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Title	Notes on the Postembryonic Development of <i>Draconema japonicum</i> Kito, 1976 (Nematoda; Draconematidae) (With 5 Text-figures and 1 Table)
Author(s)	KITO, Kenji
Citation	北海道大學理學部紀要, 22(1), 88-98
Issue Date	1979-12
Doc URL	https://hdl.handle.net/2115/27653
Type	departmental bulletin paper
File Information	22(1)_P88-98.pdf



Notes on the Postembryonic Development of *Draconema japonicum* Kito, 1976 (Nematoda; Draconematidae)

By

Kenji Kito

Zoological Institute, Hokkaido University

(With 5 Text-figures and 1 Table)

Recently Allen and Noffsinger (1978), as an outcome from their laborious works on the superfamily Draconematoidea Filipjev, 1918, revised the genus *Draconema* Cobb, 1913, and described adults and juvenile stages of the following six species, *D. cephalatum* Cobb, 1913, *D. ophicephalum* (Claparède, 1863), *D. chilense* Allen and Noffsinger, 1978, *D. haswelli* (Irwin-Smith, 1918), *D. claparedii* (Mechnikov, 1867), and *D. antarctica* Allen and Noffsinger, 1978; for the latter three species, all of the four juvenile stages were given. They also discussed the significance of some important taxonomic characters changing through the different juvenile stages. They dealt with *D. cephalatum* collected at several localities of Japan, but gave no comments on another congeneric species, *D. japonicum* Kito, 1976, already reported from Japan (Kito, 1976).

The present paper deals with adults and last three juvenile stages of *D. japonicum* which was not mentioned in the paper by Allen and Noffsinger.

The specimens were selected from a sample of algal rinsings collected at the type-locality of this species, Oshoro, on the Japan Sea coast of Hokkaido (*Laminaria* holdfasts on the rock: 25-IX-1978), and from another sample obtained at Kuroshima in the Yaeyama Group, the Ryukyu Islands, Okinawa (algae on the coral reef flat: 5-XII-1977) (for these localities see Kito 1978, Fig. 4).

Before going further I wish to express my grateful thanks to Professor Mayumi Yamada, Hokkaido University for his kind guidance and reading the manuscript. Sincere thanks are also due to Dr. Tatsunori Itô, Hokkaido University for his valuable advices on the present study.

Abbreviations

L=body length; eso=length of swollen esophageal region; hd=head diameter at level of cephalic setae; bd=body diameter at constriction just posterior to swollen esophageal region; mbd=maximum body diameter at swollen esophageal region+at middle part of body (at level of vulva in female); ad=anal (cloacal)

body diameter; ls=length of labial setae; cs=length of two circles of cephalic setae, anterior+posterior; amp=amphids, width x length; t=tail length; spic=spicule length, measured along median line, and length of chord in parentheses; gub=gubernaculum length; v=distance of vulva from anterior. All measurements are in micra.

Draconema japonicum Kito, 1976

The following description of each stage is mainly based upon the specimens from the type-locality, Oshoro, because those from two localities are identical in most of the features. The specimens from Kuroshima are compared with those from Oshoro when some significant difference is noticed. Among the present specimens, first juvenile stage was not observed.

Second juvenile stage

Measurements

Juveniles (1-2, Oshoro; ; 3-6, Kuroshima): L=356; 363; ; 321; 336; 343; 364, eso=75; 68; ; 73; 72; 74; 78, hd=17;-; ; 12-14, bd=22; 19; ; 16-19, mbd=47+32; 39+27; ; 33+20; 32+21; 30+23; 37+31, ad=17; 16; ; 13; 14; 13; 16, ls=3-4, cs=4-5+7-9, amp=5-6×7-9, t=61; 56; ; 52; 56; 52; 56.

