had been initially fixed in formaldehyde or in 70% alcohol, and were preserved in 70% alcohol. The morphological study and measurements were made after clearing in lactophenol. Variations in measurements are caused by fixation and clearing methods (see Fagerholm, 1979; Fagerholm and Lövdahl, 1984) : for the biometrical

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analysis, we used the measured lengths without correction. All measurements are in µm except the body length and distance anterior extremity-vulva, which are given in mm.

RESULTS

Hysterothylacium aduncum (Rud., 1802)

Some confusion exists concerning the systematics of the species *Hysterothylacium aduncum* (Rudolphi, 1802) and *H. gadi* (O.F. Müller, 1776) [= *H. clavatum* (Rudolphi, 1809)]. Rudolphi originally described in 1802 the species *Ascaris aduncа* from *Alosa alosa* (L., 1756) (= *Clupea alosa*); *Ascaris gadi* was created by Müller in 1776, and synonymised by Rudolphi (1809) with his new species *Ascaris clavata* parasite of *Trisopterus luscus* (L., 1758) (= *Gadus barbatus*); the description of Müller being older, the name *gadi* must prevail. The descriptions of Müller and Rudolphi are very brief, but Rudolphi (1809) placed *A. clavata* in a group of species with an alate head ("*capite alato*") and *A. aduncа* in a group with a bare head ("*capite nudo*"). Later, many authors seem to have assigned their specimens to one species or the other, by relying only on their hosts. Punt (1941) synonymised *H. gadi* with *H. aduncum*, and this was followed by Berland (1961), Petter (1969) and Fagerholm (1982). On the other hand, Dollfus (1953), in accordance with a personal communication from Baylis, questioned this synonymy and proposed an attempt of differentiation based on the shape of labial flanges and the width of cervical alae, and Hartwich (1975) considered the two species valid and gave descriptions and a key of differentiation based on the study of specimens from the "Berliner Zoologischen Museum".

According to Hartwich (1975), *H. gadi* differs from *H. aduncum* : – by having cervical alae becoming wide at the base of the lips, their maximum width reaching 140 µm, whereas in *H. aduncum*, cervical alae widen progressively, and their maximal width reaches only 50 µm; – by flanges of the dorsal lip less rounded; – by spicules measuring 5-8% of body length, whereas in *H. aduncum* they measure more than 10% of body length; – by having one or two adanal pairs and six postanal pairs of papillae, whereas in *H. aduncum* only four to six pairs of single postanal papillae are present. Also according to Hartwich, *H. gadi* is chiefly a parasite of Gadiformes, but probably also of other carnivorous and of a few migratory fish, whereas *H. aduncum* is a parasite of Clupeiformes, but has also been recorded in other plankton and small prey eating fish.

Material studied

Each lot includes specimens collected in one or several fish of the same species, at the same date and from the same locality.

Material used for the biometrical studies

86 worms (47 males and 39 females) were analysed, corresponding to the specimens on whom all measurements could be made. Numbers in square brackets are the serial numbers of specimens used in multivariate analyses.

Pollachius virens (L., 1758) (Gadidae, Gadiformes) : Lot n° 1 : 8 ♂ and 7 ♀ n° MNHN 484 BB; western Scotland, Faroe islands; collected by V. Angot, April and September 1958 [♂ 1-8; ♀ 1-7]. Lot n° 2 : 2 ♂ and 3 ♀ n° 1BF; Dublin (Ireland); collection R. Ph. Dollfus; 25-10-1937 [♂ 19-20; ♀ 18-20]. *Pollachius pollachius* (L., 1758) : Lot n° 3 : 5 ♂ and 3♀ n° 2 BF; Concarneau (France); collection R. Ph. Dollfus; 3-7-1940 [♂ 21-25; ♀ 21-23]. Lot n° 4 : 1 ♀ n° 701 BB; Roscoff (France); collection R. Ph. Dollfus; 18-9-1913 [♀ 24]. *Gadus morhua* L., 1758 (Gadidae) : Lot n° 8 : 3 ♂ and 2 ♀ n° 3 BF; Dogger Bank (North Sea); collection R. Ph. Dollfus; October 1928 [♂ 26-28; ♀ 25-26]. *Merlangius merlangus* (L., 1758) (Gadidae) : Lot n° 11 : 2 ♂ n° 489 BB; North Sea; collected by de Panafieu; 1985 [♂ 38-39]. *Merluccius merluccius* (L., 1758) (Merluciidae, Gadiformes) : Lot n° 12 : 2 ♂ and 1 ♀ n° 687 BB; Rabat (Morocco); collection R. Ph. Dollfus; January1954 [♂ 40-41; ♀ 33]. Lot n° 13 : 2 ♂ and 2 ♀ n° 691 BB; Rabat; collection R. Ph. Dollfus; 29-3-1949 [♂ 42-43; ♀ 34-35]. *Mullus surmuletus* L., 1758 (Mullidae, Perciformes) : Lot n° 16 : 1 ♀ n° 707 BB; Concarneau; collection R. Ph. Dollfus; 23-6-1944 [♀ 36]. Lot n° 17 : 1 ♂ and 3 ♀ n° 708 BB; Concarneau; collection R. Ph. Dollfus; 18-6-1942 [♂ 44; ♀ 37-39]. Lot n° 18 : 1 ♂ n° 709 BB; Concarneau; collection R. Ph. Dollfus; 18-6-1943 [♂ 45]. *Mullus barbatus* L., 1758 : Lot n° 20 : 1 ♂ n° 719BB; Rabat ; collection R. Ph. Dollfus; 30-9-1926 [♂ 46]. Lot n° 21 : 1 ♂ n° 138 G; St Malo (France); collected by A. Coumbaras; 12-7-1962 [♂ 47]. *Scomber scombrus* L., 1758 (Scombridae, Perciformes) : Lot n° 22 : 4 ♂ and 3 ♀ n° 7 BF; Concarneau; collection R. Ph. Dollfus; 26-6-1940 [♂ 34-37; ♀ 30-32]. *Trachurus trachurus* (L., 1758) (Carangidae, Perciformes) : Lot n° 24 : 2 ♂ and 1 ♀ n° 8 BF; Concarneau; collection R. Ph. Dollfus : 9-7-1941 [♂ 32-33; ♀ 29]. *Lophius piscatorius* L., 1758 (Lophiidae, Lophiiformes) : Lot n° 27 : 3 ♂ and 1 ♀ n° 468 Q; île d'Yeu (France); collected by A. J. Petter; 22-7-1968 [♂ 29-31; ♀ 27]. Lot n° 28 : 1 ♀ n° 570 HD; Concarneau; collection R. Ph. Dollfus; 22-6-1933 [♀ 28]. *Alosa fallax* (Lacépède, 1803) (Clupeidae, Clupeiformes) : Lot n° 35 : 10 ♂ and 10 ♀ n° 511 BB; Morocco; collection R. Ph. Dollfus; 20-5-1951 [♂ 9-18; ♀ 8-17].

