Nematol. medit. (1990), *18*: 179-188.

Departamento de Biologia Animal, Ecologia y Genética, Facultad de Ciencias – 18071 Granada, Spain

FIRST RECORD OF NEMATODE SPECIES IN CONTINENTAL WATER FROM SPAIN: TAXONOMIC AND ECOLOGICAL CONSIDERATIONS

by
A. OCAÑA, J. PICAZO and F. JIMENEZ-MILLAN

Summary. In samples collected in 1983/84 from 38 mineral- medicinal springs located throughout the province of Granada, and in 1985/86 from the Monachil River, Granada (Spain), twelve nematode species not previously recorded from Spain, and nine species not previously recorded from continental aquatic environments in Spain were studied. The most significant anatomical-morphological features and taxonomical characteristics of the species are illustrated and their occurrence related to the physico-chemical ecological components of the aquatic environment in which they were collected.

Springs are a continental aquatic environment characterised by a series of features which makes them unique from a hydrological point of view. In most instances springs are high in minerals and have a highly variable ionic composition which differs markedly from other natural aquatic habitats. Furthermore, they tend to be unpolluted environments and can thus serve as a point of reference when considering other aquatic habitats which are polluted to a greater or lesser extent.

The Monachil river (province of Granada, Spain) is reported (Ropero, 1984) to be the most highly variable and have the lowest-grade water quality when compared to the other rivers originating in the Sierra Nevada Mountains. It has, however, a richness and abundance of nematode species.

The contrasting characteristics of the two abovementioned habitats prompted the present study on the nematode fauna in springs throughout the Granada province and in the Monachil river. It should prove to be of special interest as very few studies on nematodes from continental aquatic habitats have been published in Spain. We can cite only those by Gadea (1950, 1952, 1953, 1954, 1955, 1957, 1961, 1962, 1963a, 1963b and 1973); Jiménez Guirado and Cadenas (1985), and Jiménez Guirado (1988).

Area of study

Figure 1 illustrates the location of the 38 springs studied as well as the Monachil river basin. The springs studied are located in the Alpujarra Mountain area, in the northern part of the province of Granada and in an area near to the city of Granada. The Monachil river, originating on the northwestern slope of the Sierra Nevada Mountains at 2975 m above sea level, travels along a 26 km course and joins with the Genil river at 650 m above sea level. Eight samples sites were established along the course of the Monachil at areas where the river was subject to organic pollution.

Materials and method

Samples collected from each of the different spring sites and from the different sites along the Monachil river were taken from submerged clay, mud and sand sediments not exposed to a current flow greater than 0.8 m/s. Sediment samples (200-250 cc) were collected with a simple hand shovel.

In order to determine the chemical nature of the spring waters the principal ions were determined: anions (carbonates, bicarbonates, sulphates and chlorides), cations (calcium, magnesium, potasium, sodium and iron), oxygen concentration, conductivity, and routinely, temperature and pH.

Temperature, pH and oxygen concentration were also routinely measured in the Monachil river, waters classified as calcium bicarbonated by Ropero (1984).

Nematodes were extracted in the laboratory, by a modified Baermann method (Hooper, 1986), fixed in 4% acetic formaldehyde and mounted in anhydrous glycerine following Seinhorst's (1962) modified method.

Results and discussion

With data obtained from chemical water analysis, each of the springs was classified according to Shchukarev's classification (Saura, 1978), based on those ions making up

more than 25% of the total anion or cation content. These results (commented on in the description and discussion of the species), together with the values obtained for conductivity, total number of anions and cations, pH, temperature and dissolved oxygen concentration (as shown in Table I), should facilitate the determination of specific ecological aspects of the nematode species.

Twelve species recorded for the first time from Spain (1-12) and nine species recorded for the first time from continental aquatic habitats in Spain (A-I) were the result of the taxonomic study of the nematode fauna found in 286 samples collected from the springs and from 48 samples collected from the Monachil river. These species and their absolute, maximum and minimum values of abundancy are listed in Table II. We have also included a description-discussion on the most relevant taxonomical and ecological data for each of these species belonging to orders *Monhysterida, Araeolaimida, Chromadorida* and *Enoplida*.

Description and Discussion of Species

MONHYSTERIDA De Coninck *et* Schuurmans Stekhoven, 1933

1. *Eumonhystera andrassyi* (Biró, 1969) Andrássy, 1981 (Fig. 2).

Females: (n = 72); L = 0.62 mm (0.44-0.72); a = 25.3 (22.7-29.5); b = 6.2 (5.2-6.7); c = 4.6 (3.8-5.6); c' = 8.5 (7.1-10.6); V = 61.9% (58.8-65.7).

Males: (n = 30); L = 0.67 mm (0.56-0.77); a = 27.8 (26.7-31.5); b = 6.3 (5.3-6.8); c = 5.9 (5.1-6.8); c' = 5.6 (5.1-6.9); SP = 36.4 µm (31-42).

Somatic setae of considerable length, 2.9-3.3 µm. Head width 8.0-8.5 µm. Cephalic setae 2.0-2.2 µm long, i.e., 1/4 the head width. Amphids somewhat wider than 1/4 body

TABLE I - *Maximum, minimum and average conductivity values (µS/cm. total anions and cations (mg/l), pH, temperature (°C) and oxygen concentration (mg/l), for each of the species studied.*

