

NEW RECORD OF THE SPECIES *Clarkus sheri* (Mulvey, 1967a) Jairajpuri, 1970 (Mononchida: Mononchidae) IN VIETNAM

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ABSTRACT

The genus *Clarkus* with a redescription of *Clarkus sheri* females is recorded and illustrated for the first time in Vietnam. Eight females of *Clarkus sheri* were collected from several natural reserves: Bac Me (Ha Giang province), Van Ban (Lao Cai province), Vu Quang (Ha Tinh province), Kon Chu Rang (Gia Lai province) and Me Linh (Vinh Phuc province). Their measurements and features corresponded well with the type population from California, USA and other populations from South Africa, Mexico, Japan and India.

Keywords: Taxonomy, free-living soil nematodes, natural reserves.

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INTRODUCTION

The genus *Clarkus* (Mononchida, Mononchidae) was proposed by Jairajpuri (1970) as a new genus for fifteen species of the genus *Mononchus* Bastian, 1865, possessing the following main characteristics: (1) Lips and labial papillae prominent; (2) Buccal cavity barrel-shaped with non-denticulate ventral ridge; (3) Dorsal tooth medium size and situated in the anterior half of buccal cavity; (4) Esophago-intestinal junction non-tuberculate; (5) Female productive system didelphic amphidelphic; and (6) Tail conoid, caudal glands poorly developed without or in-conspicuous spinneret. *Clarkus papillatus* (Bastian, 1865) Jairajpuri, 1970 became the type species. Jairajpuri & Khan (1977) erected a new genus *Coomansus*, which differs from the genus *Clarkus* (Mulvey, 1967) Jairajpuri, 1970 in the absence of the ventral ridge, and moved twelve species to the genus *Coomansus* with *C. parvus* as a type species. Currently, fourteen valid *Clarkus* species have been described with the two most recent species discovered being *C. enigmatus* Ahmad, Mizukubo and Yoshida, 2010 from Japan and *C. bulyshevae* Shmatko & Tabolin, 2017 from Rostov, Russia (Andrássy, 2009; Ahmad & Jairajpuri, 2010; Ahmad et al., 2010; Shmatko & Tabolin, 2017).

The species *Clarkus sheri* was first described by Mulvey (1967) as *Mononchus sheri* based on fourteen females and one male from California, USA. Coetzee (1968) described a new species as *Mononchus jugalis* from South Africa but Andrássy (1993) synonymized this species with *Clarkus sheri*. The species *C. sheri* was found also in Mexico (Zullini, 1977), South Africa (De Bruin & Heyns, 1992), Japan (Khan & Araki, 2002; Ahmad et al., 2010) and India (Nusrat et al., 2013).

In Vietnam, only one *Clarkus* species, *C. papillatus* (Bastian, 1865) Jairajpuri, 1970 has been reported (Nguyen, 2007). However, the redescription is poor without illustrations

from Vietnam's specimens. The record of the species *C. sheri* is the first report for the nematode fauna in Vietnam. New data and illustrations of the species *C. papillatus* are also added.

MATERIALS AND METHODS

Pristine soil samples were collected randomly around the base of trees from several nature reserves in Vietnam: Bac Me (Ha Giang province), Vu Quang (Ha Tinh province), Van Ban (Lao Cai province), Kon Chu Rang (Gia Lai province) and Me Linh Biodiversity Station (Vinh Phuc province) during 2020-2021. Nematodes were extracted from soil samples using a modified Baermann funnel technique (Southey, 1986). They were killed by heat, fixed in 4% formaldehyde, transferred to anhydrous glycerol (Seinhorst, 1959), and mounted on glass slides for microscopic observation. Microphotographs were taken with a Nikon digital camera connected onto a Nikon Eclipse Ni microscope and the images were edited using Adobe Photoshop CS6. Permanent slides were stored at the Department of Nematology, Institute of Ecology and Biological Resources, VAST, Ha Noi, Vietnam.

RESULTS AND DISCUSSION

***Clarkus sheri* (Mulvey, 1967) Jairajpuri, 1970 (Fig. 1)**

Materials: eight females in good condition. Measurements: see Table 1.

Female: Large body length, 1.6–2.1 mm, habitus after fixation ventrally arcuate, truncated anteriorly and gradually tapering towards posterior end. Under light microscope: cuticle smooth, 3–5 µm thick at the base of oesophagus. Lip region 28–35 µm wide and 9–11 µm high, offset from the body contour, rounded head with arrangement of labial and cephalic papillae in two circles (6 + 10). Amphideal fovea cup-shaped, aperture 3–4 µm at 6–8 µm from the anterior end of buccal cavity. Buccal cavity large size, 1.7–1.9 as long as wide, barrel shaped, narrowing at base;

its wall strongly sclerotized. Dorsal tooth medium size, its apex situated at about $3/4^{\text{th}}$ of buccal cavity length from its base and front edge almost perpendicular to body axis. The

ventral wall of buccal cavity provided with a longitudinal ridge, originating at anterior level to dorsal tooth apex. Two small but distinct foramina present near the base of buccal cavity.