Other material

Pollachius pollachius (L. 1758) : Lot n° 5 : 1 ♂ n° 137 BA; Roscoff; collected by A.J. Petter ; 17-7-1970. *Trisopterus luscus* (L., 1758) (Gadidae) : Lot n° 6 : 1 ♂ n° 472 Q; Le Croisic

(France); collected by A.J. Petter; 22-7-1968. Lot n° 7 : 2 ♀ n° 663 BB; Casablanca (Morocco); collection R. Ph. Dollfus; 24-4-1950. *Gadus morhua* L., 1758 : Lot n° 8 : 1 ♀ n° 3 BF; Dogger Bank (North Sea); collection R.Ph. Dollfus; October 1928. *Merlangius merlangus* (L., 1758) (Gadidae) : Lot n° 9 : 3 ♀ n° 526 BB; Concarneau; collection R. Ph. Dollfus; 18-6-1941. Lot n° 10 : 1 ♂ n° 4 BF; Boulogne (France); collection R. Ph. Dollfus; 17-11-1955. *Merluccius merluccius* (L., 1758) (Merlucciidae, Gadiformes) : Lot n° 14 : 1 ♂ and 1 ♀ n°5 BF; Concarneau; collection R. Ph. Dollfus; 2-7-1931. Lot n° 15 : 1 ♂ n° 469 Q; Le Croisic; collected by A. J. Petter; 22-7-1968. *Mullus surmuletus* L., 1758 (Mullidae, Perciformes) : Lot n° 19 : 1 ♀ n° 6 BF; Bay of Biscay; collection R. Ph. Dollfus; June 1948. *Mullus barbatus* L., 1758 : Lot n° 20 : 1 ♀ n° 719 BB; Rabat; collection R. Ph. Dollfus; 30-9-1926. Lot n° 21 : 3 ♀ n° 138 G; St Malo (France); collected by A. Coumbaras; 12-7-1962. *Scomber scombrus* L., 1758 (Scombridae, Perciformes) : Lot n° 23 : 1 ♂ and 1 ♀ n° 723 BB; Stornoway (Hebrides isles); collection R. Ph. Dollfus; 18-7-1929. *Psetta maxima* (L. 1758) (Scophthalmidae, Pleuronectiformes) : Lot n° 25 : 2 ♀ n° 497 Q; Le Croisic; collected by A. J. Petter; 5-8-1968. Lot n° 26 : 1 ♂ n° 9 BF; Concarneau; collection R. Ph. Dollfus; 18-6-1943. *Zeus faber* L., 1758 (Zeidae, Zeiformes) : Lot n° 29 : 4 ♀ n° 10 BF; Concarneau; collection R. Ph. Dollfus; 2-9-1943. Lot n° 30 : 1 ♂ and 1 ♀ n° 11 BF; collection R. Ph. Dollfus; locality and date not mentioned. Lot n° 31 : 1 ♂ and 2 ♀ n° 716 BB; Concarneau; collection R. Ph. Dollfus; 14-5-1943. Lot n° 32 : 2 ♀ n° 12 BF; Morocco; collection R. Ph. Dollfus; 19-6-1966. Lot n° 33 : 1 ♂ n° 13 BF; locality not mentioned; collection R. Ph. Dollfus; 1933. *Belone belone* (L., 1758) (Belonidae, Beloniformes) : Lot n° 34 : 1 ♀ n° 710 BB, Concarneau; collection R. Ph. Dollfus; 28-4-1946. *Alosa alosa* (L., 1758) : Lot n° 36 : 1 ♂ n° 652 BB; Casablanca; collection R.Ph. Dollfus; 30-4-1953. Lot n° 37 : 1 ♀ n° 528 BB; Morocco; collection R. Ph. Dollfus; 9-9-1926. *Salmo salar* L., 1758 (Salmonidae, Clupeiformes) : Lot n° 38 : 2 ♀ n° 726 BB; Concarneau; collection R. Ph. Dollfus; 18-6-1943.

MORPHOLOGICAL STUDIES

Detailed descriptions of the species were given by Punt (1941), Berland (1961) and Hartwich (1975), so it appeared unnecessary to give a complete description of the material studied, and we only discuss below the different characters which have been suggested to differentiate the two species.

Cervical alae

At first sight, two groups seem to be present, differing by the width of cervical alae : in the first group (Fig. 1A, F, J) the cervical alae are very wide in the oesophageal region, whereas in the second group, alae are hardly wider in the anterior region than in the middle and posterior ones (Fig. 2A, C, J). However, this character is not sufficient to differentiate the species, as all intermediaries exist between wide and narrow alae and whatever width might be chosen to differentiate the two groups, in some lots the range of width overlaps those of the two groups. Independently of their width, in most specimens the cervical alae are wide from their beginning and the figure of the anterior extremity of *Hysterothylacium gadi* given by Hartwich actually corresponds to the specimens with narrow cervical alae (Fig. 2C).

Shape of lips

We did not find any difference in the shape of the labial flanges between the two putative groups; individual variations in this shape were observed, independent of the width of cervical alae (Fig. 1D, E – Fig. 2C, D).

Caudal papillae (Fig. 1L, M, N, O – Fig. 2L, M, N, O, Fig. 3A, B, C)

No difference in the number and disposition of caudal papillae could be found. We observed in the two groups : – two subventral rows of precloacal papillae; the 10 to 12 posterior ones are small and close together; their number varies from 22 to 32 pairs in the specimens examined (Fig. 1L, Fig. 2L); the most posterior or the two posterior pairs may be adcloacal (Fig. 1N) – one precloacal medioventral papilla; – seven or eight postcloacal pairs including : – five subventral pairs with third pair from the cloaca doubled; the most anterior or the two anterior pairs may be adcloacal (Fig. 1O, Fig. 2O); one papilla may be lacking on one side Fig. 2O, Fig. 3C); – one lateral pair corresponding to phasmids; – one subdorsal pair, often invisible in ventral view; – a second lateral pair can be seen in some juvenile specimens (Fig. 3A, B).

Spicules (Fig. 1P – Fig. 2P)

The shape of spicules is the same in all specimens ; their length in relation to body length varies between the lots, but there is no evident correlation between this length and the width of cervical alae; the length ranges observed in each group are different from those given by Hartwich for *H. gadi* and *H. aduncum.*

Therefore, the morphological analysis does not allow a separation into two species; however, the biometrical analysis given below shows that two morphological entities exist.

BIOMETRICAL STUDIES

Data analysis

The following multivariate analyses were used : principal component analysis (PCA) and clustering analyses based on unweighted arithmetic average (UPGMA) in order to identify putative groups, discriminant analysis to identify the most interesting variables, and finally segmentation based on Chi-