Body (Fig. 1-1) similar to adults in general feature, swollen esophageal region, cylindrical middle part and conical tail slightly bending to ventral; width of esophageal region greater than that of middle part of body. Cuticle annulated except for anterior part of head and posterior part of tail, annules generally circled but some of which are irregular and incomplete, especially S-shaped in lateral side of middle of body; width of annules not remarkably differentiated on whole body. Somatic setae arranged in six longitudinal rows, 4 sublateral, 1 ventral and 1 dorsal, on esophageal region (33 μm long at maximum) and in four sublateral rows on the following part of body (15 μm long at maximum). Head (Fig. 3-1) not annulated but with peculiar cuticular markings, less than one-third of esophagus length. Mouth surrounded by six distinct lips each bearing a labial seta, more posteriorly two circles of cephalic setae; the anterior circle of six short setae, 2 subdorsal, 2 subventral and 2 lateral, and the posterior of five long setae, 4 sublateral and 1 dorsal, observed inside and outside labial fringe, respectively. Buccal cavity without tooth. Amphids unispiral, dorsal arm extending posteriorly; a seta located near dorsal margin of amphids. An anterior ambulatory seta stout, projecting dorsally, 14 μm long. Esophagus (Fig. 2-1) with two bulbs, the posterior bulb slightly longer and wider; nerve ring surrounding between two bulbs. Excretory pore indistinct, two pairs of small glands ventrally just posterior to esophageal end. Two pairs of posterior ambulatory setae (Fig. 4-1) in two longitudinal rows sublaterally, about 2 and 3 anal body diameters long before anus, the anterior setae (29-34 μm) longer than the posterior (25-29 μm long). Posterior half of tail (Fig. 5-1) not annulated but numerous punctations

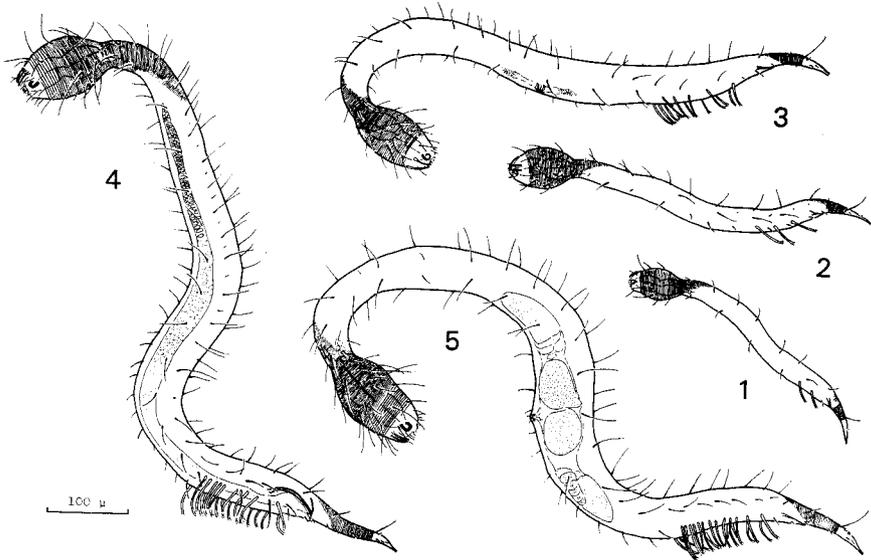


Fig. 1. *Draconema japonicum* Kito, 1976. 1. second-stage juvenile; 2. third-stage juvenile; 3. fourth-stage juvenile; 4. male; 5. female.