Species	*Conductivity* (µS/cm)				*Anions* (mg/l)				*ations* (mg/l)				*pH*								0_2 (mg/l)			
	Max	min			Max	min		e.e.	Max	min		.e.	Max	min	x	e.e.	Max	min	x	e.e.	Max	min	x	e.e.
Eumonhystera andrassyi	2918	365	1201.9	153.7	1160	244	523.4	53.0	619	123	302.2	33.4	8.4	7.1	7.6	0.1	30.8	12.8	18.9	1.0	12.6	0.0	5.9	0.8
Eumonhystera longicaudatula	930	255	592.5	337.5	485	222	353.5	131.5	280	69	174.5	105.5	8.4	7.1	7.8	0.2	20.6	6.0	11.9	1.8	11.3	5.3	9.3	0.9
Eumonhystera pseudobulbosa	6110	255	1170.5	505.2	2875	220	618.1	231.1	2128	69	368.8	177.3	8.1	5.3	7.2	0.3	38.0	10.2	18.8	2.2	10.9	0.0	5.3	1.1
Eumonhystera similis	574	255	414.5	159.5	315	221	268.0	47.0	123	115	119.0	4.0	8.1	7.3	7.7	0.4	24.3	10.2	17.3	7.1	10.8	1.5	6.2	4.7
Monhystrella macrura	757	574	665.5	91.5	400	315	357.5	42.5	203	123	163.0	40.0	7.3	7.3	7.3	0.0	24.3	19.9	22.1	2.2	6.3	1.5	3.9	2.4
Monhystrella hastata	3192	255	1306.4	172.2	1485	220	539.7	61.1	820	69	314.5	39.2	8.2	5.3	7.4	0.1	42.8	11.3	22.7	1.8	12.6	0.0	5.0	0.7
Plectus exinocaudatus	–	–	–	–	–	–	–	–	–	–	–	–	8.3	7.5	8.0	0.3	12.4	7.7	10.0	1.4	10.8	9.6	10.4	0.4
Plectus geophilus	3192	319	1359.1	291.0	1485	220	557.8	96.4	915	148	355.4	76.8	8.2	5.3	7.2	0.2	39.8	13.0	21.1	2.2	10.9	0.0	4.1	1.1
Plectus opisthocirculus	–	–	–	–	–	–	–	–	–	–	–	–	8.4	7.1	8.0	0.2	13.8	6.0	10.5	1.1	11.3	9.6	10.5	0.2
Paraplectonema pedunculatum	1167	757	957.3	118.4	555	400	491.7	47.0	303	203	265.7	31.5	7.7	7.3	7.5	0.1	21.4	18.7	20.0	0.8	6.3	6.2	6.3	0.0
Prodesmodora circulata	3192	757	1370.8	277.9	1065	400	615.1	80.7	674	203	342.4	55.1	7.7	7.2	7.4	0.1	23.9	13.0	19.1	1.4	8.7	0.7	5.1	0.9
Ethmolaimus pratensis	930	255	592.5	337.5	485	222	353.5	131.5	280	69	174.5	105.5	7.6	7.1	7.4	0.2	20.6	6.0	12.6	4.3	11.3	5.3	7.6	1.9
Achromodora terricola	1167	1167	1167.0	0.0	555	555	555.0	0.0	303	303	303.0	0.0	8.2	7.1	7.7	0.3	18.7	6.0	11.5	3.8	11.3	6.3	9.5	1.6
Paracyatholaimus intermedius	8208	948	3395.7	1234.5	3950	490	1589.2	599.0	3516	255	1183.0	549.4	8.0	7.1	7.5	0.1	38.0	16.1	24.7	3.5	7.4	0.7	4.8	1.0
Odontolaimus aquaticus	8208	255	2658.3	1861.1	3950	222	1305.3	884.5	3516	69	1051.3	823.6	8.2	7.2	7.6	0.2	25.7	9.9	18.5	3.3	10.8	4.2	7.0	1.1
Odontolaimus chlorurus	1222	255	840.0	224.9	529	222	389.8	66.4	329	69	200.0	57.3	8.4	7.3	7.9	0.2	39.8	11.3	21.1	4.4	10.4	2.4	7.0	1.3
Ironus tenuicaudatus	3192	930	1444.4	438.9	870	475	581.0	73.6	674	271	363.8	77.7	7.7	7.2	7.5	0.1	23.9	13.0	19.5	1.8	6.3	4.2	5.6	0.4
Prismatolaimus intermedius	6110	137	1226.7	372.2	2875	109	589.5	169.1	2128	69	342.6	130.0	8.4	4.9	7.4	0.2	38.0	6.0	19.1	1.8	11.3	0.0	6.0	0.9
Trischistoma monohystera	2280	365	1062.8	166.7	635	268	482.3	34.5	434	133	271.3	27.2	8.2	7.2	7.6	0.1	30.8	9.9	19.0	1.9	12.6	1.8	7.0	1.0
Tobrilus grandipapillatus	–	–	–	–	–	–	–	–	–	–	–	–	8.4	7.1	8.0	0.2	17.0	6.0	11.3	1.2	11.3	6.5	10.0	0.5
Udonchus tenuicaudatus	8208	574	3162.3	849.4	3950	315	1231.0	426.9	3516	123	986.1	375.9	7.8	7.1	7.4	0.1	42.8	15.7	28.7	2.7	8.7	1.5	5.3	0.8

diameter at the same level, located 1.7-1.8 times head diameter, behind anterior body end. Body diameter at cardia level 2.0-2.2 times the head width. Male spicule length approximately 5 times spicule width. Female tail 115-160 µm long. Male tail 105-120 µm long. Tail length/vulva-anus distance 1.5-1.6. Rectum about equal with anal body diameter.

The poor original description of *Eumonhystera filiformis* (Bastian, 1865) Andrássy 1981, a species taxonomically related to *E. andrassyi*, and the relatively recent description of the latter (Biró, 1969) may have contributed to the confusion of the two on several occasions. In the present study we obtained abundant material of both species and therefore have described several essential features based on our study of individual adult females (Table III) which should facilitate the identification of the two species.

E. andrassyi has previously been recorded from only three localities: the Balaton Lake (Biró, 1969), the Tiber river in Italy (Zullini, 1982) and Hungary (Andrássy, 1973). This species was found in 20 springs, sometimes in large numbers, and regularly encountered in the Monachil river (Sites 5 and 6).

Our data show that this species may be found in aquatic environments with varying conductivity, pH, temperature and oxygen concentration values. Nevertheless, in those springs in which the species was found in greatest abundance, sulphates and bicarbonates were constant and comprised more than 25% of the total anions. In those springs in which the species was rare, chloride ions constituted more than 25% of the total anions.

TABLE II - *Absolute, maximum and minimum abundance values; presence index for each of the species studied.*

Species	Σ	Max	min	I.P. (%
Eumonhystera andrassyi	798	214	1	53.84
Eumonhystera longicaudatula	89	72	3	7.69
Eumonhystera pseudobulbosa	106	35	1	28.21
Eumonhystera similis	2	1	1	5.13
Monhystrella macrura	17	15	2	5.13
Monhystrella hastata	712	188	1	58.97
Plectus exinocaudatus	21	21	21	2.56
Plectus geophilus	94	27	2	30.77
Plectus opisthocirculus	483	483	483	2.56
Paraplectonema pedunculatum	26	14	3	7.69
Prodesmodora circulata	245	221	1	20.51
Ethmolaimus pratensis	13	9	2	7.69
Achromodora terricola	12	9	3	5.13
Paracyatholaimus intermedius	579	525	1	15.38
Odontolaimus aquaticus	123	110	1	12.82
Odontolaimus chlorurus	770	754	1	12.82
Ironus tenuicaudatus	69	30	1	12.82
Prismatolaimus intermedius	106	26	1	41.02
Trischistoma monohystera	142	57	1	28.20
Tobrilus grandipapillatus	1218	1218	1218	2.56
Udonchus tenuicaudatus	43	23	1	23.77