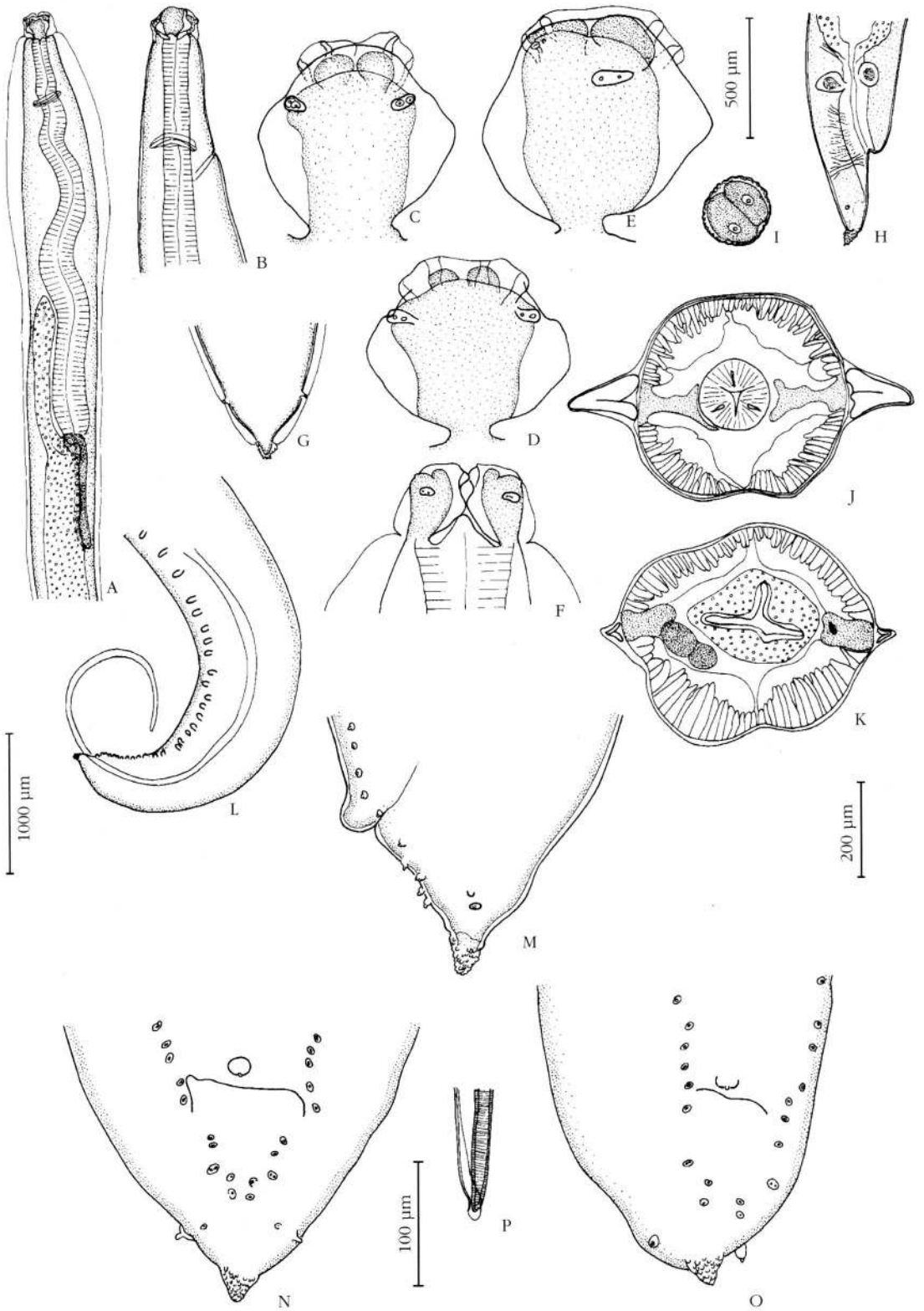

Fig. 1. – *Hysterothylacium aduncum gadi* (O.F. Müller, 1776, species), specimens parasitizing *Pollachius virens* (lot n° 1). A, anterior part, median view ; B, anterior part, lateral view ; C,D, dorsal lips ; E, latero-ventral lip ; F, female, anterior end, lateral view ; G, female, posterior end, ventral view ; H, female, posterior end, lateral view ; I, egg ; J, cross-section at level of oesophagus ; K, cross-section at level of ventricular appendage ; L, male, posterior part, lateral view ; M, male, posterior end, lateral view ; N,O, males, posterior ends, ventral views ; P, spicule, distal end. Scale lines (µm) : A,B,L, 1000 ; C,D,E,I,M,N,O,P, 100 ; H, 500 ; F,G,J,K, 200.

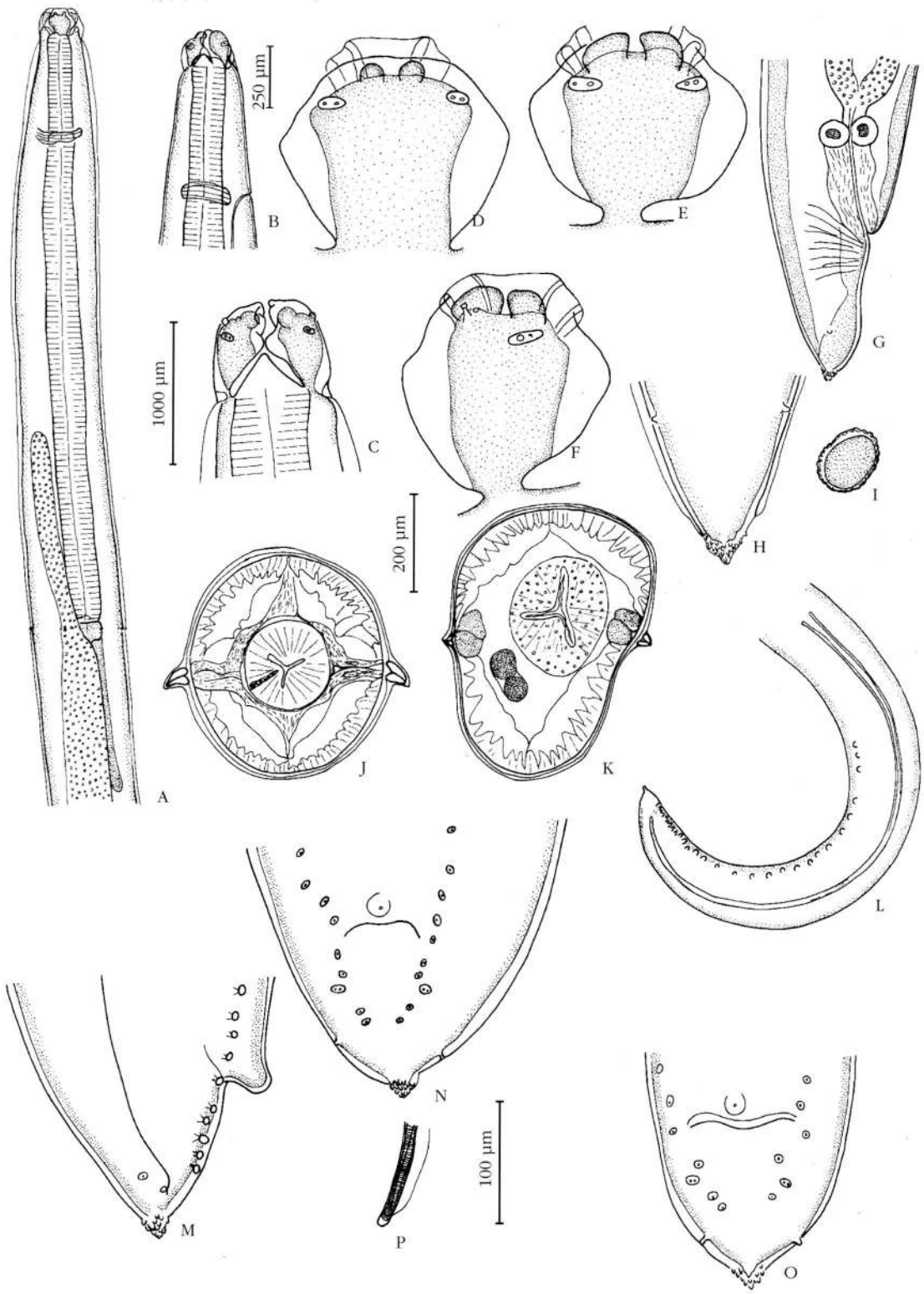

Fig. 2. – *Hysterothylacium aduncum aduncum* (Rud., 1802), specimens parasitizing *Alosa fallax* (lot n° 35). A, anterior part, median view ; B, anterior part, lateral view ; C, anterior end, lateral view ; D,E, dorsal lips ; F, latero-ventral lip ; G, female, posterior end, lateral view ; H, female, posterior end, ventral view ; I, egg ; J, cross-section at level of oesophagus; K, cross-section at level of ventricular appendage ; L, male, posterior part, lateral view ; M, male, posterior end, lateral view; N,O, males, posterior ends, ventral views ; P, spicule, distal end. Scale lines (µm) : A,L, 1000 ; B, 250 ; C,G,J,K, 200; D,E,F,H,I,M,N,O,P, 100.

Host	lot	serial n°	l	L	s	o	a	c
P. virens	1	1	29	110	3200	2600	700	850
		2	31	120	4000	2750	600	1180
		3	34	150	3650	2140	600	850
		4	36	95	3100	2850	775	1050
		5	38	80	3000	2825	675	1050
		6	39	125	3550	3325	850	1400
		7	39	120	4000	3100	800	1250
		8	41	115	3125	2750	700	1250
A. fallax	5	9	21	30	3000	2940	720	1075
		10	22	20	3380	2700	680	1150
		11	23	30	3820	2150	700	800
		12	29	30	3715	2900	900	970
		13	29	30	3645	3150	940	1040
		14	31	30	3575	3100	850	900
		15	32	40	3385	3400	1070	1440
		16	33	35	3735	2860	850	1000
		17	34	20	4425	3460	1025	1400
		18	35	50	3335	3300	980	1300
P. virens	2	19	37	90	2300	3650	1275	1250
		20	45	100	1850	3150	850	1100
P. pollachius	3	21	16	50	1300	1880	430	700
		22	15	40	1100	1400	360	460
		23	19	50	1100	2000	460	650
		24	44	75	2560	3200	850	1300
		25	26	85	1800	1850	630	850
G. morhua	8	26	58	120	2160	4300	1060	1525
		27	56	60	3250	4050	1120	1200
		28	40	60	2400	2800	760	1000
L. piscatorius	27	29	41	30	1800	2850	950	600
		30	30	35	1500	2800	810	1200
		31	25	35	1560	2650	900	1300
T. trachurus	24	32	29	50	1330	2700	1000	1050
		33	36	45	1800	3450	1100	1130
S. scombrus	22	34	33	90	1770	2600	1120	950
		35	31	70	2000	2550	920	1020
		36	29	80	1250	3150	1150	1450
		37	27	70	1500	2450	900	900
M. merlangius	11	38	20	55	980	1800	600	580
		39	17	40	1260	1400	430	225
M. merluccius	12	40	14	30	850	1920	500	600
		41	25	30	2100	2350	850	800
	13	42	24	30	1570	2000	900	650
		43	23	30	1150	2100	850	850
M. surmuletus	17	44	29	70	2200	3525	1060	940
	18	45	47	60	2170	4950	1450	1700
M. barbatus	20	46	52	50	3750	4500	1860	1800
	21	47	44	65	2400	4200	1100	1600

Table I. – *Hysterothylacium aduncum* : measurements of males analysed for the biometrical study.