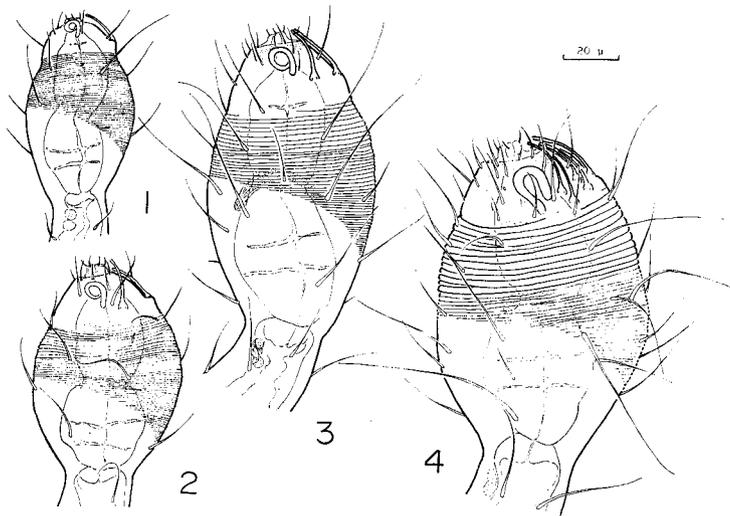


Fig. 2. *Draconema japonicum* Kito, 1976. Anterior end. 1. second-stage juvenile; 2. third-stage juvenile; 3. fourth-stage juvenile; 4. male.

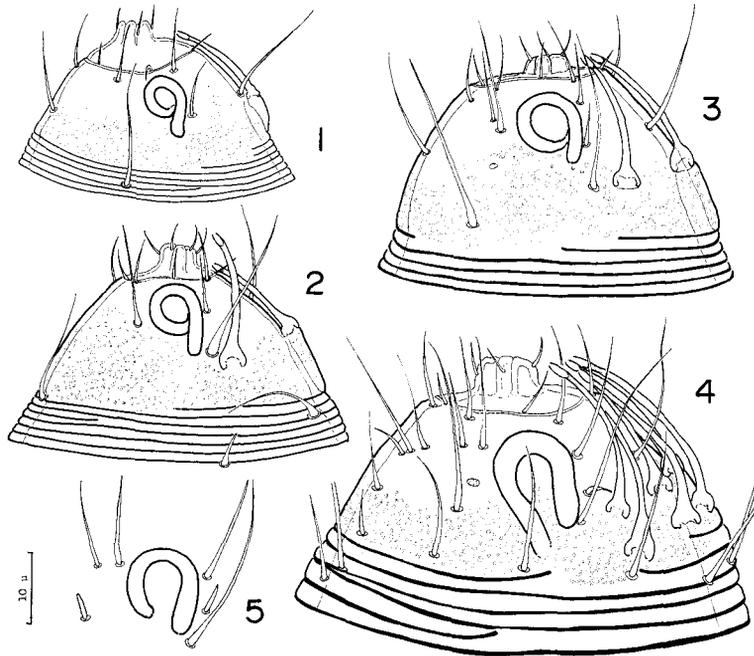


Fig. 3. *Draconema japonicum* Kito, 1976. Head. 1. second-stage juvenile; 2. third-stage juvenile; 3. fourth-stage juvenile; 4. male; 5. female.

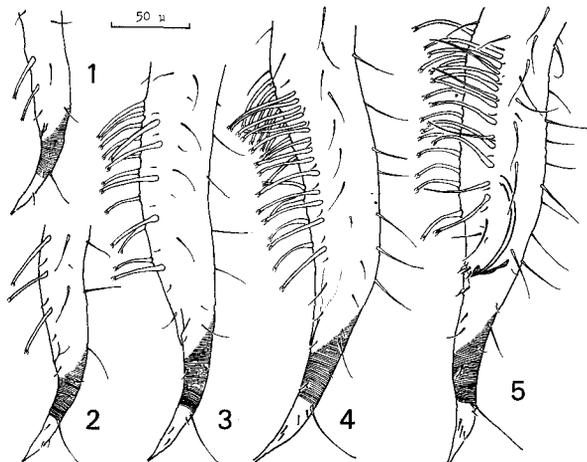


Fig. 4. *Draconema japonicum* Kito, 1976. Posterior end. 1. second-stage juvenile; 2. third-stage juvenile; 3. fourth-stage juvenile; 4. female; 5. male.

faintly observed; 1 subdorsal pair of setae (23–25 μm long) anterior to last complete annule longer than other setae on tail, 1 short lateral pair of setae just anterior to that annule; 1 single dorsal seta about 40% on non-annulated tail region (measured from last complete annule to tail tip). *Kuroshima*. Two pairs of posterior ambulatory setae shorter, less than 26 μm long, about 2 and 4 anal body diameters long before anus. One juvenile (L=356) in the molting to next stage was collected.