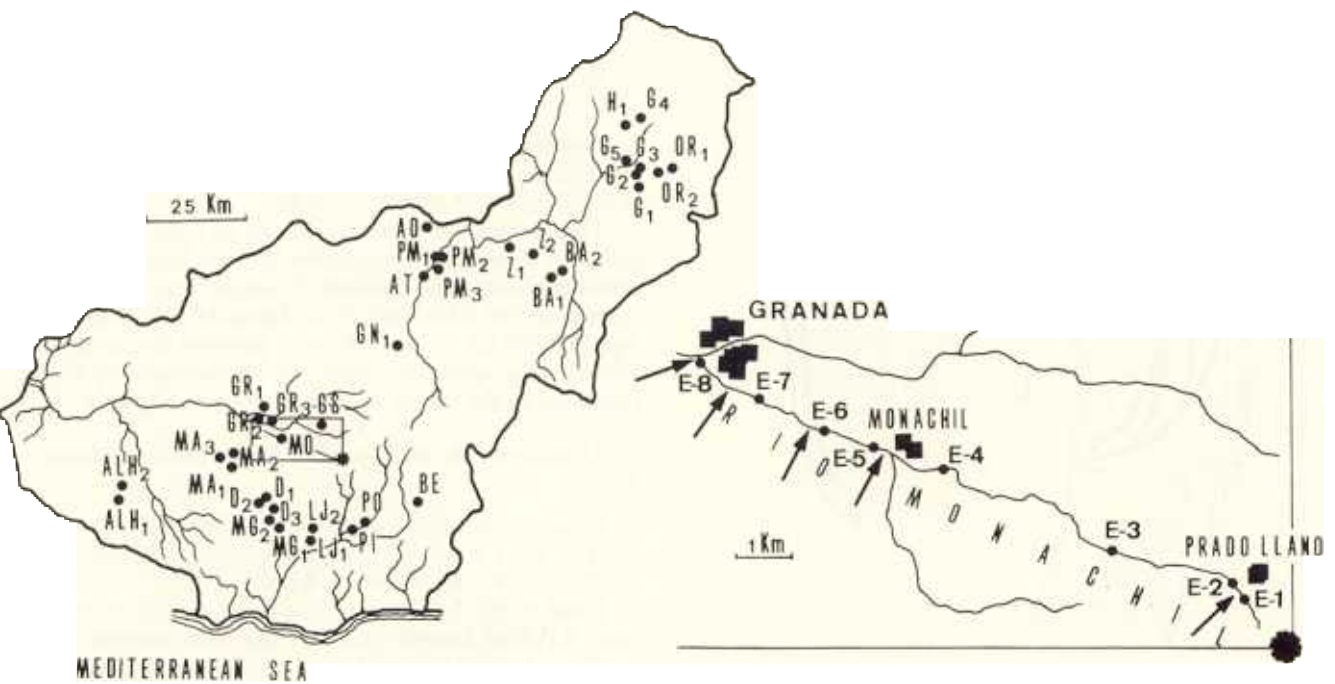

Fig. 1 - Map of the province of Granada indicating location of the 38 springs studied, and the 8 sites sampled on the Monachil river.

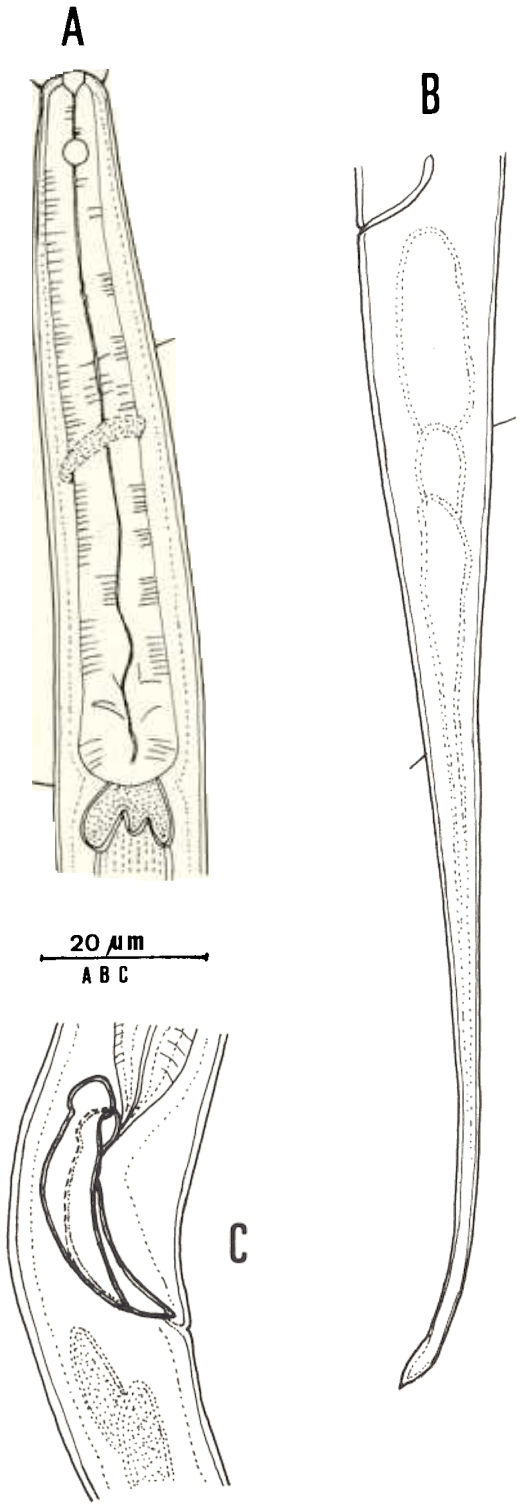

Fig. 2 - *Eumonhystera andrassyi*. A: detail of the esophageal region. B: tail. C: detail of male spicules.

2. *Eumonhystera longicaudatula* (Gerlach *et* Riemann, 1973), Andrássy, 1981.

Females: (n = 28); L = 0.57 mm (0.41-0.80); a = 35.3 (30.2-42.8); b = 4.4 (3.1-5.1); c = 3.7 (2.9-4.4); c' = 14.7 (10.5-19.6); V = 58.1% (52.0-65.0).

Head width 8.2-8.6 µm. Cephalic setae 3.5-4.0 µm long. Amphid diameter 2.4-2.5 µm, i.e., 1/4 of body diameter at the same level, located 1.4-1.6 head diameter from anterior body end. Body diameter at cardia level, 1.7-1.9 head diameter. Tail 170-181 µm long. Distance vulva-anus 1/2 tail length. Rectum as long as anal diameter.

E. longicaudatula was found in two of the springs sampled (OR1, GJ). Both are classified as calcium bicarbonated, with sediment consisting mainly of small particles (90% mud and clay sediment). This species was also encountered in the Monachil river, particularly in the first three sites. Conductivity, anion and cation concentration, temperature and oxygen concentration values were found to be relatively variable (Table I), with pH ranging between 7.1 and 8.4.

A. *Eumonhystera pseudobulbosa* (Daday, 1896) Andrássy, 1981.

Females: (n = 19); L = 0.42 mm (0.30-0.55); a = 30.7 (26.2-40.2); b = 4.9 (4.1-5.9); c = 4.0 (3.4-4.7); c' = 11.5 (9.1-15.6); V = 59.5% (52.5-63.3).

This species was previously found by Gadea (1964) in soil with moss and lichen in the Pitiusas Islands. In Granada, *E. pseudobulbosa* was found in 11 springs, but its presence could not be associated with any common physicochemical characteristics.