Host	lot	serial n°	l	L	o	a	c
P. virens	1	1	32	75	2500	600	1100
		2	36	85	3100	775	1550
		3	46	120	3600	700	1600
		4	46	125	3620	600	1600
		5	49	130	3950	850	1525
		6	51	130	3800	1000	1400
		7	51	125	4700	950	1500
A. fallax	5	8	33	30	3475	680	1400
		9	35	30	3480	900	950
		10	36	30	3650	850	1260
		11	37	40	3600	950	1340
		12	37	35	4070	1000	1300
		13	38	40	3850	910	1350
		14	39	40	4235	1140	1340
		15	39	45	3900	1000	1250
		16	40	40	4600	1320	1600
		17	41	40	4650	1100	1750
P. virens	2	18	56	100	4050	950	1450
		19	49	90	3790	940	1350
		20	68	120	4770	900	2200
P. pollachius	3	21	45	85	3400	725	1150
		22	53	100	3900	775	800
		23	45	90	3200	850	1160
	4	24	45	80	3600	950	1500
G. morhua	8	25	69	80	4100	960	1600
		26	67	110	3700	1350	2420
L. piscatorius	27	27	39	40	2880	850	1000
	28	28	33	60	3400	1050	1350
T. trachurus	24	29	46	40	4610	1050	1075
S. scombrus	22	30	39	90	3080	1100	1250
		31	38	110	2900	850	1100
		32	38	70	2800	900	950
M. merluccius	12	33	23	40	2350	700	800
	13	34	20	25	2225	800	950
		35	15	20	1460	580	600
M. surmuletus	16	36	62	60	5450	1200	1875
	17	37	65	65	5100	1000	1640
		38	73	70	6550	1400	2060
		39	83	100	6450	1200	2100

Table II. – *Hysterothylacium aduncum* : measurements of females analysed for the biometrical study .

a : ventricular appendage length (µm); c : intestinal caecum length (µm); l : body length (mm); L : width of cervical alae (µm); o : oesophagus length (µm); s : spicules length (µm).

square in order to find easy criterion for identification. The analyses were performed with a Stat-Ictf (1988) statistical computer package and interpreted according to Dagnelie (1975).

The data matrix was constituted with five measures for each female worm and by six measures for each male worm. The measures were : cervical alae (L), body length (l), oesophagus length (o), ventricular appendage (a), intestinal caecum (c), and additionally spicule length for males (s) [tables I (males) and II (females)].

Results

The different measures were significantly linked (P<0,01). Among males, width of cervical alae and body length, length of spicules and body length, oesophagus and intestinal caecum lengths, ventricular appendage and intestinal caecum lengths. The worms harboured by *Pollachius virens* were very different from others, on second axis, whereas first axis did not allow differentiation between groups. Two groups (in males and females) were distinguished by means of cluster analysis based on relative values of parameters (actual value/width of cervical alae). The measures of the two putative groups (*gadi versus aduncum*) are shown in table III. The use of discriminant analysis did allow identification of the two groups : 100% of the worms were successfully classified into *gadi* and *aduncum*. Pseudo-F was 122 whereas highest F value was 118 for ventricular appendage in male worms. Pseudo-F was 235 and highest F value 190 for oesophagus in female worms. The advantage of multivariate analysis was reduced for males (pseudo-F and F values were similar) but was clear for female identification. Segmentation analysis based on two most important parameters (lengths of oesophagus and ventricular appendage) did show that two groups were significantly distinct (P<0,01), either in male or female worms (results shown in Figs. 4 and 5). Both measures were useful in identification (Chi-square of respectively 70.7 and 70.4 for 86 specimens). Group 1 (*gadi*) was characterized with a/L < 15 and o/L < 54 and group 2 (*aduncum*) was characterized with a/L >15 and o/L >54.

Those identification criteria were tested on 39 additional specimens (Fig. 6). Eight specimens (four parasites of *Zeus faber*, two of *Mullus surmuletus*, one of *Trisopterus luscus* and one of *Merluccius merluccius*) could not be classified, as the two parameters placed them in different groups. All specimens from the same lot and all the lots from the same host species belonged to the same group, except in four host species the specimens of which were distributed as follows : *Gadus morhua* : six specimens studied : four in group 1, two in group 2 (lot n°8). *Zeus faber* : 12 specimens studied : six in group 1 (in lots n° 29 and 31), two in group 2 (in lots n° 29 and 30), four could not be classified (in lots 30, 32 and 33). *Mullus surmuletus* : seven specimens studied : one in group 1 (in lot n° 17), four in group 2 (in lots n° 16, 17 and 18), two could not be classified (in lots n° 17 and 19). *Mullus barbatus* : six specimens studied : two in group 1 (in lot n° 21), four in group 2 (in lots n° 20 and 21).

CONCLUSIONS

The preceding data allowed a differentiation into two groups, which in the majority of cases were isolated, probably because of ecological rather than geographical reasons. In four hosts only, these two groups cohabited and in two of these four hosts (*Zeus faber, Mullus surmuletus*), intermediary forms were found, which, according to our interpretation, are crossbreeds. In the present state of knowledge, we therefore propose to consider these groups as two subspecies of *Hysterothylacium aduncum*.

The subspecies *gadi* was found chiefly in Gadiformes (*Pollachius virens, P. pollachius, Gadus morhua, Merlangius merlangus*), but also in one Perciform (*Scomber scombrus*) and one Clupeiform (*Salmo salar*) ; the subspecies *aduncum* in Clupeiformes (*Alosa fallax, A. alosa*), Beloniformes (*Belone belone*), Pleuronectiformes (*Psetta maxima*), Lophiiformes (*Lophius piscatorius*), Perciformes (*Trachurus trachurus*), but also in Gadiformes (*Merluccius merluccius, Trisopterus luscus*).

In most lots, the fishing places were not known. Only the harbours of arrival of boats were recorded. Nevertheless, we may conclude that fishes parasitised by the subspecies *gadi* have a geographical range not extending southwards beyond the European coasts, while the geographical range of the subspecies *aduncum* extends more southwards. These results are in agreement with the observations of Hartwich (1975).

		H. a. gadi		*H. a. aduncum*	
males	s/L	27.3	(6.4)	87.7	(45.6)
	o/L	36.1	(11.9)	89.9	(25.1)
	a/L	10.5	(3.9)	28.2	(6.9)
	c/L	13.0	(4.3)	32.7	(11.7)
	l/L	409.7	(112.1)	928.5	(237.8)
females	o/L	36.7	(9.9)	99.5	(16.3)
	a/L	9.8	(3.2)	25.4	(4.7)
	c/L	15.0	(3.7)	33.8	(6.3)
	l/L	514.5	(131.2)	1000.9	(118.0)

Table III. – *Hysterothylacium aduncum* : Relative values of parameters of the two subspecies distinguished by means of cluster analysis (means, standard deviations in brackets).
a : ventricular appendage length (µm); c : intestinal caecum length (µm); l : body length (µm); L : width of cervical alae (µm); o : oesophagus length (µm); s : spicules length (µm).

