Poikilolaimus carsiops n. sp. (Rhabditida: Rhabditidae) associated with Neotermes koshunensis (Kalotermitidae) in Kenting National Park, Taiwan

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Summary – During a survey of termite-associated nematodes in southern Taiwan (Kenting National Park), two species of Poikilolaimus, Poikilolaimus cf. floridensis and an undescribed species, were isolated from termites in the family Kalotermitidae. The undescribed species is morphologically observed, described and figured herein as P. carsiops n. sp. The new species is characterised by an unusual cross-shaped stomatal opening formed by two well developed dorsal and two subventral lip sectors, each with a triangular flap and two vestigial lateral lip sectors lacking a flap, and several other morphological characters. Based upon morphology and molecular phylogenetic analysis, P. carsiops n. sp. is closest to P. floridensis; i.e., these two species share a plesiomorphic regular cuticle and short tail in both males and females, and a lack of metastegostomatal teeth or denticle. In the molecular phylogenetic analysis, P. carsiops n. sp. and P. floridensis formed a well-supported clade which was clearly separated from, but monophyletic with, a clade that includes the other Poikilolaimus species. Because both P. carsiops n. sp. and P. floridensis have been isolated only from the kalotermitid termites, the P. floridensis/P. carsiops n. sp. clade is considered to be specialised with dry wood and damp wood termites (Kalotermitidae).

Keywords – description, molecular, morphology, morphometrics, new species, taxonomy.

Termites (Isoptera) are one of the most important insect groups – as urban pests which cause severe damage to structures and products containing wood (Edwards & Mill, 1986) and as critical components of the tropical ecosystems (Bignell & Eggleton, 2000) – and of scientific interest because of their social behaviour and symbiotic associations with micro-organisms. Therefore, termite-associated nematodes could have ecological relevance as potential mutualists, parasites or competitors. However, until recently, there was very little information available about nematode associates of termites (reviewed by Fürst von Lieven and Sudhaus, 2008; Kanzaki et al., 2009a). Only two cases have been reported of nematodes being associated with kalotermitid termites (Pemberton, 1928; Kanzaki et al., 2009a).

In our previous work, we conducted a field survey of termite-associated nematodes in southern Florida, and described Poikilolaimus floridensis Kanzaki & Giblin-Davis, 2009 from Neotermes jouteli (Banks), N. castaneus (Burmeister), Incisitermes snyderi (Light), I. schwarzi (Banks), I. milleri (Emerson) and Cryptotermes cavifrons Banks (Kanzaki et al., 2009a, b). In the present study, we conducted a parallel field survey at Kenting National Park, Taiwan. During this survey, P. cf. floridensis was isolated from two species of termites in the family Kalotermitidae, i.e., N. koshunensis Shiraki and C. domesticus (Haviland),

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and an undescribed Poikilolaimus species was isolated from N. koshunensis. The newly discovered Poikilolaimus species was morphologically and molecularly close to P. floridensis, but was determined to be sufficiently different to be considered a new species. Herein, the new species is described and figured as P. carsiops n. sp. and its molecular phylogenetic status is determined as inferred from SSU rRNA sequences. The generic definition of the genus Poikilolaimus Fuchs, 1930 is further emended because the lateral field morphology of the new species does not fit the previously emended generic definition (Kanzaki et al., 2009a).

Materials and methods

Nematode isolation

Field colonies of termites were collected on 18-21 October 2008 from damp wood, dry wood and soil environments at the Kenting National Park, Taiwan, which is located at the southern tip of Taiwan Island. The termite colonies obtained during the sampling were stored in 50 ml plastic tubes at room temperature until nematode isolation.

In total, 43 colonies from eight species, i.e., four colonies of N. koshunensis, four colonies of C. domesticus, five colonies of I. inamurae (Oshima) (Kalotermitidae), two colonies of Prorhinotermes japonicus (Holmgren), a colony of Coptotermes gestroi (Wasmann), four colonies of Coptotermes formosanus Shiraki (Rhinotermitidae), 15 colonies of Odontotermes formosanus (Shiraki), seven colonies of Nasutitermes takasagoensis (Shiraki) and a colony of Nasutitermes parvonatus (Shiraki) (Termitidae), were collected during the present study (see Table 1).