B. *Eumonhystera similis* (Bütschli, 1873) Andrássy, 1981.

Females: (n = 2); L = 0.34 mm (0.32-0.36); a = 21.8 (21.1-22.6); b = 5.4 (4.9-5.9); c = 3.5 (3.5-3.6); c' = 10.0 (9.7-10.3); V = 53.4% (51.5-55.4).

This species was previously found by Gadea (1964) in soil with moss and lichen in the Pitiusas Islands. In the province of Granada, however, *E. similis* is scarcely represented and was found only in the Monachil (MO) and Melegís #2 (MG2) springs. The only common characteristic found in both springs was relatively low conductivity when compared to the overall average of the other springs.

3. *Monhystrella macrura* (De Man, 1880) Andrássy, 1981.

Females: (n = 4); L = 0.6 mm (0.59-0.61); a = 39.5 (37.1-41.8); b = 5.2 (4.8-5.6); c = 3.6 (3.3-3.8); c' = 17.4 (17.0-17.7); V = 46.9% (46.2- 47.6).

Head width 5.7-5.8 µm. Cephalic setae 0.8-0.9 µm long. Amphids located 11.2-11.5 µm from anterior end, twice head width behind anterior body end. Amphids diameter 2.3-2.4 µm, i.e., 30% body diameter at same level. Body diameter at cardia level twice head width. Tail 149-

152 μm long. Rectum 1.2 times anal body diameter. Spinneret 10.5-10.6 μm long.

This species was found only in the Galera #1 (G1) and Melegís #2 (MG2) springs, and in greater abundance in MG2. The most outstanding physical-chemical characteristic encountered in these latter springs was medium salinity (574-575 μS/cm), variable oxygen concentration values (1.5-6.3 mg/l) and temperature values ranging between 19.9 and 24.3°C (thermal water, i.e. temperature equal or greater than 19°C).

4. *Monhystrella hastata*, Andrássy, 1968.

Females: (n = 35); L = 0.04 mm (0.31-0.47); a = 30.2 (21.1-36.0); b = 5.9 (4.8-6.4); c = 3.3 (2.4-3.9); c' = 14.3 (10.5-16.5); V = 45.7% (41-53).

Head width 4.1-4.3 μm. Cephalic setae 1.2-1.3 μm long, about 1/3 head width. Amphids diameter 2.2-2.3 μm, 1/3-1/4 body diameter at same level, located at 10.5-10.7 μm from anterior body end, 2.8 times head width. Body diameter at cardia level 2.8-3.0 times head width. Tail 103-119 μm long. Rectum 1/2-1/3 times anal body diameter. Spinneret 5.0-11.5 μm long.

This species was found in 23 of the springs sampled. It was found in greatest abundance in thermal springs (average temperature of 24.1°C) which had the highest conductivity values (average 1275 μS/cm) recorded. On several occasions, the species appears in substrates in which the *Chara* genus predominates, as has previously been recorded by Juget (1969).

ARAEOLAIMIDA, De Coninck *et* Schuurmans Stekhoven, 1933

5. *Plectus exinocaudatus* Truskova, 1976 (Fig. 3).

Females: (n = 3); L = 0.38 mm (0.35-0.40); a = 24.7 (22.6-26.6); b = 3.7 (3.5-3.8); c = 6.1 (5.9-6.2); c' = 8.5 (8.3-8.6); V = 48.9% (47.7- 49.7).

Head width 4.7-5.1 μm. Cephalic setae 2.3-2.5 μm long, 1/2 the corresponding body diameter. Stoma 2.8 times head width. Amphids 1/4 body diameter at same level, posterior to the middle of stoma, at 8.6-9.5 μm from anterior body end. Body diameter at cardia level, 2.3 times head width. Lateral fields 1/4 of body diameter at mid-level with two longitudinal bands. Vulva-anus distance 2.1-2.3 times tail length. Tail 59-65 μm long. Rectum 1.3-1.5 times anal body diameter.

Our specimens had a somewhat shorter tail than those described by Andrássy (1985) and by Coomans *et al.* (1985), although tail length does coincide with that recorded for the holotype (Truskova, 1976). With regard to the latter, our material, as was the case with Andrássy (1985) and Coomans *et al.* (1985), has a more posteriorly situated vulva and smaller amphids.

To date, this species has been recorded only in the Soviet Union, Hungary and the Salomon Islands. In the Monachil river, the species was encountered at Sites 2, 3 and 6, with pH 7.5-8.3, temperature 7.7-12.4°C and oxygen concentration 9.6-10.8 mg/l.

6. *Plectus geophilus* De Man, 1880.

Females: (n = 15); L = 0.51 mm (0.42-0.65); a = 32.4 (27.8-35.4); b = 3.9 (3.6-4.8); c = 9.4 (7.7-12.8); c' = 5.3 (4.2-6.1); V = 52.3% (49.9-53.9).

Head width 6.0-6.5 μm. Cephalic setae 1.6-2.0 μm long. Stoma 2.0-2.2 times head diameter. Amphids 2.0-2.2 μm wide, located 6.2-7.0 μm from anterior body end. Body diameter at cardia level 2.7-2.9 times head width. Lateral fields 1/6 body diameter at mid-level, with two longitudinal bands. Tail 40-60 μm long. Vulva-anus distance 3.5-3.7 times longer than tail. Rectum approximately equal to anal body diameter.

This species was found in 12 springs. Ionic concentration varied considerably in each spring although the majority are classified as calcium bicarbonated with an elevated sulphate content. Oxygen concentration, pH and temperature values also varied. Most of the springs in

TABLE III - *Morphometric data for* Eumonhystera filiformis *and* E. andrassyi *from Granada springs.*

	E. filiformis	*E. andrassyi*
Somatic setae length (μm)	2.0 – 2.2	2.9 – 3.3
Head width/cephalic setae length	1/3	1/4
De Man a index	25.8 – 39.8	20.8 – 29.5
Body width at cardia level/head width	1.8 – 1.9	2.0 – 2.2
Amphid-anterior end distance/head width	1.7 – 2.2	1.7 – 1.8
Tail length (μm)	150 – 170	115 – 160
Tail length/vulva-anus distance	1.7 – 1.8	1.5 – 1.6
Egg size (μm)	44.3 – 47.2 × 18.3 – 19.7 (egg more elliptic)	44.7 – 50.3 × 22.3 – 24.2 (egg more round)

which this species was found were thermal water (i.e. temperature ⩾ 19°C.)

C. *Plectus opisthocirculus* Andrássy, 1952

Females: (n = 20); L = 0.56 mm (0.45-0.68); a = 23.7 (20.5-28.9); b = 4.0 (3.3-4.6); c = 8.5 (7.8-9.2); c' = 4.6 (4.0-5.8); V = 50.3% (49.0- 53.2).