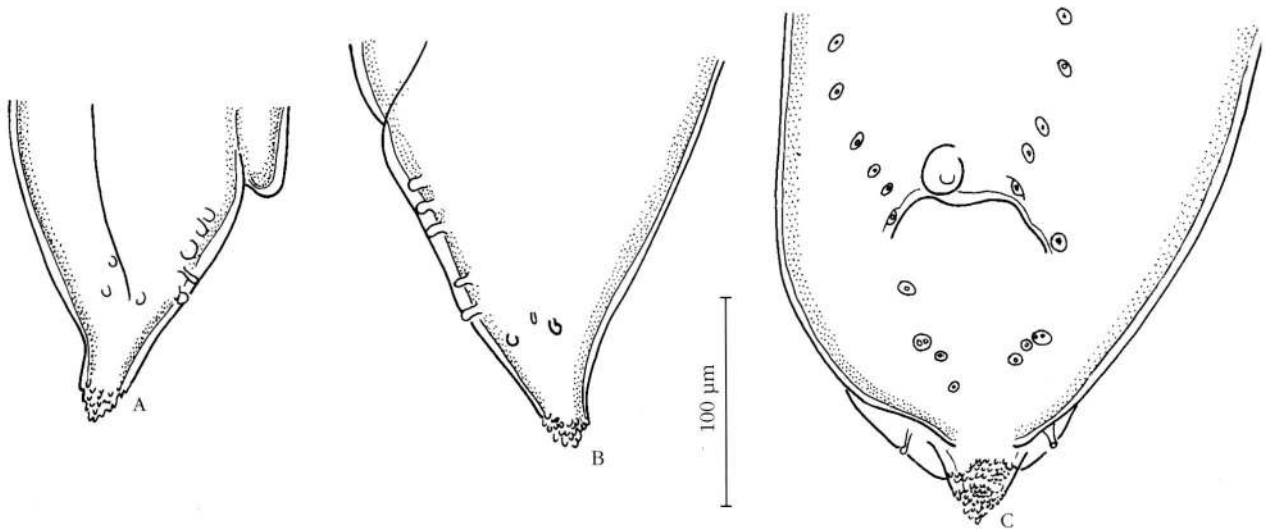

Fig. 3. – Male posterior ends. A, *Hysterothylacium aduncum gadi*, juvenile male parasitizing *Scomber scombrus* (lot n° 22), lateral view; B, *Hysterothylacium aduncum aduncum*, juvenile male parasitizing *Trachurus trachurus* (lot n° 24), lateral view; C, *Hysterothylacium aduncum aduncum*, male parasitizing *Lophius piscatorius* (lot n° 27), ventral view.

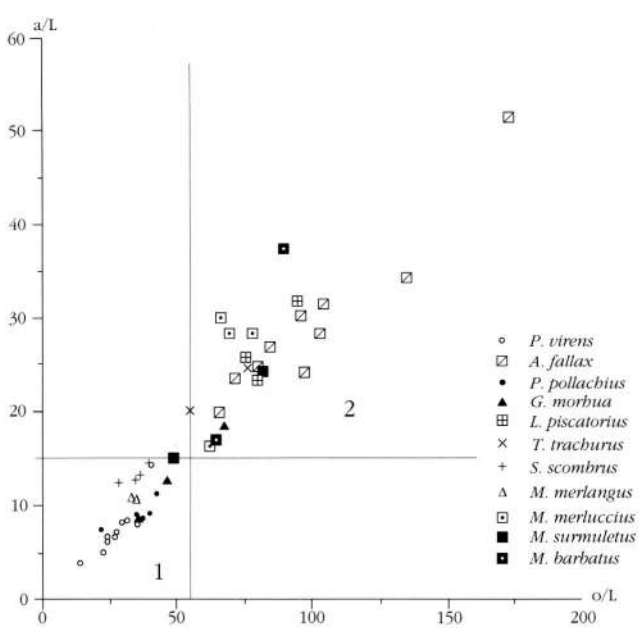

Fig. 4. – *Hysterothylacium aduncum*. Distribution of males in relation to parameters o/L (oesophagus length/width of cervical alae) and a/L (ventricular appendage length/width of cervical alae) in 11 fish species. Groups 1 (*gadi*) and 2 (*aduncum*) are significantly distinct according to segmentation analysis.

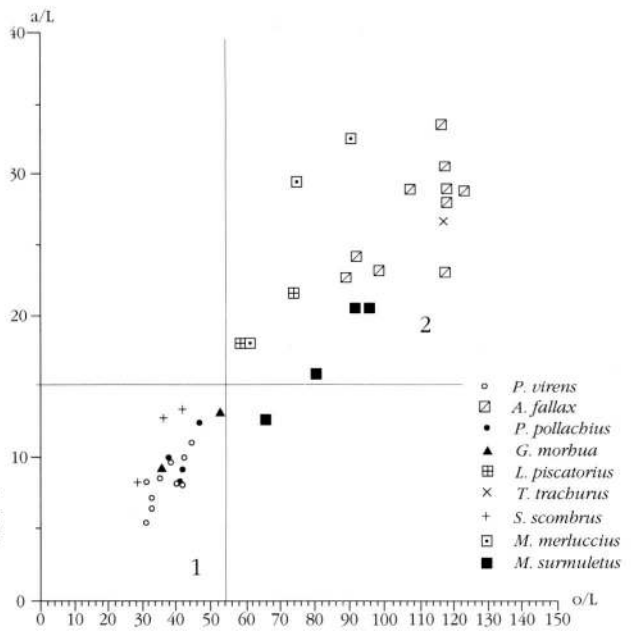

Fig. 5. – *Hysterothylacium aduncum*. Distribution of females in relation to parameters o/L and a/L in 9 fish species. Groups 1 (*gadi*) and 2 (*aduncum*) are significantly distinct according to segmentation analysis.

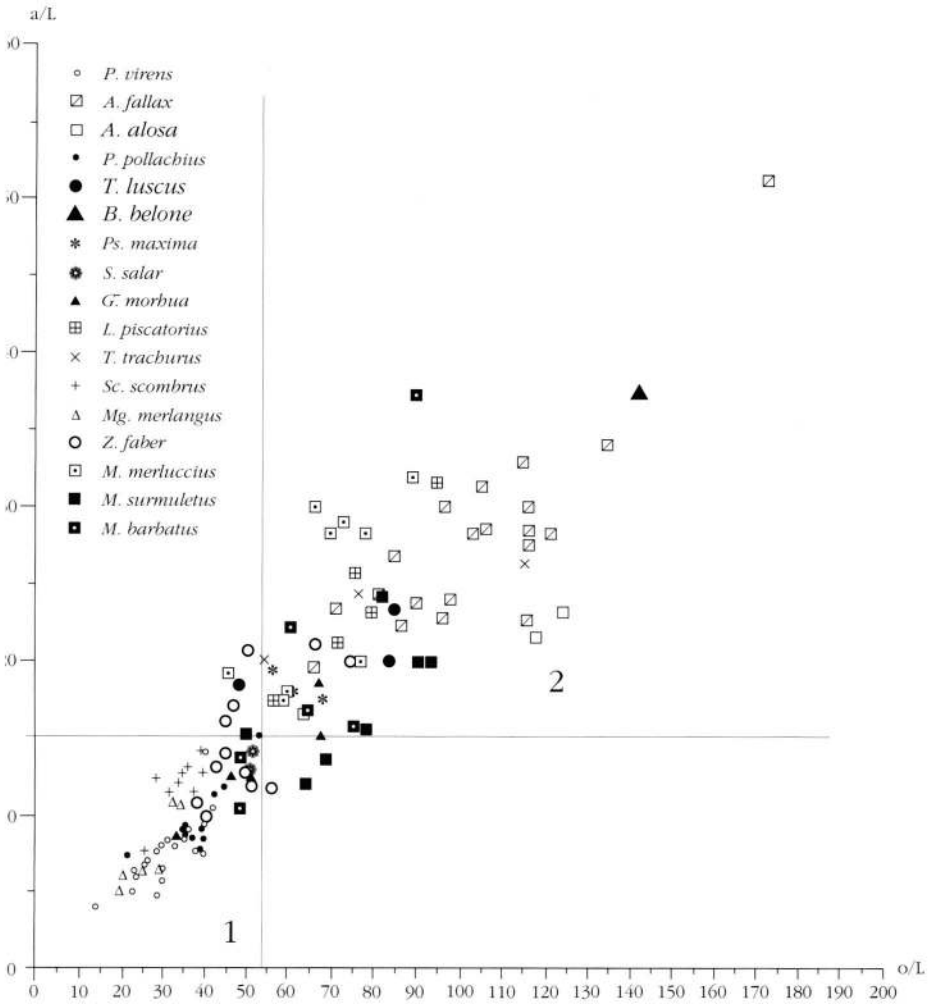

Fig. 6. – *Hysterothylacium aduncum*. Distribution of male and female specimens in relation to parameters o/L et a/L in 17 fish species. 1 : sub-species *gadi*; 2 : sub-species *aduncum*.