Twenty to 40 individual termites were randomly chosen from each colony, squashed on a 2.0% water agar plate and incubated at room temperature (ca 25°C). The culture plates were examined with a dissecting microscope daily for 1 month, and the proliferating nematodes were hand-picked and transferred onto a NGM agar plate for continuous sub-culturing. The successfully cultured nematodes served for all subsequent morphological and molecular analyses.

Molecular operational taxonomic unit (MOTU) analysis

Several nematodes were individually collected from each successful culture from different termite host species and locations, and a DNA sample was prepared as described by Ye et al. (2007). The DNA sequences of the molecular operational taxonomic unit (MOTU) barcode (ca 600 bp of ribosomal SSU) was determined following the methods of Powers et al. (2009). The resulting MOTUs were compared with sequences stored in the GenBank database using the BLAST homology search program.

Table 1. Isolation of nematodes from the termites in Kenting, Taiwan.

<table>
<thead>
<tr>
<th>Termite family</th>
<th>Termite species</th>
<th>Number of colonies examined</th>
<th>Isolated nematode species (number of isolates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kalotermitidae</td>
<td>Neotermes koshunensis</td>
<td>4</td>
<td>Poikilolaimus cf. floridensis (1), P. carsiops n. sp. (1), Halicephalobus sp. 3 (3)</td>
</tr>
<tr>
<td></td>
<td>Incisitermes inamurae</td>
<td>5</td>
<td>-1)</td>
</tr>
<tr>
<td></td>
<td>Cryptotermes domesticus</td>
<td>4</td>
<td>P. cf. floridensis (1) H. sp. 3 (1)</td>
</tr>
<tr>
<td>Rhinotermitidae</td>
<td>Prorhinotermes japonicus</td>
<td>2</td>
<td>-1)</td>
</tr>
<tr>
<td></td>
<td>Coptotermes gestroi</td>
<td>1</td>
<td>-1)</td>
</tr>
<tr>
<td></td>
<td>Coptotermes formosanus</td>
<td>4</td>
<td>H. sp. 2 (1), 4 (1)</td>
</tr>
<tr>
<td>Termitidae</td>
<td>Odontotermes formosanus</td>
<td>15</td>
<td>H. sp. 1 (1)</td>
</tr>
<tr>
<td></td>
<td>Nasutitermes takasagoensis</td>
<td>7</td>
<td>H. sp. 1 (1), 5 (1)</td>
</tr>
<tr>
<td></td>
<td>Nasutitermes parvonatus</td>
<td>1</td>
<td>-1)</td>
</tr>
</tbody>
</table>

1)Nematode was not isolated.
**Morphological Observation of Poikilolaimus spp.**

Adults of *P. carsiops* n. sp. from 2-week-old cultures on NGM were killed by heat (65°C), fixed in formalin-glycerin, processed through a glycerin-ethanol series using Seinhorst’s method (see Hooper, 1986) and mounted in glycerin according to the method of Maeseneer and d’Herde (see Hooper, 1986).

For the species description, the morphological terminology suggested by Kiontke and Sudhaus (2000) and Sudhaus and Koch (2004) was employed.

**Molecular Characterisation of *P. carsiops* n. sp.**

In addition to the MOTU barcode, near full length SSU and D2/D3 LSU were determined for the two *Poikilolaimus* species using methods described in Ye et al. (2007) and Kanzaki et al. (2008) to determine the molecular phylogenetic status of these two *Poikilolaimus* species.

The sequences of *Poikilolaimus* species and other rhabditid species were aligned using the MAFFT program (Katoh et al., 2002). Otherwise, we employed the methods in Kanzaki et al. (2009a) for inference of the molecular phylogenetic relationship, i.e., the model of base substitution was evaluated using MODELTEST version 3.7 (Posada & Crandall, 1998), and the molecular phylogenetic tree was constructed by Bayesian analysis using the computer program MrBayes 3.1.2 (Huelsenbeck & Ronquist, 2001) with Markov Chain Monte Carlo methods (Larget & Simon, 1999).

