Deep in the systematics of Camallanidae (Nematoda): using integrative taxonomy to better understand the phylogeny and consistency of diagnostic traits

Running title: Integrative taxonomic assessment of Camallanidae

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Morphological and life history traits matrix of all representatives used in the present study; see as follows the details on characters and their respective states.

Species	Number of cephalic papillae	Sclerotized trident associated with buccal capsule	Buccal capsule structure	Buccal capsule ridges	Laminar teeth at base of buccal capsule	Relative position of deirids	Relative position of excretory pore	Relative position of vulva in females	Protrusion of vulval lips	General morphology of tail in females	Number of caudal spikes in tail of femalesl	Presence of caudal alae in males	Number of caudal spikes on tail in males	Presence of pedunculate papillae in males	Presence of adcloacal papillae in males	Spicule symmetry in males	Presence of gubernaculum in males	Habitat	Host Order	Biogeographic Origin
B. slomei	0	0	0	0	0	1	1	1	0	1	3	1	0	1	1	1	0	1	3	3
B. xenopodis	1	0	0	1	1	1	1	1	0	1	3	1	0	1	1	1	0	1	3	3
C. beveridgei	1	1	1	3	0	1	?	0	1	1	0	1	0	1	0	1	?	1	4	5
C. cotti	0	1	1	2	0	1	1	2	1	1	0	1	0	1	1	1	0	1	0&1&2&B&H	0&1&2&3&5
C. hypophthalmichthys	0	1	1	2	0	1	1	1	1	1	3	1	3	1	1	1	0	1	1	4
C. kaapstaadi	0	1	1	2	0	1	1	2	1	1	3	1	2	1	1	1	0	1	3&J	3
C. lacustris	0	1	1	2	0	1	1	1	1	1	3	1	0	1	0	1	0	1	0&1&5&6&7&8&I	2
C. nithoggi	0	1	1	3	0	1	1	1	0	1	0	1	0	1	1	1	0	1	4	5
C. oxycephalus	1	1	1	2	0	?	?	2	1	1	0	1	0	1	0	1	0	1	0&1&6&G&2&9&A	1
C. sodwanaensis	0	1	1	2	0	?	1	0	1	1	0	1	0	1	1	1	0	0	0	3
C. sprenti	1	1	1	3	0	1	?	0	1	1	0	1	0	1	0	1	0	1	4	5
C. tuckeri	1	1	1	2	0	1	?	0	1	1	0	1	0	1	1	1	0	1	4	5
C. waelhreow	0	1	1	3	0	1	1	1	0	1	0	1	0	1	1	1	0	1	4	5
C. xenopodis	0	1	1	2	0	1	1	1	1	1	3	1	0	1	1	1	0	1	3	3
Pa. cyathopharynx	1	1	2	2	0	1	1	1	0	1	3	1	3	1	0	1	0	1	2	3
P. annulatus	0	0	0	0	0	0	2	0	1	1	0	1	0	1	1	1	1	0	0	6

P. laeviconchus	1	0	0	0	0	1	1	2	0	1	3	1	0	1	0	1	1	1	2&B&C	3
P. pacificus	1	0	0	0	0	1	1	2	1	1	3	?	?	?	?	?	?	1	5	5
P. pseudolaeviconchus	1	0	0	0	0	1	1	2	1	1	3	1	0	1	0	1	1	1	2	3
P. sigani	?	0	0	0	0	?	?	0	0	1	0	1	0	0	0	1	0	0	0	6
P. spiculogubernaculus	0	0	0	0	0	1	1	2	0	1	3	1	0	1	1	1	1	1	2	4
S. fulvidraconis	1	0	0	1	0	1	1	2	0	1	3	1	0	1	0	1	1	1	0&1&2	2&4
S. huacraensis	1	0	0	1	1	1	2	2	0	0	0	0	0	0	0	0	0	1	2	0
S. hilarii	1	0	0	1	0	1	1	1	0	0	0	0	0	0	0	0	0	1	2&B&G	0
S. inopinatus	2	0	0	1	0	0	1	2	0	1	0	0	0	0	0	0	0	1	0&2&B	0
S. istiblenni	2	0	0	1	0	0	2	0	0	0	2	1	3	1	1	1	0	0	0&E	6&9&A
S. macaensis	2	0	0	1	0	0	1	0	0	1	2	1	2	1	1	1	0	0	0	7
S. monotaxis	2	0	0	1	0	0	1	0	0	0	2	1	2	1	1	1	0	0	0	6&A
S. pintoi	1	0	0	1	0	0	1	2	0	1	0	0	0	0	0	0	0	1	2	0
S. rarus	?	0	0	1	1	?	1	1	0	1	0	1	0	1	0	1	0	1	0&2&B	0
S. rebecae	1	0	0	1	0	0	1	2	0	1	3	1	3	1	1	1	0	1	0	0
Se. cayennensis	0	1	1	3	0	?	2	1	1	1	3	1	0	1	1	1	0	1	4	0
Se. octorugatum	0	1	1	3	0	1	1	1	0	1	3	1	0	1	1	1	0	1	4	4
S. lupi	3	2	3	4	2	3	3	3	2	2	4	2	4	2	2	2	2	2	K	B

Description of characters and their respective states that were used for phylogenetic analyses, which were chosen mainly based on Moravec and Thatcher (1997), Moravec (1998), Anderson et al. (2009) Moravec and Van As (2015)

CHARACTER: Number of cephalic papillae

Refers to the number of papillae, surrounding the oral opening at cephalic end, excluding the amphids.