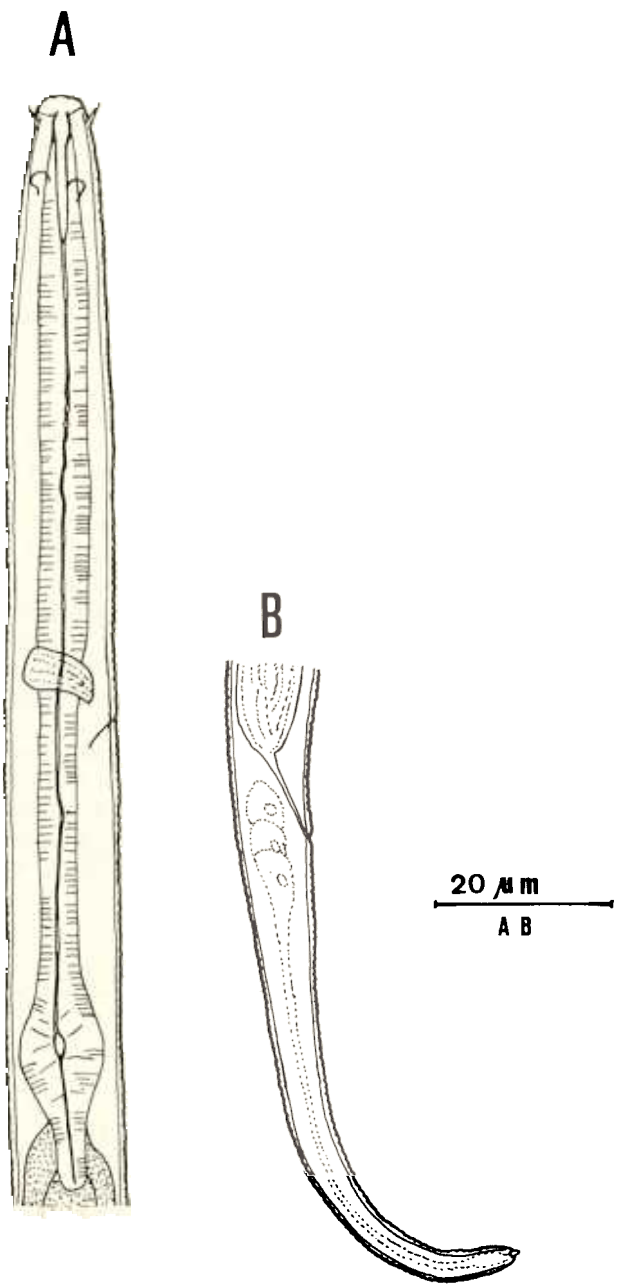

Fig. 3 - *Plectus exinocaudatus*. A: detail of the esophageal region. B: tail.

This species was previously recorded by Mateo and Campoy (1983) from beech groves and grass meadows in the Peñas de Echauri (province of Navarre), and by Monreal and Campoy (1982) from soil samples collected from different biotopes in the Macizo de Quinto Real (Western Pyrenees, province of Navarre).

P. opisthocirculus was encountered throughout the year in the Monachil river and was abundant at all of the sites sampled, with the exception of Site 8. The species was particularly abundant at Sites 2, 3 and 5 with pH values between 7.1 and 8.4, temperature values 6.0-13.8°C and oxygen concentration 9.6-11.3 mg/l.

7. *Paraplectonema pedunculatum* (Höfmanner, 1913) Straud, 1934.

Females: (n = 3); L = 1.11 mm (1.07-1.15); a = 31.7 (29.8-33.7); b = 7.5 (7.0-7.9); c = 5.7 (5.4-6.1); c' = 9.8 (8.4-11.0); V = 44.8% (44.4-45.0).

Head width 10.7-11.0 µm. Cephalic setae 3.0-3.2 µm long. Amphids 4.0-4.5 µm wide, located at 2.0-2.2 µm from the anterior body end. Stoma 36-38 µm long. Cardia 10.0-10.2 µm long. Short vagina. Tail 175-208 µm long, with a claviform end. Rectum as long as anal diameter.

P. pedunculatum was recorded only from 3 springs located in the same geographic area and sharing common physico-chemical characteristics. Bicarbonate, calcium and sulphate ions were dominant, and all springs had high salinity values (average 957 µS/cm). Temperature ranged from 18.7-21.4°C, pH 7.3-7.7 and oxygen concentration 6.2-6.3 mg/l.

CHROMADORIDA Chitwood, 1933

8. *Prodesmodora circulata* (Micoletzky, 1913) Micoletzky, 1925.

Females: (n = 8); L = 1.05 mm (0.69-1.07); a = 28.1 (25.8-33.5); b = 6.7 (6.3-7.3); c = 6.7 (6.1-7.7); c' = 7.2 (6.0-8.3); V = 43.1% (39.2- 45.2).

Head width 15.9-17.4 µm. Cephalic setae 3.0-3.5 µm long. Amphids circular, 3.6-3.8 µm wide, somewhat wider than 1/4-1/5 body diameter at the same level, located about one head width behind the anterior body end. Stoma 10.5-10.7 µm long. Basal bulb 1/5 total oesophagus length. Body cavity with abundant elongated crystalloids. Tail 95-115 µm long. Rectum about equal to anal body diameter.

P. circulata was found in 8 of the springs sampled. With the exception of Granada #1 (GR1) spring, sulphate and chlorine ions comprised over 25% of the total number of anions, conductivity was high (757-3192 µS/cm), temperatures ranged from 13.0-23.9°C, pH 7.2-7.7 and oxygen concentration values were highly variable.

D. *Ethmolaimus pratensis* De Man, 1880.

Females: (n = 6); L = 0.59 mm (0.54-0.70); a = 22.9 (20.9-24.1); b = 5.2 (4.8-5.6); c = 6.4 (5.8-8.4); c' = 5.9 (4.3-7.8); V = 52.2% (50.2- 57.6).

This species was recorded by Gadea (1950) from calcareous terrain with abundant humus in Barcelona, from a beech grove with siliceous soil in the province of León (Gadea, 1953) and from moss in the central region of the Catalonian Pyrenees (Gadea, 1982).

E. pratensis was found in the Güejar Sierra (GJ) and Orce #1 (OR1) springs, and in the Monachil river, all classified as calcium biocarbonates which was the only common physico-chemical characteristic.

E. *Achromodora terricola* (De Man, 1880) Micoletzky, 1925.

Females: (n = 3); L = 0.82 mm (0.78-0.83); a = 23.3 (22.3-23.9); b = 6.0 (5.9-6.1); c = 6.9 (6.9-7.0); c' = 5.5 (4.9-5.9): V = 45.9% (46.4- 49.0).

A. terricola was previously recorded by Monreal and Campoy (1982) from a beech grove and from moss areas in the Macizo Central de Quinto Real (Western Pyrenees, province of Navarre).

A total of 3 individuals were found in the Galera #2 (G2) spring. In the Monachil river, the species was found at Site 1 (pH 6.8 and 8.2, temperature 3.8-10°C and oxygen concentration between 9.3-13 mg/1).