**Results**

**Isolation of Nematodes from Termites**

The results are shown in Table 1. Seven MOTUs were identified from five species of termites, i.e., *P. cf. floridensis*, which is almost identical to *P. floridensis* in general morphology but has several molecular sequence differences (near full length SSU: AB551430; D2/D3 LSU: AB551431), *P. carsiops* n. sp. (near full length SSU: AB553556; D2/D3 LSU: AB5535569), *Halicephalobus* sp. 1 (MOTU: AB551432), *H. sp. 2* (MOTU: AB551433), *H. sp. 3* (MOTU: AB551434), *H. sp. 4* (MOTU: AB551435), *H. sp. 5* (MOTU: AB551436). Within these nematodes, *H. sp. 3* occurred concomitantly with *P. cf. floridensis* and *P. carsiops* n. sp. from *Neotermes koshunensis*. Otherwise, only a single species of nematode was isolated from a single colony of termites. Two *Poikilolaimus* species were isolated only from kalotermitids.

All five *Halicephalobus* MOTUs were close to those of *H. gingivalis* sequences but differed from them. The survey of the Taiwanese termite-associated nematodes is currently ongoing, and the detailed analysis of the nematode fauna and morphological and molecular characterisation of *Halicephalobus* spp. isolated here will be provided elsewhere.

**Poikilolaimus carsiops** Kanzaki, Li & Giblin-Davis n. sp. (Figs 1-3)

**Measurements**

See Table 2.

**Description**

**Adults**

Medium length species. Body cylindrical, slender. Cuticle smooth, thin, with shallow transverse annulations. Lateral field narrow (ca 3 μm) but distinctive, starting just posterior to stoma and continuing almost to posterior end of body. Six lips, each bearing a short and conical labial sensilla at periphery, dorsal and subventral lips well developed, bearing a wide triangular flap almost covering stomatal opening, lateral lips compressed (or vestigial), difficult to distinguish, lacking a flap. Stomatal opening cross-shaped, formed by four (right and left subventral and right and left dorsal) wide triangular flaps. Amphidial apertures elliptical, located at level of posterior end of gymnostom. Cheilostom a short, sclerotised ring. Gymnostom tube-like, occupying ca half of total stoma in lateral view. Stegostom long, tube-like, lacking clear glottoid apparatus, teeth or denticles, almost same length as gymnostom in lateral view, forming pharyngeal sleeve. Dorsal pharyngeal gland orifice located at base of stegostom. Procorpus cylindrical, muscular. Metacorpus not well developed, forming an irregular expansion in lateral view (= median bulb). Isthmus long, slender, muscular. Terminal bulb well developed, muscular, elongated oval to polygonal in form, with clear valvular (grinder) apparatus at middle. Cardia well developed, opening into intestine, funnel-like. Nerve ring surrounding posterior part, two-thirds from anterior end of isthmus. Excretory pore

* Named for its cross-shaped *en face* view, *karsios* (= crosswise in Greek) + *ops* (= eye or face in Greek).
Fig. 1. Poikilolaimus carsiops n. sp. A: Adult male; B: Adult female; C: Anterior region (lateral view); D: Stoma (ventral view); E: Body surface of stomatal region (lateral view); F: Lateral field; G: Schematic drawing of en face view (stomatal opening).
Poikilolaimus carsiops n. sp. from Neotermes koshunensis

Fig. 2. Poikilolaimus carsiops n. sp. A: Anterior region of male gonad; B: Male tail (lateral view); C: Male tail (ventral view); D: Female reproductive system; E: Spicule; F: Female tail (lateral view); G: Female tail (ventral view). Abbreviations: PCS = precloacal sensillum; v1-4 = subventral paired papillae; pd = subdorsal paired papillae; Ph = phasmids.

40 µm for A-C, F, G
125 µm for D
20 µm for E
visible, heavily sclerotised, near anterior end of terminal bulb. Deirid and postdeirid not observed.

**Male**

Testis single, positioned on right of intestine, anterior part reflexed to left in most individuals, germ cells arranged as double and triple rows in anterior (reflexed) part in single or double rows in middle part and in single row in posterior part. Single midventral papilla (pre-cloacal sensillum: PCS) and five pairs of genital papillae present (*i.e.*, 11 papillae in total). Single midventral papilla ca 1.5 cloacal body diam. anterior to cloacal aper-
**Table 2. Morphometrics of Poikilolaimus carsiops n. sp. All measurements are in μm and are in the form: mean ± s.d. (range).**