States:

0 = 1 circle composed of 4 papillae (4 papillae in total)

1 = 2 circles, each composed of 4 papillae (8 papillae in total)

2 = 3 circles, each composed of 4 papillae (12 papillae in total)

3 = Other

CHARACTER: Scletorized tridents associated with buccal capsule

Refers to the presence of cuticular structures, trident shaped, associated with buccal capsule, on its ventral and dorsal sides.

States:

0 = Absent

1 = Present

2 = Other

CHARACTER: Buccal capsule structure

Refers to the number of articulated valves that form the buccal capsule, and the presence of the basal cavity.

States:

0 = One piece

1 = Two valves without basal cavity

2 = Two valves with basal cavity

3 = Other

CHARACTER: Buccal capsule ridges

Refers to the presence or absence and orientation of the ridges in the buccal capsule.

States:

0 = Absent

1 = Present transversal at least in one sex

2 = present longitudinal not separated into dorsal and ventral groups, at least in one sex

3 = present longitudinal separated into dorsal and ventral groups, at least in one sex

4 = Other

CHARACTER: Laminar teeth at base of buccal capsule

Refers to presence or absence of teeth on the base of buccal capsule.

States:

0 = Absent in both sexes

1 = Present at least in one sex

2 = Other

CHARACTER: Relative position of deirids

Refers to position of deirids in the anterior end, respect to the nerve ring and muscular oesophagus.

States:

0 = Anterior to nerve ring

1 = Between nerve ring and muscular oesophagus end

2 = Posterior to muscular / glandular oesophagus junction

3 = Other

CHARACTER: Relative position of excretory pore

Refers to position of the excretory pore in the anterior end, respect to the nerve ring and muscular oesophagus.

States:

0 = Anterior to nerve ring

1 = Between nerve ring and muscular oesophagus end

2 = Posterior to muscular / glandular oesophagus junction

3 = Other

CHARACTER: Relative position of vulva

Refers to position of the vulva respect to total body length.

States:

0 = Pre-equatorial

1 = Equatorial

2 = Postequatorial

3 = Other

CHARACTER: Protrusion of vulval lips

Refers to the protusion of vulval lips respect to body surface.

States:

0 = Not protruded

1 = Protruded

2 = Other

CHARACTER: General morphology of tail in females

Refers to the shape of female tail, including the presence or absence of terminal constriction.

States:

0 = Terminal constriction present

1 = Terminal constriction absent

2 = Other

CHARACTER: Number of caudal spikes on tail in females

Refers to the presence or absence and number of caudal projections on female tail

States:

0 = Absent

1 = One present (similar to mucron)

2 = Two present (similar to mucron)

3 = > Two present (similar to mucron)

4 = Other

CHARACTER: Presence of caudal alae in males

Refers to the presence or absence of caudal alae in males

0 = Absent

1 = Present

2 = Other

CHARACTER: Number of caudal spikes on tail in males

Refers to the presence or absence and number of caudal projections on male tail

States:

0 = Absent

1 = One present (similar to mucron)

2 = Two present (similar to mucron)

3 = > Two present (similar to mucron)

4 = Other

CHARACTER: Presence of pedunculate papillae in males

Refers to the presence or absence of caudal pedunculate papillae on male tail.

States:

0 = Absent

1 = Present

2 = Other

CHARACTER: Presence of adcloacal papillae in males

Refers to the presence or absence of adcloacal papillae on posterior end of male.

States:

0 = Absent

1 = Present

2 = Other

CHARACTER: Spicule symmetry in males

Refers to the symmetry and size of spicules in male.

States:

0 = Equal

1 = Unequal

2 = Other

CHARACTER: Presence of gubernaculum in males

Refers to the presence or absence of gubernaculum on male tail

States:

0 = Absent

1 = Present

2 = Other

CHARACTER: Habitat

Refers to the type of environment that in which parasite host inhabits

States:

0 = Marine

1 = Freshwater

2 = terrestrial

CHARACTER: Host Order

Refers to the order to which the host belongs

States:

0 = Perciformes

1 = Cypriniformes

2 = Siluriformes

3 = Anura

4 = Testudines

5 = Anguilliformes

6 = Salmoniformes

7 = Gadiformes

8 = Gasterosteiformes

A = Clupeiformes

B = Osmeriformes

C = Characiformes

D = Tetraodontiformes

E = Oesteoglossiformes

F = Pleuronectiformes

G = Cyprinodontiformes

H = Ophidiiformes

I = Batrachoidiformes

J = Scorpaenoformes

K = Myliobatiformes

L = Esociformes

M = Crocodilia

N = Mammals

CHARACTER: Biogeographic Origin

Refers to biogeographic occurrence of species.

States:

0 = Neotropical

1 = Nearctic

2 = Palaearctic

3 = Ethiopean

4 = Oriental

5 = Australian

6 = Central Indo-Pacific

7 = South Atlantic

8 = Temperate Northern Atlantic

A = Temperate Northern Pacific

B = Eastern Indo-Pacific

C = several