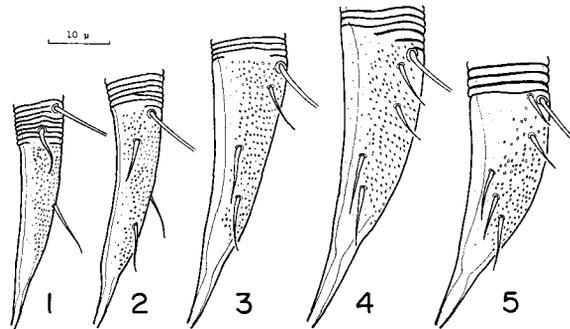


Fig. 5. *Draconema japonicum* Kito, 1976. Non-annulated tail region. 1. second-stage juvenile; 2. third-stage juvenile; 3. fourth-stage juvenile; 4. female; 5. male.

Third juvenile stage

Measurements

Juveniles (1–6, Oshoro; ; 7–11, Kuroshima): L=427; 464; 468; 524; 526; 554; ; 438; 444; 452; 498; 500, eso=78; 78; 81; 91; 92; 92; ; 84: 90; 90; 93; 95, hd=14–17; ; 12–17, bd=24–27; ; 21–27, mbd=48+31; 53+33; 51+34; 51+35; 57+37; 54+36; ; 38+24; 44+29; 47+29; 52+34; 54+36, ad=17; 19; 18; 18; 19; 18; ; 16; 17; 16; 18; 18, ls=4–5, cs=4–5+7–9, amp=6–8×9–11; ; 6×7–8, t=67; 70; 71; 70; 71; 86; ; 59; 67; 68; 68; 69.

Some anterior annules (Fig. 2–2) somewhat differentiated. Somatic setae (Fig. 1–2) arranged in eight longitudinal rows on esophageal region, 4 sublateral, 2 subventral and 2 subdorsal, and in five longitudinal rows on following middle part of body, 4 sublateral and 1 dorsal. Head (Fig. 3–2) equipped with two circles of cephalic setae and three anterior ambulatory setae, a pair of sublateral setae longer dorsal one, 15–21 μm long. A seta located at both sides of amphids and another one posterior to dorsal end of amphids. Three pairs of posterior ambulatory setae (Fig. 4–2) in two longitudinal rows, 29–42 μm long, located at 4.2–5.9 (mean 4.9), 3.2–4.6 (3.7) and 1.9–2.6 (2.2) anal body diameters long before anus, respectively; distance between the posterior two setae longer than that between the anterior two. Six setae located on non-annulated tail region (Fig. 5–2); 1 subdorsal pair (33–39 μm long) just posterior to last incomplete annule longer than other setae on tail, 1

short lateral pair about 12%, 2 asymmetrical subdorsal setae, anterior seta about 33% on either side and posterior seta about 51% on the other side. *Kuroshima*. Three pairs of posterior ambulatory setae 5.1–5.6 (mean 5.3), 3.5–4.4 (4.0) and 1.6–2.1 (1.9) anal body diameters long before anus.

Fourth juvenile stage

Measurements

Juveniles (1–5, Oshoro; ; 6–11, Kuroshima): L=534; 635; 730; 756; 774; ; 512; 580; 652; 669; 704; 706, eso=87; 99; 107; 109; 111; ; 94; 103; 109; 109; 117; 118, hd=17–19; ; 14–18, bd=26–32; ; 21–30, mbd=49+35; 52+37; 56+42; 62+48, 61+50; ; 43+28; 49+36; 47+42; 56+41; 56+43; 57+46, ad=21; 23; 20; 24; 20; ; 18; 21; 18; 20; 20; 19, ls=4–6, cs =4–6+7–13, amp=8–9×10–13; ; 7–8×7–11, t=74; 83; 77; 86; 83; ; 73; 73; 78; 86; 77; 77, v=-; -; -; -; 413; ; -; -; -; -; 393; 370.