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Holotype</td>
<td>Paratypes</td>
</tr>
<tr>
<td>n</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>L</td>
<td>655 ± 43 (570-740)</td>
<td>709 ± 38 (660-790)</td>
</tr>
<tr>
<td>a</td>
<td>21.8 ± 2.6 (20.4-28.3)</td>
<td>23.1 ± 2.5 (20.0-30.0)</td>
</tr>
<tr>
<td>b</td>
<td>5.2 ± 0.3 (4.7-5.9)</td>
<td>4.5 ± 0.2 (4.1-4.9)</td>
</tr>
<tr>
<td>c</td>
<td>16 ± 1.6 (14.6-21.1)</td>
<td>17.8 ± 1.1 (15.0-19.0)</td>
</tr>
<tr>
<td>c'</td>
<td>2.0 ± 0.3 (1.6-2.6)</td>
<td>2.3 ± 0.3 (1.9-2.9)</td>
</tr>
<tr>
<td>T or V</td>
<td>45.2 ± 4.1 (35.3-52.7)</td>
<td>56.1 ± 2.7 (51.9-62.5)</td>
</tr>
<tr>
<td>Max. body diam.</td>
<td>30 ± 3.6 (22-36)</td>
<td>31 ± 3.1 (24-35)</td>
</tr>
<tr>
<td>Stoma length</td>
<td>25 ± 1.2 (23-27)</td>
<td>25 ± 1.0 (23-27)</td>
</tr>
<tr>
<td>Stoma diam.</td>
<td>3.0 ± 0.2 (3.0-3.5)</td>
<td>3.5 ± 0.3 (3.0-4.0)</td>
</tr>
<tr>
<td>Stoma length/diam.</td>
<td>7.9 ± 0.3 (7.1-8.2)</td>
<td>7.2 ± 0.5 (6.3-8.3)</td>
</tr>
<tr>
<td>Pro/meta corpus</td>
<td>69 ± 3.1 (64-76)</td>
<td>70 ± 4.2 (60-75)</td>
</tr>
<tr>
<td>Post corpus</td>
<td>56 ± 2.8 (53-65)</td>
<td>62 ± 3.4 (56-71)</td>
</tr>
<tr>
<td>Excretory pore</td>
<td>114 ± 6.2 (106-129)</td>
<td>120 ± 4.5 (111-128)</td>
</tr>
<tr>
<td>Tail length</td>
<td>41 ± 1.8 (35-41)</td>
<td>40 ± 3.1 (36-47)</td>
</tr>
<tr>
<td>Cloacal or anal body diam.</td>
<td>20.5 ± 2.1 (15.0-23.0)</td>
<td>17.5 ± 2.1 (14.0-22.0)</td>
</tr>
<tr>
<td>Testis length</td>
<td>337 ± 38 (290-434)</td>
<td>–</td>
</tr>
<tr>
<td>Anterior ovary</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Posterior ovary</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Vulva body diam.</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Spicule</td>
<td>18.5 ± 0.7 (16.5-19.0)</td>
<td>–</td>
</tr>
<tr>
<td>Gubernaculum</td>
<td>5.5 ± 0.3 (5.5-6.5)</td>
<td>–</td>
</tr>
</tbody>
</table>

1) Procorpus + median bulb length.
2) Isthmus + basal bulb length.
3) Distance from anterior end to excretory pore.
4) Curved median line.

*We are not sure whether this pair is really the homologue of the pd papillae of the stem ancestor. However, judging from its location, the papillae are tentatively referred to as “pd”.

**Male**

Anterior to cloacal aperture, second subventral pair (v2) ca one cloacal body diam. posterior to cloacal aperture, third and fourth subventral pairs (v3 and v4) close to each other, about half way between v2 and tail tip with v4 slightly more posterior and ventral to v3, fifth pair (pd*) dorsal, ca two-fifths of distance between v3/v4 and tail tip. Phasmids (Ph) visible in lateral field, between v3/v4 and pd. Spicules separate, stout, weakly arcuate, each possessing a roundish squared and distinctive capitulum and pointed distal end in lateral view. Gubernaculum short, thorn-like in lateral view, difficult to observe in ventral view. Cloacal region protuberant, slit dome-shaped, anterior lip slightly covering slit. Tail short, conical, ventrally arcuate, distal end bluntly pointed. Bursa absent.