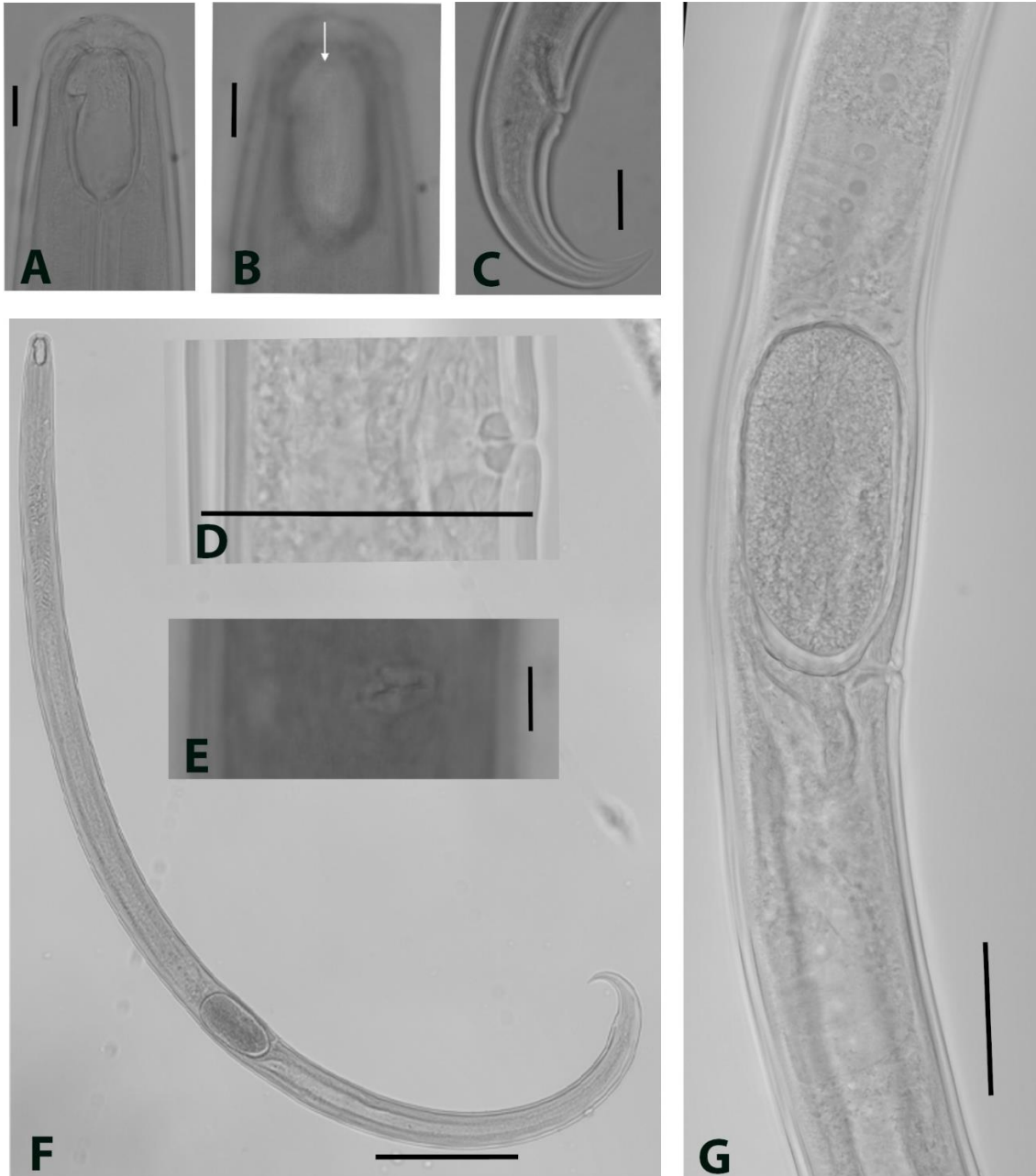


Figure 1. Clarkus sheri (Mulvey, 1967) Jairajpuri, 1970, female. A: Head region; B: Head region with amphid, see arrow; C: Tail region; D: Vagina region showing pars refringens; E: Vulva in ventral view; F: Entire body; G: Reproductive systems (scale bars: A, B, E = 10 μm ; C = 25 μm ; D, G = 50 μm ; F = 200 μm)