Anterior annules (Fig. 2–3) differentiated rather than those of the preceding stage, but their border still indistinct. Somatic setae (Fig. 1–3) arranged in seven longitudinal rows on middle part of body, 4 sublateral, 2 subdorsal and 1 ventral; ventral side of setae (up to 16 μm long) shorter than those of dorsal side (32–44 μm long). Head (Fig. 3–3) equipped with six anterior cephalic setae and seven posterior cephalic setae, 4 sublateral, 2 subventral and 1 dorsal, and with two pairs of anterior ambulatory setae 22–26 μm long. Five setae located around amphids, 2 setae ventrally and 3 dorsally. Posterior ambulatory setae (Fig. 4–3) arranged in three longitudinal rows, each 5 sublateral setae 33–47 μm long and 9 ventral setae 26–40 μm long, the anteriormost ventral seta 4.8–7.8 (mean 5.8) and the posteriormost 1.4–2.8 (2.0) anal body diameters long before anus. Reproductive system beginning to develop, and the sex being distinguishable in relatively grown individuals; juvenile males (L=677; 712; 735, from Kuroshima) in the molting with a single testis, spicules and gubernaculum formed incompletely, juvenile female (L=746) in the molting with ovaries which are paired and slightly developed before and after distinct vulva. Four pairs of setae on non-annulated tail region (Fig. 5–3); 2 pairs of subdorsal setae at anterior, 1 pair (33–44 μm long) just posterior to last incomplete tail annule longer than other setae on tail, 1 short pair just posterior to long pair; 2 pairs of short setae at middle, 1 lateral pair about 33%, 1 subdorsal pair about 50%. *Kuroshima*. Posterior ambulatory setae shorter, 20–39 μm long, the anteriormost ventral seta 5.5–8.2 (mean 7.0) and the posteriormost 1.4–2.2 (1.8) anal body diameters long before anus.

Adult stage

See the original description (Kito, 1976).

Measurements

Males (1–7, Oshoro; ; 8–13, Kuroshima): L=989; 1057; 1118; 1150; 1202; 1241; 1243; ; 676; 785; 946; 956; 977; 1022, eso=119; 122; 125; 132; 131; 134;

140; ; 112; 118; 131; 132; 122; 137, hd=21-25; ; 17-22, bd=32-36; ; 29-33, mbd=76+65; 73+66; 73+65; 71+68; 69+62; 71+60; 79+68; ; 67+48; 55+44; 59+55; 57+49; 57+53; 58+53, ad=31; 29; 34; 32; 31; 32; 35; ; 28; 25; 27; 25; 26; 25, ls=4-5, cs=6-7+9-14, amp=10-12×15-20; ; 7-10×12-19, t=120; 124; 124; 124; 124; 121; 135; ; 90; 100; 104; 111; 111; 114, spic=73(64); 86(71); 83(71); 76(56); 79(64); 77(63); 86(67); ; 61(54); 66(58); 73(69); 78 (69); 75(64); 70(62), gub=24; 23; 23; 23; 24; 22; 25; ; 18; 17; 21; 21; 23; 19.

Females (1-5, Oshoro; ; 6-10, Kuroshima): L=872; 970; 1067; 1089; 1209; ; 698; 965; 981; 1001; 1004, eso=122; 134; 139; 132; 136; ; 121; 140; 142; 143; 134, hd=21-26; ; 18-23, bd=31-37; ; 29-36, mbd=64+52; 73+72; 72+92; 73+83; 74+108; ; 52+42; 63+76; 61+84; 61+81; 60+80, ad=23; 25; 22; 21; 22; ; 20; 21; 24; 22; 23, ls=5-6, cs=7-8+12-13; ; 6-7+9-11, amp=9-11×12-15; ; 7-9×9-10, t=87; 94; 88; 85; 89; ; 74; 88; 95; 92; 89, v=481; 528; 615; 624; 698; 369; 524; 524; 533; 510.