The fact that this species was found in habitats with widely differing physico-chemical characteristics confirms its already recognized cosmopolitan character (Zullini, 1982).

F. *Paracyatholaimus intermedius* (De Man, 1880) Micoletzky, 1922.

Females: (n = 9); L = 0.84 mm (0.74-1.27); a = 28.2 (21.4-41.4); b = 6.8 (6.2-7.8); c = 10.3 (8.4-11.7); c' = 4.0 (3.1-4.6); V = 52.0% (49.5-54.0).

Males: (n = 2); L = 1.63 mm (1.53-1.72); a = 46.6 (45.9-47.2); b = 8.1 (8.0-8.2); c = 9.3 (8.2-10.3); c' = 5.5 (4.2-6.8); SP = 31.1 µm (31.0- 31.2).

P. intermedius was previously recorded by Santos (1986) in soil and epiphytic moss samples from the provinces of Cadiz and Seville. It was found in 6 of the springs sampled and was particularly abundant in Zújar #1 (Z1). The springs had high conductivity values (average 3396 µS/cm) and sulphate and chloride ions comprised more than 25% of the total number of anions.

ENOPLIDA (Filipjev, 1929) Schneider, 1937

9. *Odontolaimus aquaticus* (Filipjev, 1929) Schneider, 1937. (Fig. 4)

Females: (n = 4); L = 0.81 mm (0.77-0.85); a = 45.7 (34.4-55.0); b = 6.2 (5.9-6.8); c = 2.9 (2.5-3.1); c' = 26.6 (24.0-31.0); V = 36.3% (33.5-38.7).

Head width 6.3-7.4 µm. Cephalic setae 10 in number; four long setae (6.2-6.5 µm long) and six shorter setae (3.3-4.1 µm). Amphids 1/3 body diameter at the same level, located 1.7-2.0 times head width behind anterior body end. Stoma 27.8-29.3 µm long, 3.9-4.5 times head width. Body diameter at posterior end of oesophagus 2.0-2.2 times head width. Tail 268-305 µm long. Caudal setae, 3.0-3.3 µm long. Rectum length 0.8-0.9 times anal body diameter.

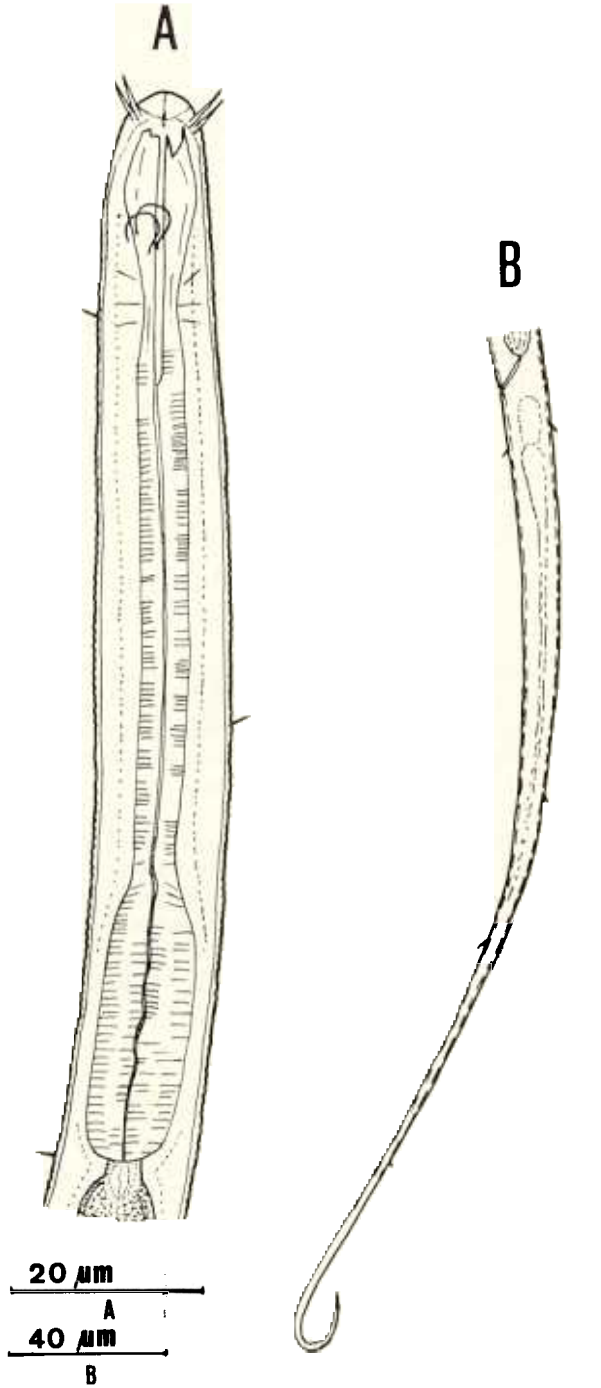

Fig. 4 - *Odontolaimus aquaticus*. A: detail of the oesophageal region. B: tail.

O. aquaticus has been recorded from Argentina, Paraguay, Indonesia (Sumatra) and Italy (Sardinia) by Andrássy (1963; 1968), Schneider (1937) and Zullini (1982) respectively. It was found in 4 springs and was particularly abundant in Güejar Sierra (GJ) spring. Only one individual was found in the Monachil river at Site 4. Ionic composition, conductivity, temperature, pH and oxygen concentration values at these sites were variable.

G. *Odontolaimus chlorurus* De Man, 1880.

Females: (n = 7); L = 0.80 mm (0.58-0.99); a = 42.6 (32.3-54.5); b = 5.9 (5.1-6.6); c = 4.3 (3.9-5.0); c' = 15.4 (12.7-20.0); V = 48.4% (43.4-52.9).

This species was previously recorded from a holm oak grove in the province of Granada (Peña, 1981). In the present study, *O. chlorurus* was found in 4 of the springs sampled and at 2 sites in the Monachil river. The species was particularly abundant in the Güejar Sierra (GJ) spring with 90% clay and mud sediment.

10. *Ironus tenuicaudatus* De Man, 1876.

Females: (n = 6); L = 2.83 mm (2.72-2.92); a = 46.1 (42.4-51.2); b = 4.7 (3.8-5.3); c = 10.3 (9.0-13.1); c' = 9.7 (6.6-12.5); V = 52.4% (49.6-56.8).

Males: (n = 2); L = 2.72 mm (2.60-2.83); a = 50.6 (48.8-52.3); b = 5.1 (4.8-5.3); c = 12.0 (10.9-13.1); c' = 7.9 (6.8-9.0); SP = 61.5 µm (59- 64).

Cuticle 1.6-1.8 µm thick at mid-body. Head width 14.4-16.8 µm. Cephalic setae 4.9-5.2 µm long, approximately 1/3 head width. Stoma 118-122 µm long, 3.8 µm wide. Stomatic teeth 4.0-4.2 µm long. Amphids approximately 1/2 body diameter at the same level. Vulva-anus distance 5-6 times tail length. Female tail 225-240 µm long. Male tail 210-232 µm long. Male adanal setae 6 µm long. Rectum 1.2-1.3 times anal body diameter.