**Female**

Vulval opening an oval-shaped pore, strongly sclerotised, apparently with muscular tissue surrounding vagina when observed in ventral view. Four vaginal glands observed in ventral view, but difficult to confirm in lateral view. Gonads paired, anterior gonad to right, posterior gonad to left of intestine. Ovary antidoromously-reflexed, anterior ovary reflexed to the right, posterior to the left, germ cells (nuclei) arranged as triple rows in distal part and then oocytes arranged as double to single row. Oviducts long, serving as spermatheca. Uterus small, sometimes holding a developing embryo. Junction of uterus and oviduct slightly constricted, connected with a distinctive tissue. Rectum ca 1.5 anal body diam. long, surrounded by sphincter muscle and three large cells (= rectal glands) at...
intestinal-rectum junction. Anus a dome-shaped slit, anterior lip slightly covering opening, posterior lip forming dome-shaped expansion. Tail short, conical, ventrally arcuate, distal end bluntly pointed or forming short and triangular ‘mucro’ in some individuals. Phasmid visible at two-thirds of tail length from anus.

TYPE HOST AND LOCALITY

*Poikilolaimus carsiops* n. sp. was isolated from the squashed body of a *Neotermes koshunensis* worker collected at the Kenting National Park, Taiwan on 21, October 2008.

TYPE MATERIAL

Obtained from 2-week-old cultures of *P. carsiops* n. sp. Holotype male (slide number *P. carsiops* M-01), two paratype males (slide number M-02-03) and three females (slide numbers F-01–F-03) deposited in the National Museum of Natural Science, Taichung, Taiwan (NMNS); three paratype males (slide number M-04-06) and three females (slide numbers F-04–F-06) deposited in the Taiwan Forestry Research Institute, Taipei, Taiwan (TFRI); three paratype males (slide numbers *P. carsiops* M-07–M-09) and three paratype females (slide numbers F-07–F-09) deposited at USDA Nematode Collection, Beltsville, MD, USA; three paratype males (slide numbers *P. carsiops* M-10-12) and three paratype females (slide numbers F-10–F-12) deposited in Fort Lauderdale Research and Education Center, University of Florida, Fort Lauderdale, FL, USA; three paratype males (slide numbers *P. carsiops* M-13–M-15) and three paratype females (slide numbers F-13–M-15) deposited in the Forest Pathology Laboratory collection, Forestry and Forest Products Research Institute, Tsukuba, Japan.

Besides the type specimens, unmounted glycerin-processed materials are deposited in the Harold W. Manter Laboratory of Parasitology, University of Nebraska State Museum, Lincoln, NE, USA, and Canadian National Collection, Ottawa, ON, Canada.

VOUCHER CULTURE

In addition to the fixed type material, a culture has been deposited at the Forest Pathology Laboratory collection, Forestry and Forest Products Research Institute, Tsukuba, Japan.

DIAGNOSIS AND RELATIONSHIPS

*Poikilolaimus carsiops* n. sp. is characterised by its thin and smooth cuticle, long (ca 6-8 times longer than wide) stoma which has a cross-shaped opening formed by four wide triangular flaps, stegostom lacking glottoid apparatus, cuticularised secretory-excretory pore and short tail in both sexes.

The genus *Poikilolaimus* currently contains eight species; namely, *P. ernstmayri* Sudhaus & Koch, 2004, *P. floridensis*, *P. incisocaudatus* (De Coninck, 1935) Andrässy, 1983, *P. istvani* Tahseen, Hussain, Sultana & Khan, 2009, *P. jodhpurensis* (Khera, 1969) Sudhaus & Koch, 2004, *P. oxicercus* (de Man, 1895) Sudhaus & Koch, 2004, *P. piniperdae* Fuchs, 1930 and *P. regenfussi* (Sudhaus, 1980) Sudhaus & Koch, 2004. Relative to these eight species, *P. carsiops* n. sp. is closest to *P. floridensis*. These two species share several important characters, i.e., smooth and tight cuticle, a long stoma lacking a clear tooth or glottoid apparatus, and associations with termites in the family Kalotermitidae. However, the new species is distinguished from *P. floridensis* by the lateral field being tape-like (ca 3 μm wide) vs ridge-like (ca 0.5 μm of width), stoma possessing a cross-shaped opening formed by four triangular flaps vs having an opening closed by six triangular flaps, gymnostom/stegostom length ratio 1 : 1 vs 1 : 2, stomatal length-width ratio of 6-8 vs 5-6, female vulva an oval-shaped pore vs circular pore, male spicule short and stout with roundish capitulum vs long and slender with squared capitulum, and the number and arrangement of male genital papillae ((PCS, v1/v2, (v3, v4), Ph, pd) vs (v1, v2, PCS/v3, v4, pd, Ph, (v5, v6)) (Kanzaki et al., 2009a).