Male. Anterior 8-12 annules (Fig. 2-4) conspicuously differentiated, about 2.0 μm wide and those of following part about 1.0 μm wide. Somatic setae (Fig. 1-4) densely distributed on swollen esophageal region, so that longitudinal rows of setae indistinct (12 rows ?), and arranged in eight longitudinal rows on following middle part of body, 4 sublateral, 2 subdorsal and 2 subventral. Head (Fig. 3-4) equipped with six anterior cephalic setae and eight posterior cephalic setae, 4 sublateral, 2 subdorsal and 2 subventral. Twelve anterior ambulatory setae arranged in two transverse rows of six setae, up to 29 μm long. Amphids large, elongate loop-shaped, ventral arm extending posteriorly, circumferential setae of amphids somewhat regularly located as figured. Spicules (Fig. 4-5) paired, arcuate, cephalate proximally. Gubernaculum (see Kito 1976, Fig. 3-3 and 4) conspicuously dilating around distal end of spicules. Four pairs of anal setae located, 2 inner pairs short (6-9 μm long), broad-based and unevenly tapered, 2 outer pairs (8-12 μm) uniformly tapered; another short pair of setae (6-8 μm) more laterally present. Posterior ambulatory setae arranged in four longitudinal rows; two sublateral rows each comprising 9 ambulatory (A) and 4 usual setae (U) (36-60 μm long), regularly in order of AAUAAUAAUAAU from anterior; two subventral rows each comprising 17 or 18 (15 or 16 in ♂ -2) ambulatory setae (28-49 μm long), the anteriormost 4.1-5.9 (mean 5.2) and the posteriormost 1.2-2.2 (1.6) cloacal body diameters long before cloaca; short setae intermingled in sublateral rows of setae. Non-annulated tail region (Fig. 5-5) about 35% of tail length, with six pairs of setae; 3 subdorsal pairs of setae at anterior, 1 pair (39-44 μm long) just posterior to last annule longer than other setae (less than 31 μm long) on tail, 1 short pair adjacent to or slightly lateral to long pair, 1 short pair about 21%; 3 short pairs of setae at middle, 1 subventral pair about 35%, 1 lateral pair about 39% and 1 subdorsal pair about 48%. *Female.* Body diameter at level of vulva wider than that on swollen esophageal region in well-grown individuals (Fig. 1-5). Amphids (Fig. 3-5) more round than those of male, dorsal arm extending posteriorly. Posterior ambulatory setae (Fig. 4-4) in four longitudinal rows; two sublateral rows each 13 to 15 ambulatory

setae; two subventral rows each 18 or 19 ambulatory setae, the anteriormost 6.8–9.7 (mean 7.8) and the posteriormost 1.5–4.0 (2.6) anal body diameters long before anus; short setae intermingled in sublateral rows. Vulva not encircled by any projections; paravulval setae 8–11 μm long. Tail shorter than that of male; non-annulated region (Fig. 5-4) about 45% of tail length, with five pairs of setae; 3 pairs of subdorsal setae at anterior, 1 pair just posterior to last incomplete annule longer than other setae on tail, 1 short pair slightly posterior to long pair, 1 short pair about 29%; 2 short pairs of setae at middle, 1 subventral pair about 42% and 1 lateral pair about 53%. *Kuroshima*. Posterior ambulatory setae show the local variation in number: *Male*. Two sublateral rows are in the same arrangement as in those from Oshoro; two subventral rows each comprising 15 or 16 ambulatory setae, the anteriormost 5.5–7.4 (mean 6.8) and the posteriormost 1.3–2.3 (1.7) cloacal body diameters long before cloaca. *Female*. Two sublateral rows each 11 to 13 ambulatory setae; two subventral rows each 17 or 18 ambulatory setae, the anteriormost 6.3–9.9 (mean 8.5) and the posteriormost 1.3–2.0 (1.7) anal body diameters long before anus.