Ironus tenuicaudatus was found in 5 springs characterized by having bicarbonate, sulphate and calcium content greater that 25% of the total number of ions, and with either high or very high salinity (930-3192 µS/cm). Temperature ranged between 13- 23.9°C, pH 7.2-7.7, and dissolved oxygen 4.2-6.3 mg/l.

11. *Prismatolaimus intermedius* (Bütschli, 1873) De Man, 1880.

Females: (n = 21); L = 0.66 mm (0.50-0.84); a = 41.2 (28.7-54.9); b = 4.2 (3.4-5.3); c = 3.4 (2.2-3.9); c' = 18.0 (11.8-29.8); V = 54.6% (41.8-68.2).

Head width 7.5-8.8 µm. Cephalic setae 10 in number, four long setae (4.4-4.6 µm) and six short setae, approximately 1/2 length of longer setae. Amphids located about three times head width, behind anterior body end. Stoma 6-7.5 µm long, 3-3.5 µm wide. Tail 210-250 µm long. Tail terminating in a small spur. Rectum length 0.8-0.9 times anal body diameter.

P. intermedius was found in 15 springs and at Sites 1, 4 and 6 in the Monachil river. Ionic composition, conductivity, temperature, pH and oxygen concentration values at these sites were variable, confirming the cosmopolitan character of the species.

H. *Trischistoma monohystera* De Man, 1880.

Females: (n = 12); L = 1.39 mm (0.90-1.70); a = 39.7 (36.6-54.9); b = 4.8 (4.1-5.5); c = 12.5 (9.0-14.8); c' = 5.2 (4.3-6.5); V = 80.6% (76.9-89.7).

Males: (n = 5); L = 1.76 mm (1.63-1.90); a = 66.8 (62.8-72.2); b = 6.4 (5.5-8.0); c = 13.4 (12.2-14.3); c' = 6.0 (5.4-6.7); SP = 35.6 µm (32.0-42.0).

Previously recorded by Gadea (1950) from calcareous soil samples collected from the Monserrat area (province of Barcelona), *T. monohystera* was found in 10 springs and at Site 4 in the Monachil river, all classified as calcium bicarbonated. The remaining parameters analyzed were found to be highly variable.

12. *Tobrilus grandipapillatus* Brakenhoff, 1914.

Females: (n = 13); L = 1.95 mm (1.69-2.45); a = 29.9 (22.5-40.4); b = 5.0 (4.2-5.9); c = 7.6 (6.5-10.7); c' = 6.5 (4.3-7.1); V = 46.6% (43.0-49.6).

Males: (n = 8); L = 2.13 mm (1.81-2.39); a = 36.6 (30.8-45.0); b = 5.2 (4.5-5.5); c = 15.8 (13.5-17.6); c' = 3.1 (2.2-3.8); SP = 58.9 µm (49.9- 66.2).

Cuticle 3.3-3.5 µm thick at mid-body. Somatic setae approximately 4.0 µm long. Head width 33.5-36.1 µm. Cephalic setae 15.5-16.0 µm long for the outermost and 9-10 µm, innermost setae. Stoma 27.5-31 µm long, (anterior mouth cavity 13 µm long). Amphids 1/5 body diameter at same level. Eggs 54 x 34 µm (48-64 x 29-32). Distances between male supplements as follows:

Mean (µm)	Min-Max (µm)
S1-S2: 17.3	12.9-23.8
S2-S3: 21.2	16.2-29.0
S3-S4: 33.0	25.9-38.8
S4-S5: 58.8	54.9-67.8
S5-S6: 15.8	10.1-22.6
S6-Anus: 36.5	32.3-42.0

Female tail 188-310 µm long. Male tail 113-115 µm long. Subterminal tail setae at extreme end 16-17 µm long.

T. grandipapillatus was found only in the Monachil river, at all of the sites and sometime during our study (pH 7.1-8.4, temperature 6-17.8°C, and dissolved oxygen content 6.5-11.3 mg/l).

I. *Udonchus tenuicaudatus* Cobb, 1913

Females: (n = 13); a = 0.53 mm (0.38-0.64); a = 37.4 (31.3-41.2); b = 6.2 (5.3-7.1); c = 3.4 (2.7-4.7); c' = 17.7 (10.6-25.8); V = 45.6% (40.0-51.2).

Previously recorded by Castillo *et al.* (1985) from soil in the southeast region of the province of Jaén.

U. tenuicaudatus was found in 9 springs sampled. These had high to very high salinity values, calcium, sodium and sulphate ions predominated and temperature varied from 15.7-42.8°C (average 28.7°C). The presence of *U. tenuicaudatus* in habitats with high temperature and high saline concentrations has previously been recorded by Schneider (1937) and Schiemer (1978).

Conclusions

Considering the ecological data presented (summarised in Tables I and II), the following points are highlighted.

First, the following species were found in greatest abundance: *Eumonhystera andrassyi, Monhystrella hastata, Paracyatholaimus intermedius, Odontolaimus chlorurus* and *Tobrilus grandipapillatus*. Moreover, *Eumonhystera andrassyi* and *Monhystrella hastata* together with *Prismatolaimus intermedius* were found to be the most abundant. *Eumonhystera similis, Monhystrella macrura, Ethmolaimus pratensis* and *Achromadora terricola*, recorded from both aquatic and terrestrial environments, were the least abundant. *Monhystrella macrura* has previously been reported to have the highest presence index in aquatic environments.

Secondly, the physico-chemical characteristics of the habitats studied contribute to a better understanding of the autoecology of the following species: *Monhystrella hastata, Plectus geophilus, Prismatolaimus intermedius* and *Udonchus tenuicaudatus* were found in samples collected from habitats with average water temperature 19-29°C and particularly in those localities where water temperature was between 38-42.8°C.

Eumonhystera pseudobulbosa, Monhystrella hastata, Plectus geophilus and particularly *Prismatolaimus intermedius* were found to be outstanding as species capable of tolerating wide pH, from 4.9 to 8.4.

Conductivity, the parameter relating to the amount of ions dissolved in the water, was extremely high in several of the springs sampled with values that are rarely found in other natural aquatic environments. Sulphate and chloride anions were responsable for the high conductivity values in the springs sampled. *Paracyatholaimus intermedius, Odontolaimus aquaticus* and *Udonchus tenuicaudatus* were found in springs in which conductivity values reached 8208 µS/cm.

With regard to oxygen concentration, *Eumonhystera andrassyi, Eumonhystera pseudobulbosa, Monhystrella hastata, Plectus geophilus, Prismatolaimus intermedius*, and to a lesser degree, *Prodesmodora circulata* and *Paracyatholaimus intermedius*, were found to successfully survive in entirely anoxic spring waters.