HYSTEROTHYLACIUM RELIQUENS

(Norris and Overstreet, 1975) Fig. 7

Material : 3 ♂ and 12 ♀ n° MNHN 675 BB, 486 BC, 537 BC; host : *Pagellus acarne* (Risso, 1826) (Sparidae); Morocco; 21-6-1957 and 18-4-1968. 1 ♂ n° MNHN 669 BB; host : *Microcheirus azevia* (Capello, 1867) (Soleidae); Morocco. Collection R.Ph. Dollfus.

DESCRIPTION

Body thinner anteriorly. Lateral alae very thin (5-10µm), with supports V-shaped in cross-section, originating from the base of the lips and extending all along the body. Dorsal lip slightly wider than long, latero-ventral lips longer than wide. Lips lacking posterior lobes. Labial flanges constricted at middle of lips. Interlabia very short, not more than 1/4 of lip length. Oesophagus 8.5-14.7 % of body length, ventricular appendage very thin, ratio oesophagus/ventricular appendage 1.8-3.9, intestinal caecum short, ratio oesophagus/caecum 3.6-7.9. Excretory pore at level of nerve ring. Tail with spined conical mucronate extremity.

Male : Spicules 4.9-7% of body length. About 27 pairs of preanal papillae, the ten most posterior pairs very close together; one big large medio-ventral preanal papilla; 5-7 postcloacal pairs (including phasmids) : one or two lateral and four or five ventro-laterals; second or third pair from the cloaca doubled.
Female : vulva without salient lips, slightly posterior to anterior third of body.

Measurements (range, means in parentheses) :
Females, n = 7 : length 18-75 (36.6); oesophagus 2350-8000 (4124.3); caecum 500-1100 (671); ventricular appendage 1100-2050 (1495); tail 300-650 (457.5).
Males, n = 4 : length 14-43 (24.1); oesophagus 2060-3650 (2687.5); caecum 260-680 (425); ventricular appendage 1080-2000 (1407.5); tail 190-200 (196.6) ; spicules 720-2160 (1371.2).

DISCUSSION

Measurements and morphology of these specimens, especially the shape of lips, agree with those of *H. reliquens*, given by Norris and Overstreet, 1975 and Deardorff and Overstreet, 1980. *H. reliquens* has been

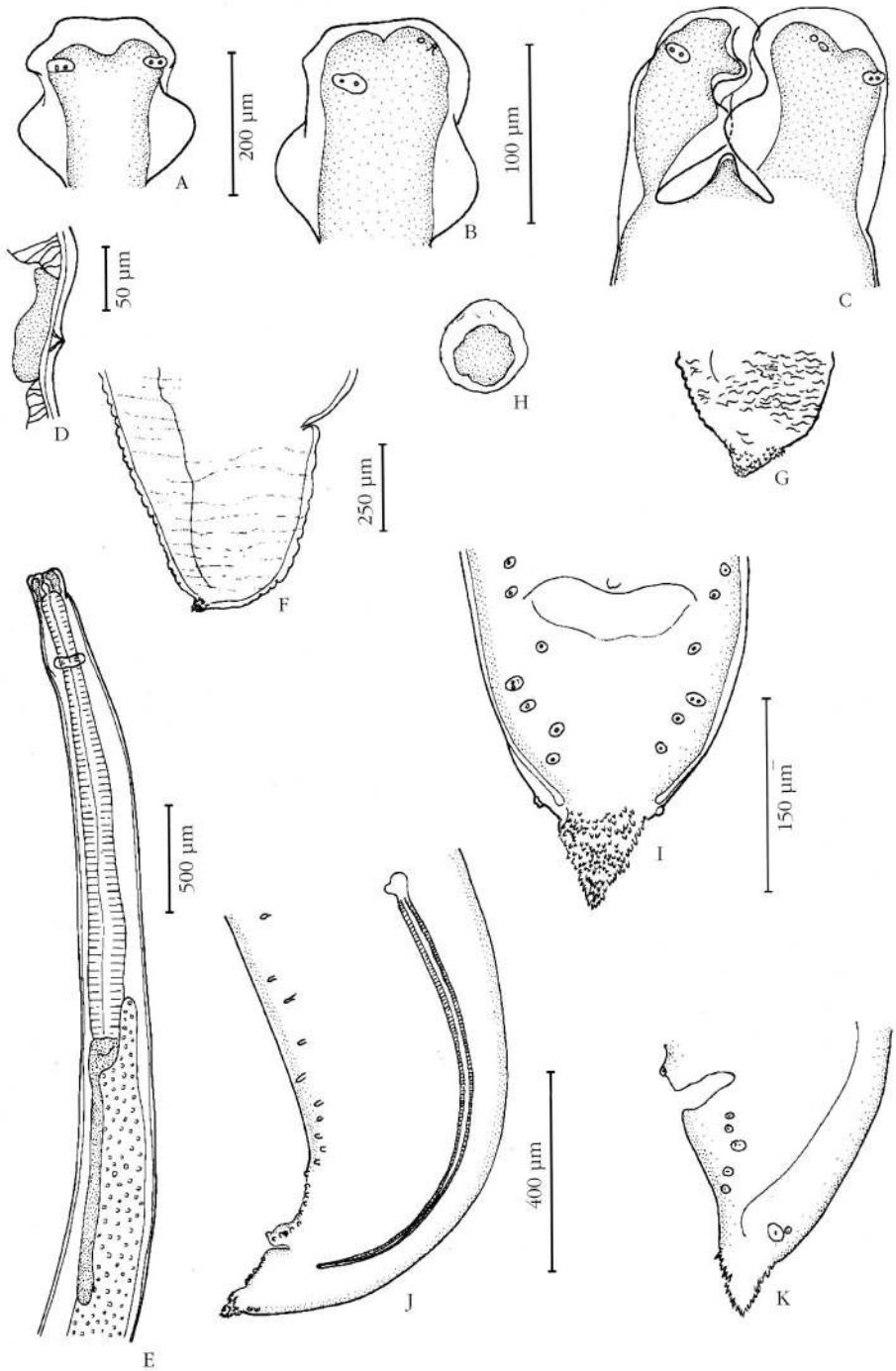

Fig. 7. – *Hysterothylacium reliquens* (Norris and Overstreet, 1975). A, dorsal lip; B, latero-ventral lip; C, anterior end, lateral view; D, cross-section of lateral ala at level of the anterior part of oesophagus; E, male, anterior part, lateral view; F,G, female, posterior ends; H, egg; I, male, posterior end, ventral view; J, male, posterior part, lateral view ; K, male, posterior end, lateral view. Scale lines (µm) : A,C,G, 200; D, 50; B,H,J : 100; E, 500; F, 250; J, 400; K, 150.

reported from a Sparidae (*Archosargus probatocephalus*) (type-host) and other hosts in the Gulf of Mexico, Western North Atlantic and Pacific, but is recorded for the first time from Eastern North Atlantic.

HYSTEROTHYLACIUM CORNUTUM

(Stossich, 1904)

Material : several ♂ and ♀ n° MNHN 568 HD and 455 BB, Concarneau, 1931-1937, 1947; collection R.Ph. Dollfus. 1 ♂ and 1 ♀ n° MNHN 517 Q, Le Croisic, 10-8-1968; collected by A.J. Petter. Host : *Thunnus* (*Germo*) *alalunga* (Scombridae).