Remarks. The specimens collected at Kuroshima differ from those of Oshoro in some minor characteristics; they are slender, and have fewer posterior ambulatory setae in the adult.

Discussion

The development through the last three juvenile stages to the adult of *Draconema japonicum* is summarized as follows (Table 1): 1) *Annules*. Anterior annules begin to differentiate in the third juvenile stage, and the anterior 8–12 coarse annules are fully distinguishable from those of succeeding part of the body in the adult. 2) *Somatic setae*. The number of longitudinal rows of the somatic setae on the middle part of the body increases with the stages; second-stage juveniles with 4 sublateral rows, third-stage juveniles with 4 sublateral and 1 dorsal, fourth-stage juveniles with 4 sublateral, 2 subdorsal and 1 ventral, and adults with 4 sublateral, 2 subdorsal and 2 subventral. 3) *Amphids*. The unispiral amphids with long dorsal arm in the juveniles change in the shape and show the sexual dimorphism in the adult; large, elongate loop-shaped amphids with long ventral arm in males, more round loop-shaped amphids with rather long dorsal arm in females. 4) *Anterior ambulatory setae*. The number and arrangement is different in each stage; only one dorsal seta in second-stage juveniles, 1 sublateral pair of setae besides dorsal one in third-stage juveniles, 1 sublateral and 1 subdorsal pair of setae in fourth-stage juveniles, and 12 setae in two transverse rows in adults. 5) *Posterior ambulatory setae*. The number and arrangement vary with the stages and show the sexual dimorphism in the adult; a sublateral pair of rows each consisting of 2 setae in second-stage juveniles, those of 3 setae in third-stage juveniles, those of 5 setae and 1 ventral row of 9 setae in fourth-stage juveniles, 2 sublateral rows each of 9 setae and 4 usual setae and 2 subventral rows of 15–18

Table 1. Developmental changes of the major morphological characters of *Draconema japonicum* Kito, 1976. The data in parentheses represent those of the Kuroshima-specimens.

Stage	Juvenile			Adult	
	Second	Third	Fourth	Male	Female
Length (μm)	356-363 (321-356)	427-554 (438-500)	534-774 (512-735)	989-1243 (676-1022)	872-1209 (698-1004)
Annules ¹⁾	—	±	±	+	+
Somatic setae	4	5	7	8	8
Amphids	unispiral, long dorsal arm	ditto	ditto	elongate loop-shaped, long ventral arm	round loop- shaped, long dorsal arm
Ambulatory setae					
Anterior	1	3	4	12	12
Posterior ²⁾	2=2	2=3	3=5/9	4=9+4/15-18 (9+4/15-16)	4=13-15/18-19 (11-13/17-18)
Non-annulated tail region ³⁾	50=1	50=6	50=8	35=12	45=10
Reproductive system ⁴⁾	—	—	—~±	±~+	±~+

1) — (undifferentiated), ± (slightly differentiated), + (differentiated)

2) number of rows=setae in a sublateral row or a sublateral row/a subventral row

3) proportion (%)=number of setae

4) — (undeveloped), ± (immaturely developed), + (maturely developed)