*Poikilolaimus carsiops* n. sp. also shares its tight cuticle and long stoma with *P. istvani* but is distinguished from it by the thinner cuticle, absence of teeth or glottoid apparatus, nerve ring and excretory pore positioned at the level of the posterior vs anterior part of the isthmus, female tail conical vs narrowing just posterior to the anus and somewhat spike-like, spicule short and stout with roundish capitulum vs long and slender with triangular capitulum, number and arrangement of male genital papillae ((PCS, v1/v2, (v3, v4), Ph, pd) vs (v1, v2/v3, v4, ad, pd, v5, v6, v7 = Ph)), phasmid in male simple, pore-like vs papilla-like*, and male tail lacking a bursa and

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* *Poikilolaimus istvani* is assumed to have a pore-like phasmid in males and females and appears to lack a male bursa (presumably because these features are difficult to see or interpret due to its thick cuticle).
Poikilolaimus carsiops n. sp. from Neotermes koshunensis

tail spike vs with bursa and spike (Tahseen et al., 2009). Judging from the drawing and photographs provided in the description, the morphologies of the stomatal opening and the female phasmid of Poikilolaimus istvani are also different from Poikilolaimus carsiops n. sp. (Tahseen et al., 2009). The stoma of Poikilolaimus istvani has six lips of equal size.

EMENDED GENERIC DEFINITION

In the previous study, we identified five generic apomorphic characters of the genus Poikilolaimus from 53 stem-species patterns suggested by Sudhaus and Koch (2004) and emended the generic definition as follows (see Kanzaki et al., 2009a): i) polygonal terminal bulb; ii) strongly cuticularised secretory-excretory pore; iii) phasmids opening at ca 75% of tail length in females; iv) two parallel lateral lines forming a narrow lateral field; and v) absence of deirids and postdeirids.

The new species generally fits the above definition excluding its lateral field morphology, i.e., the new species has a tape-like lateral field which is relatively wider than the ridge-like lateral field observed in the other Poikilolaimus species (Sudhaus & Koch, 2004; Kanzaki et al., 2009a). However, we cannot determine the ancestral polarity of this form of lateral field based upon the molecular phylogenetic analysis. Therefore, we alter the definition of character iv to “iv) lateral field formed by one ridge or band visible as two lateral lines in the light microscope”.

MOLECULAR CHARACTERISATION

Based upon the BLAST search, both near full length SSU and D2/D3 LSU of the two Taiwanese Poikilolaimus species are close to P. floridensis, and formed a well-supported clade within the genus, which was clearly separated from the other four Poikilolaimus species (the phylogenetic tree is not shown because the tree topology did not change from the previous study; see Kanzaki et al., 2009a).

REMARKS

In the present study, two Poikilolaimus species have been isolated only from kalotermitids. Similarly, P. floridensis, the close relative of these Taiwanese Poikilolaimus species, has been isolated from the foreguts of six species of kalotermitid dry wood and damp wood termites, namely, workers of I. snyderi (Light), nymphs of I. schwarzi (Banks), alates and workers of I. milleri (Emerson), workers of Neotermes castaneus (Burmeister), workers of N. jouteli (Banks) and alates of Cryptotermes cavifrons Banks (Kanzaki et al., 2009a, b).

Poikilolaimus carsiops and the other species form a well-supported clade with P. floridensis. During three field surveys (see Kanzaki et al., 2009a, b), this P. floridensis/P. carsiops n. sp. clade has only been isolated from termites belonging to the family Kalotermitidae (= damp wood and dry wood termites). Therefore, we hypothesise that this clade is evolutionarily associated and co-adapted with damp wood and dry wood termites, which prefer relatively dry conditions. Further global surveys focusing on nematode associates of termites are needed to test this hypothesis.

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