Lastly, *Eumonhystera longicaudatula, Odontolaimus aquaticus* and *Odontolaimus chlorurus* were most commonly found in habitats predominantly comprised of mud and clay sediments.

Literature cited

ANDRASSY I., 1963 - The zoological results of Gy. Topal's collectings in South Argentina 2. *Nematoda*. Neue und einige seltene Nematoden Arten aus Argentina. *Ann. Hist. Nat. Mus. Nat. Hung., 55*: 243-273.

ANDRASSY I., 1968 - Nematoden aus den Galeriewäldern des Acaray-Flusses. *Opusc. Zool. Budapest, 8*: 167-315.

ANDRASSY I., 1973 - 100 neue Nematodenarten in der ungarischen Fauna. *Opusc. Zool. Budapest, 11*: 7-48.

ANDRASSY I., 1985 - The genus *Plectus* Bastian, 1865 and its nearest relatives (*Nematoda: Plectidae*). *Acta Zoologica Hungarica, 31*: 1-52.

BIRO' K., 1969 - Eine neue *Monhystera* Art (*Nematoda*) aus dem Balaton, Ungarn. *Opusc. Zool. Budapest, 9*: 255-257.

CASTILLO P., PEÑA R. and JIMENEZ-MILLAN F., 1985 - Modelos de distribución vertical de las especies de nematodos en un biotopo natural. *Bol. Serv. Plagas, 11*: 155-162.

COOMANS A., VINCX M. and DECRAEMER W., 1985 - Nematodes from a fresh-water pool on a coral island in the Salomon Island. *Hidrobiologia, 123*: 265-281.

GADEA E., 1950 - *Contribucion al estudio de los nematodos libres terrestres y dulceacuicolas*. Inst. Biol. Apli. Ser. Zool. Barcelona. 213 pp.

GADEA E., 1952 - Sobre algunos nematodos libres de agua dulce de la Plana de Castellón. *Publ. Inst. Biol. Apl., 11*: 173-186.

GADEA E., 1953 - Free-living nematodes of high mountains of Spain. Proceeding XIV Int. Congress of Zoology, Copenhagen. pp. 381-382.

GADEA E., 1954 - Nematodos dulceacuícolas de la Sanabria. *Publ. Inst. Biol. Apl., 18*: 133-150.

GADEA E., 1955 - Nematodos dulceacuicolas de Galicia. *Publ. Inst. Biol. Apl., 20*: 77-114.

GADEA E., 1957 - Comunidades nematológicas representativas de las altas montañas españolas. *Publ. Inst. Biol. Apl., 26*: 127-133.

GADEA E., 1961 - Algunas consideraciones sobre los nematodos de las aguas dulces de la fauna española. *Bol. R. Soc. Esp. Hist. Nat. (B)*, 59: 25-28.

GADEA E., 1962 - Nematodos muscícolas y de agua dulce del 'Parque Nacional de Aigües Tortes y San Mauricio' (Pirineos Centrales). Actas del III Congreso Internacional de Estudios Pirenaicos, pp. 129-138.

GADEA E., 1963a - Nota sobre nematodos dulceacuicolas de la Isla de Menorca. *Publ. Inst. Biol. Apl., 34*: 101-110.

GADEA E., 1963b - Sobre la nematofauna del rio Carrión. *Publ. Inst. Biol. Apl., 35*: 141-147.

GADEA E., 1964 - Sobre la fauna muscícola y liquenica de las Islas Pitiusas. *Publ. Inst. Biol. Apl., 37*: 73-93.

GADEA E., 1973 - La nematofaune d'eau douce des cirques de Pessons et d'Engors (Pyrinées). *Pirineos, 108*: 87-92.

GADEA E., 1982 - Nematofauna muscicola de los Pirineos Centrales de Cataluña. *Publ. Dept. Zool., 8*: 37-43.

HOOPER D.J., 1986 - Extraction of nematodes from plant material. In: Laboratory Methods for work with Plant and Soil Nematodes. Ministry of Agriculture, Fisheries and Food. London. 201 pp.

JIMENEZ GUIRADO D. and CADENAS M.J., 1985 - Especies de *Laimidorus* Siddiqi, 1969 y descripcion de *Chrysodorus longicaudatus* gen. et sp. n. (*Nematoda, Dorylaimidae*) de la Cuenca del rio Guadalquivir. *Miscellania Zoologica, 9*: 49-54.

JIMENEZ GUIRADO D., 1988 - Nematodos acuaticos del Parque Nacional de Doñana. *Oxyura* (in press).

JUGET J., 1969 - Description de quelques formes rares ou nouvelles des Nematodes libres du bassin du Léman. *Bull. Soc. Vand. Sc. Nat., 70*: 141-173.

MATEO M.D. and CAMPOY A., 1983 - Estudio de los Nematodos libres de las Peñas de Echauri (Navarra). *Publ. Biol. Univ. de Navarra Ser. Zool., 9*: 1-64.

MONREAL J. and CAMPOY A., 1982 - Estudio faunistico del Macizo de Quinto Real —Pirineos Orientales— Nematodos (*Nematoda*). *Publ. Biol. Univ. Navarra Ser. Zool., 8*: 1- 92.

PEÑA R., 1981 - *Estudio de la nematocenosis de un encinar en las estribaciones de Sierra Nevada.* Tesis de Licenciatura. Univ. de Granada. 154 pp.

ROPERO M.L., 1984 - *Calidad de las aguas corrientes de Sierra Nevada. (Granada).* Tesis de Licenciatura. Univ. de Granada. 150 pp.

SANTOS M.C., 1986 - *Contribución al conocimiento de los nematodos libres de Andalucia Occidental.* Tesis de Doctorado. Univ. de Sevilla. 430 pp.

SAURA I., 1978 - *Aguas minerales de la provincia de Malaga: Estudio hidrológico y posibles aplicaciones terapeúticas.* Tesis de Doctorado. Univ. de Granada. 614 pp.

SCHIEMER F., 1978 - Verteilung und Systematik der freilebenden Nematoden des Neussiedlersees. *Hydrobiologia, 58*: 167-194.

SCHNEIDER W., 1937 - Freilebende Nematoden der Deutschen Limnologischen Sunda. Expedition nach Sumatra, Java und Bali. *Arch. Hydrobiol. Suppl-Bod., 15*: 30-108.

SEINHORST J.W., 1962 - On the killing, fixation and transferring to glycerine of nematodes. *Nematologica, 8*: 29- 32.

TRUSKOVA G.M., 1976 - Six new species of the genus *Plectus (Nematoda, Plectidae)* from dark-coniferous forest of the far-East. *Zool. Zhurn., 55*: 1718-1723.

ZULLINI A., 1982 - Guide per il Riconoscimento delle Specie Animali delle Acque Interne Italiane, *17*. Nematodi. Consiglio Nazionale delle Ricerche. AQ/1/190. Verona, 117 pp.

Accepted for publication on 4 July 1990.