setae in males, and the former of 11–15 and the latter of 17–19 setae in females. 6) *Non-annulated tail region*. The proportion of its region to the tail length is about 50% in the juveniles but about 35% in the male and about 45% in the female. The setation varies with the stages and shows the sexual dimorphism in the adult; setal number in second-, third-, fourth-stage juveniles, males and females being 1, 6, 8, 12 and 10 setae, respectively; 1 long subdorsal pair and another short pair of setae located anterior to last complete annule in second-stage juveniles but translocated just posterior to last annule in the individuals in the succeeding three stages. 7) *Reproductive system*. It begins to develop in the third juvenile stage and fully matures in the adult, therefore the sex of each individual is distinguishable on the way of growth in the third juvenile stage. Besides these characters the number of the posterior cephalic setae and circumferential setae of amphids also appears to vary with the stages as well as that of longitudinal rows of setae on the swollen esophageal region. But these setae and those of such rows are occasionally missed and indistinguishable from the similar cervical setae, especially in the adult. Since these three juvenile stages found in the present species agree well with the second to fourth stages of other *Draconema* species reported by Allen and Noffsinger (1978), the first juvenile stage of the present species which is not yet recognized is probably characterized by

the absence of the anterior and posterior ambulatory setae as in *D. haswelli*, *D. claparedii* and *D. antarctica*.

Although *D. japonicum* is entirely discernible from all of other known species of *Draconema* by the structure of the gubernaculum distally dilated around the spicule end in the male as described and figured in the original report (Kito, 1976), this species is reconsidered on the above characters, especially in the relation to other known species revised by Allen and Noffsinger. *D. japonicum* belongs to the second group, "Males with 7 to 10 SIAT (sublateral ambulatory setae in the present text). Females with 9 to 16 SIAT" in the key to species proposed by them, together with *D. cephalatum*, *D. haswelli*, *D. claparedii*, and *D. antarctica*. The males most closely resemble *D. cephalatum* by having 2 pairs of uniformly tapered anal setae and 2 pairs of short, broad-based, unevenly tapered anal setae but differ from the latter in having another pair of short setae located more laterally to such anal setae, and 6 pairs of setae less than 50% on the non-annulated tail region besides the gubernaculum distally dilated. The females also resemble *D. cephalatum* but differ in having the vulva not encircled by spin-like projections, and 5 pairs of setae less than 60% on the non-annulated tail region. The females of *D. chilense* have the same two preceding characters as those of *D. japonicum* but are distinguished in having more sublateral ambulatory setae. The second-stage juveniles are identical to those of *D. haswelli* in having a single dorsal seta about 50% on the non-annulated tail region, though indistinguishable from them due to their insufficient description. The third-stage juveniles differ from those of other known *Draconema* species in having 2 asymmetrical dorsal setae. The fourth-stage juveniles differ from those of other known *Draconema* species by having 1 short lateral pair of setae about 33%, and 1 short subdorsal pair of setae about 50% on the non-annulated tail region. Besides the above differences, the long subdorsal pair of setae located just anterior (the second stage) or posterior (the succeeding stages) to last complete annule on the tail are always markedly elongated rather than other setae on the tail in the present species.

Draconema japonicum is assumed to be distributed from the northern to far southern coasts of the Japanese Islands because a previously unknown locality of the species, Kuroshima, Okinawa, was added to the type-locality, Oshoro, Hokkaido. On the other hand, *D. cephalatum* has been recorded from several localities in Japan (Allen and Noffsinger, 1978): Akkeshi, Hokkaido; Nakaminato, Shimoda and Wajima, Honshu; Ibusuki, Kyushu; thus this species is also widely distributed along both the Japan Sea coasts and the Pacific coast of Japan. These two species closely resemble each other in the general feature, especially in the females and juveniles. Their systematics and ecological relation between these two species is another interesting problem.

Summary

The postembryonic development of *Draconema japonicum* Kito, 1976 examined at Oshoro and Kuroshima in Japan shows a similar pattern previously known for other *Draconema* species. The third- and fourth-stage juveniles of this species, however, differ from those of other known species in the setation on the non-annulated tail region. The second-stage juveniles are indistinguishable from those of *D. haswelli* with the same setation. The adults closely resemble those of *D. cephalatum* but differ in the feature of the gubernaculum and anal setae in the male, and the vulva in the female besides the setation on the non-annulated tail region.

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