A part of the material from Concarneau was described by Dollfus, as *Thynnascaris legendrei* (n. gen. n. sp.), a species synonymised with *T. cornutum* by Berland (1961). Specimens from Le Croisic were studied by Petter (1969). The species is otherwise well known by the descriptions of Hartwich (1975), Deardorff and Overstreet (1982) and Bruce and Cannon (1989).

HYSTEROTHYLACIUM RIGIDUM (Rudolphi, 1809) Fig. 9H

Material : 6 ♂ and 5 ♀ , n° MNHN 704 BB and 540 BC, Concarneau, 1-2-1943 and 20-2-1946; collection R.Ph. Dollfus. 2 ♀ , 2 ♂ and 4 anterior extremities, n° MNHN 488 Q, 637 Q, 653 Q and 696 Q, Le Croisic, 22-7-1968, 11-7-1969 and 26-7-1969; collected by A.J. Petter. Host : *Lophius piscatorius* L., 1758 (Lophiidae).

A part of this material was studied by Petter (1969) and the species was well described by Hartwich (1975). Contrary to the observations of Petter (1969), the two components of the ventricular appendage appear unequal in cross-section in the anterior part of the appendage, as in *H. aduncum*; therefore, this character cannot be used to differentiate the cross-sections of the two species.

HYSTEROTHYLACIUM SP. Fig. 8

Material : 2 ♀, 1 mature and 1 juvenile ♂, n° MNHN 538 BC; host : *Callionymus lyra* L., 1758 (Callionymidae); La Rochelle (France); May 1941; collected by J. Cadenat.

DESCRIPTION

Body thinner anteriorly. In the females and the mature male, very thin (3-5 µm) lateral alae originate at 340-800 µm posterior from lips and disappear before the posterior end of oesophagus. In the juvenile male, they originate just posterior to lips, are wider at their beginning and extend all along body. In cross-section, alal sclerotized supports nearly flat. Dorsal lip slightly wider than long, latero-ventral lips longer than wide. Lips lacking posterior lobes. Labial flanges triangular. Interlabia about half length of lips. Labial pulp widening anteriorly; lobi rounded. Oesophagus 9.4-13.1 % of body length. Ratio oesophagus/ventricular appendage 2.6-3.2. Ratio oesophagus/intestinal caecum 2.7-3. Intestinal caecum slightly longer than ventriculus plus appendage in the biggest female, and slightly shorter in the other specimens. Excretory pore slightly posterior to nerve ring. Tail with spined conical mucronate extremity.

Male : spicules slightly unequal, 5-7% of body length. Preanal papillae 26-29 pairs, one large medioventral preanal papilla, postanal papillae eight pairs : five subventral with the fourth from cloaca doubled, one lateral and one small lateroventral (probably phasmids).

Female : vulva sligthly posterior to the anterior third of body. Thin shelled eggs 65/60 µm.

Measurements

Females : length 63, 42; oesophagus 6050, 3950; ventriculus : length 350, 250; width 325, 325; intestinal caecum 2250, 1350; ventricular appendage 1850, 1400; distance vulva-anterior extremity 22, 16; tail 400, 225.

Males : length 35, 16; oesophagus 3600, 2100; ventriculus : length 180,100; width 200,100; intestinal caecum 1200,725; ventricular appendage 1300, 800; tail 150,115; left spicule 2350, 750; right spicule 2420, not visible.

DISCUSSION

These specimens are close to *H. aduncum* by their measurements and morphology, but the mature specimens differ by having very thin lateral alae originating far behind lips and not extending beyond posterior end of oesophagus. By alae originating behind the lips, the specimens are similar to *H. auctum* according to the description of Hartwich (1975), a species synonymised with *H. aduncum* by Punt (1941). *H. auctum* was recorded from *Callionymus lyra* by Baylis (1939); however, in this latter species lateral alae extend all along the body and originate nearer the base of the lips (50 µm), and the number of postanal papillae is larger (eight pairs). Examination of more specimens from *Callionymus lyra* would be necessary to know if these differential characters are constant and so we prefer to designate the specimens as *Hysterothylacium* sp.

MARICOSTULA INCURVA (Rudolphi, 1819) Fig. 9G

Material : 1 ♂ n° MNHN 539 BC; host : *Xiphias gladius* L., 1758 (Xiphiidae); Hossegor (France); 5-10-1960 ; collection R.Ph. Dollfus.

This female corresponds to the description of *Hysterothylacium incurvum* given by Hartwich (1975). Bruce and Cannon (1989) placed this species in their new genus *Maricostula*. Lateral alae are pointed in

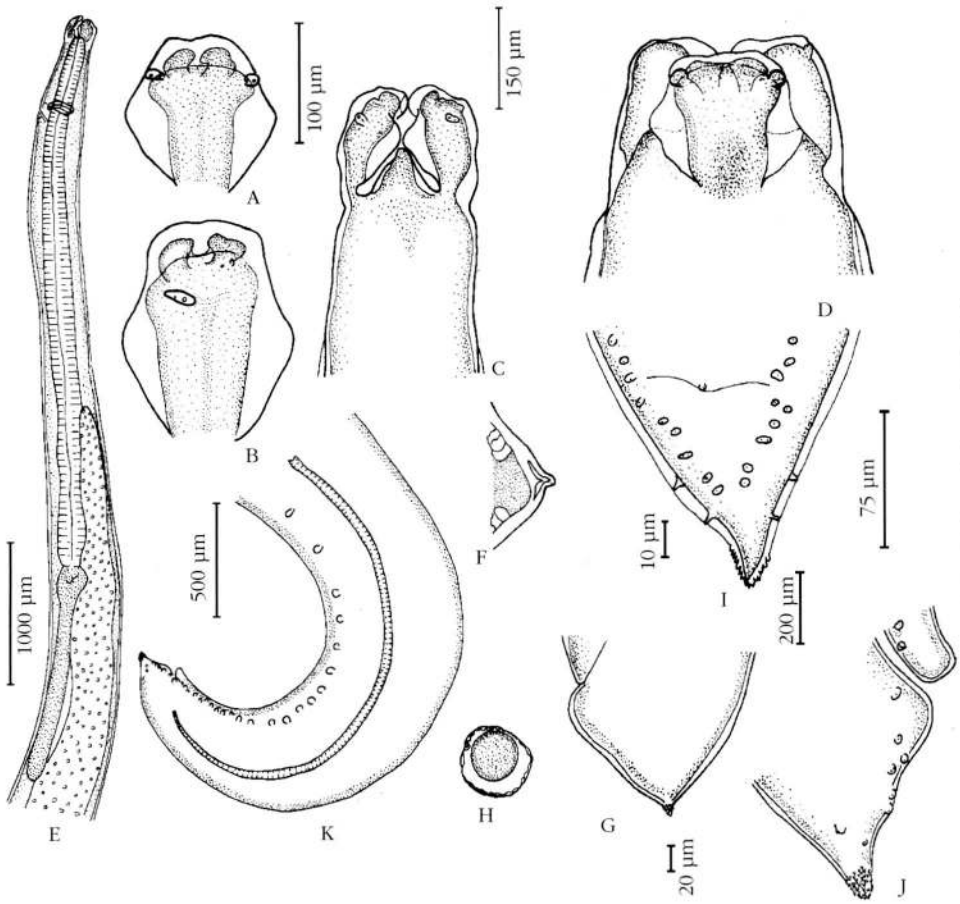

Fig. 8. – *Hysterothylacium* sp. A, female, dorsal lip; B, female, latero-ventral lip; C, female, anterior end, ventral view; D, juvenile male, anterior end, dorsal view; E, anterior part, lateral view; F, juvenile male, cross-section of lateral ala; G, female, posterior end; H, egg; I, male, posterior end, ventral view; J, male, posterior end, lateral view; K, male, posterior part, lateral view. Scale lines (µm) : A,B,J, 100; C, 150; D,I, 75; E, 1000; F, 10; G, 200; H, 20; K, 500.

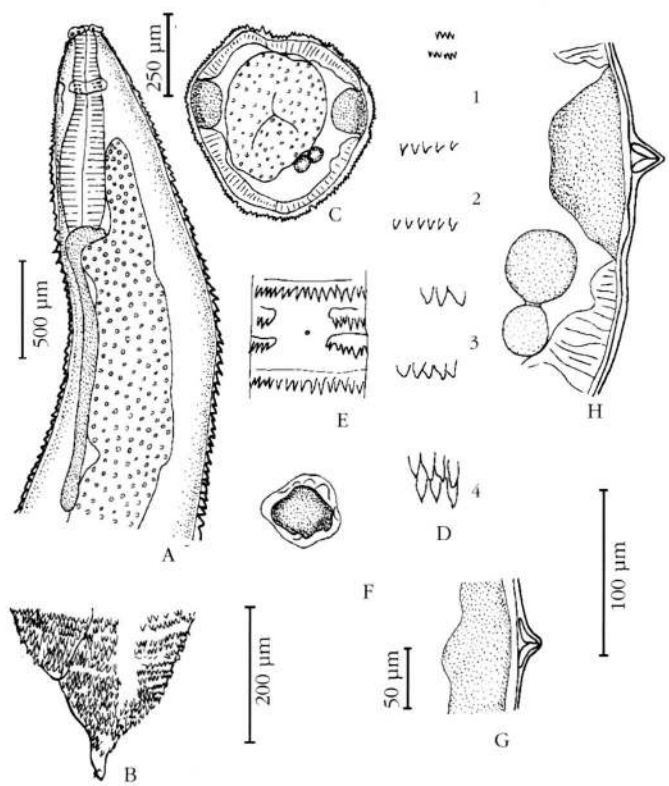

Fig. 9. – A - F, *Goezia* sp. A, anterior part, lateral view; B, posterior end, lateral view; C, cross-section at level of ventricular appendage; D, spines at different levels : 1, anterior part of oesophagus; 2, posterior part of oesophagus; 3, vulva ; 4, anus; E, deirid; F, egg; G, *Maricostula incurva* (Rud., 1819), cross-section of lateral ala; H, *Hysterothylacium rigidum* (Rud., 1809), cross-section of lateral ala. Scale lines (µm) : A, 500 ; B, 200 ; C, 250 ; D,E,F,H, 100 ; G, 50.

cross-section as in the specimens from Mediterranean Sea studied by Petter and Maillard (1987). Deardorff and Overstreet (1981) identified as *H. incurvum* specimens from Florida with lateral alae bifurcated at the tips. Their material was collected from two hosts : *Xiphias gladius* and *Tetrapterus albidus*. Bruce and Cannon (1989) reexamined material of Deardorff and Overstreet from *T. albidus* and observed that it is not conspecific with *M. incurva*, differing by characters of the male caudal extremity and by narrower cervical alae. Alae bifurcated at the tip should be another character differentiating these parasites from *M. incurva*.

GOEZIA SP. Fig. 9A-F

Material : 1 ♂, 10 ♀ n° MNHN 508 BC; host : *Trisopterus luscus* (L., 1758) (Gadidae); île d'Yeu (France); collected by J. Callot.

DESCRIPTION

Small nematodes with transverse rows of spines. Oesophagus short, small ventriculus wider than long (80/150 µm); ventricular appendage thin, double, 1.3-2 times length of oesophagus; intestinal caecum thick, variable in length (ratio intestinal caecum/oesophagus 1/6-1/2). Excretory pore slightly anterior to nerve ring. Deirids slightly posterior to nerve ring, surrounded by an area without spines. Tail short with a fingerlike terminal portion without spines, terminating in 5-6 small spikes. Transverse rows of spines begin just posterior to lips (70 µm) from anterior extremity; spaces between rows 10 µm in anterior part, 50 µm in middle part and 16-20 µm in posterior part; length of spines 3-6 µm in anterior part, 8-12 µm in middle part and 15-20 µm in anal region; about 160 spines per row in the middle part of body.

Male : spines lacking dorsally from caudal extremity up to 350 µm. Spicules subequal. Gubernaculum lacking. The single male specimen being damaged, the number and disposition of papillae could not be determined.

Female : rows of spines interrupted laterally in the anal region. Vulva generally slightly posterior to middle of body. Rounded, thin shelled eggs (40 µm in diameter).

DISCUSSION

As the most important characters differentiating the species in the genus *Goezia* [number and disposition of anal papillae, see Deardorff and Overstreet (1980)] were not studied, specific identification was not performed.

Two species of *Goezia* were described in eastern North Atlantic and seas of North of Europe : Stefanski (1938) described *G. sigalasi* from *Trachinus draco* in the Atlantic; this species differs from the specimens described above by having unequal spicules; Punt (1941) identified as *G. ascaroides* a female parasite of *Trachinus vipera* in the North Sea; this identification, based only on females, is doubtful, as *G. ascaroides* was originally described from a freshwater fish, *Silurus glanis*.

CONCLUSION

Key to the Ascarid species parasitizing Teleostean fishes from Eastern North Atlantic and Seas of the North of Europe :

1(6) Cuticule with transverse rows of spines

2(3) Male unknown ..... *Goezia* sp. (= *G. ascaroides* sensu Punt, 1941)

3(2) Male known

4(5) Spicules markedly unequal ..... *Goezia sigalasi* Stefanski, 1938

5(4) Spicules subequal ..... *Goezia* sp. Petter (present paper)

6(1) Cuticule without transverse rows of spines

7(8) Male tail ending in a long tapering spike, without spines. Four pairs of single postanal and one pair of doubled adanal papillae. Intestinal caecum more than 2/3 of oesophagus length. Lips with posterior lobes not extending as far as the posterior margins of interlabia. Parasites of *Xiphias gladius* ..... *Maricostula incurva* (Rud., 1819)

8(7) Male tail ending in a short spike with or without spines. More than four pairs of postanal papillae. Intestinal caecum less than 2/3 of oesophagus length

9(10) Lips with posterior lobes extending as far as the posterior margins of interlabia. Ventricular appendage longer than oesophagus. Parasites of *Lophius piscatorius* ..... *Hysterothylacium rigidum* (Rud.1809)

10(9) Lips lacking posterior lobes. Ventricular appendage shorter than oesophagus

11(12) 10 pairs or more than 10 pairs of postanal papillae. Caudal extremity lacking spines. Parasites of fishes belonging to the genus *Thunnus* ..... *Hysterothylacium cornutum* (Stossich,1904)

12(11) Less than 10 pairs of postanal papillae. Caudal extremity with spines. Host specificity not restricted to one genus or one species

13(14) Lips constricted at mid-length. Interlabia measuring less than 1/4 of lip length ..... *Hysterothylacium reliquens* (Norris and Overstreet, 1975)

14(13) Lips constricted at anterior third of lips. Interlabia measuring about half the lip length

15(18) Lateral alae originating far behind the base of lips

16(17) Lateral alae originating at about 50 µm from base of lips and extending all along body ..... *Hysterothylacium auctum* (Rud., 1802) (this species was synonymized with *H. aduncum* by Punt, 1941)

17(16) Lateral alae originating at more than 300 µm from base of lips and not extending beyond posterior end of oesophagus in mature worms.....
.....*Hysterothylacium* sp. Petter (present paper)

18(15) Lateral alae originating from base of lips .....
.....*Hysterothylacium aduncum* (Rud.,1802)

19(20) Cervical alae very wide. Ratio oesophagus/maximal width of cervical alae <54. Ratio ventricular appendage/maximal width of cervical alae<15 .....
.....*H. aduncum gadi* (O.F.Müller, 1776, species)

20(19) Cervical alae hardly wider than lateral alae. Ratio oesophagus/maximal width of cervical alae >54. Ratio ventricular appendage/maximal width of cervical alae>15 .....
.....*H. aduncum aduncum* (Rud., 1802, species)

These species have various geographical distributions. Three species or sub-species were recorded only in Eastern North Atlantic and seas of the North of Europe : *Hysterothylacium auctum*, *H. aduncum gadi* and *Goezia sigalasi*. *Hysterothylacium reliquens* is common to Eastern and Western Atlantic and Pacific. *H. rigidum* occurs like its host, *Lophius piscatorius*, in Mediterranean Sea and Eastern North Atlantic. The three other species have a widespread geographical distribution, two of them, *Maricostula incurva* and *Hysterothylacium cornutum* parasitizing only one genus or one host species, while the third one, *H. aduncum aduncum* was found in fishes of different orders.

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