Table 1. Comparison of morphometric data of *Clarkus sheri* (Mulvey, 1967) Jairajpuri, 1970

| Local | <i>Clarkus sheri</i> (Mulvey, 1967) Jairajpuri, 1970 | | | | | | | |
|--|--|-----------------|-------------------|------------------|-------------------|------------------|-----------------|-----------------------|
| | California, USA (Mulvey, 1967) | | | Bac Me, Ha Giang | Vu Quang, Ha Tinh | Van Ban, Lao Cai | Me Linh, Ha Noi | Kon Chu Rang, Gia Lai |
| Characters | Holotype ♀ | Paratype 1 ♂ | Paratype 13 ♀♀ | 4 ♀♀ | 1 ♀ | 1 ♀ | 1 ♀ | 1 ♀ |
| L (mm) | 1.8 | 1.8 | 1.6–2.1 | 1.6–2.1 | 1.8 | 1.6 | 1.7 | 1.6 |
| V (%) | 59 | - | 59–63 | 60–61 | 62 | 61 | 58 | 59 |
| a | 27 | 33 | 24–30 | 28–32 | 32 | 32 | 27 | 31 |
| b | 4.2 | 4.3 | 3.9–4.3 | 4.1–4.4 | 4.4 | 4.2 | 4.6 | 4.1 |
| c | 17 | 22 | 16–21 | 16–18 | 18 | 18 | 15 | 16 |
| c' | 3.0* | 2.4* | - | 2.8–3.2 | 2.6 | 2.6 | 2.9 | 2.7 |
| Oesophageal length (µm) | - | - | - | 383–468 | 416 | 390 | 365 | 380 |
| Position excretory pore of oesophageal region length (%) | - | - | - | 35–39 | 35 | 36 | 35 | 37 |
| Position nerve-ring of oesophageal length (%) | - | - | - | 31–35 | 30 | 33 | 32 | 33 |
| Buccal cavity length (µm) | 35 | 33 | 32–38 | 37–42.5 | 39 | 38 | 37 | 38 |
| Buccal cavity width (µm) | 20 | 20 | 19–23 | 20–23 | 22 | 22 | 21 | 21 |

| Local | <i>Clarkus sheri</i> (Mulvey, 1967) Jairajpuri, 1970 | | | | | | | |
|--|--|--------|-------|------------------|-------------------|------------------|-----------------|-----------------------|
| | California, USA (Mulvey, 1967) | | | Bac Me, Ha Giang | Vu Quang, Ha Tinh | Van Ban, Lao Cai | Me Linh, Ha Noi | Kon Chu Rang, Gia Lai |
| Position of dorsal tooth apex (%) from the base of buccal cavity | 75* | - | 72–75 | 72–74 | 72 | 74 | 72 | 75 |
| G1 (%) | - | - | - | 10.3–12.3 | 11.4 | 10.4 | 13.2 | 10.8 |
| G2 (%) | - | - | - | 8.1–10.7 | 11.3 | 10.5 | 13.5 | 9.3 |
| Lip region height (µm) | - | - | - | 10–11 | 10 | 11 | 9 | 11 |
| Lip region width (µm) | 31* | - | - | 28–35 | 33 | 35 | 34 | 32 |
| Body width at the base of oesophageal (µm) | - | - | - | 46–65 | 54 | 48 | 54 | 51 |
| Maximum body width (µm) | - | - | - | 53–69 | 57 | 52 | 62 | 51 |
| Anal body width (µm) | - | - | - | 35–40 | 40 | 36 | 40 | 37 |
| Vagina length (µm) | - | - | - | 18–24 | 18 | 19 | 19 | 21 |
| Rectum length (µm) | - | - | - | 28–40 | 29 | 31 | 34 | 33 |
| Tail length (µm) | 105 | 85–108 | - | 97–116 | 104 | 93 | 118 | 100 |
| Spicule length (µm) | - | 80 | - | - | - | - | - | - |
| Supplements | - | 10 | - | - | - | - | - | - |

Notes: * Calculated from original drawings; - No information.

Table 2. Comparison of morphometric data of the *Clarkus sheri* (Mulvey, 1967) Jairajpuri, 1970 females from different countries

| <i>Clarkus sheri</i> (Mulvey, 1967) Jairajpuri, 1970 | | | | | | | | | | | | |
|--|--------------|---------------|---------------|-------------------------|------------------------|--------------|--------------|--------------|--------------------|--------------------|---------------------|---------------|
| Reference | Mulvey, 1967 | Coetzee, 1968 | Zullini, 1977 | Jairajpuri & Khan, 1982 | De Bruin & Heyns, 1992 | | | | Khan & Araki, 2002 | Ahmad et al., 2010 | Nusrat et al., 2013 | Current paper |
| Local | USA | South Africa | Mexico | India | South Africa | South Africa | South Africa | South Africa | Japan | Japan | India | Vietnam |
| Characteristics | 14 ♀♀ | 13 ♀♀ | 1 ♀ | ? ♀♀ | 2 ♀♀ | 5 ♀♀ | 3 ♀♀ | 4 ♀♀ | 8 ♀♀ | 2 ♀♀ | 6 ♀♀ | 8 ♀♀ |
| L (mm) | 1.6–2.1 | 1.5–1.9 | 2.1 | 1.9–2 | 2.2–2.5 | 1.8–2.3 | 1.5–2 | 1.7–2.2 | 1.8–2.0 | 1.8; 2.1 | 1.5–1.9 | 1.6–2.1 |
| V (%) | 59–63 | 60–64 | 63 | 58–61 | 57–61 | 60–63 | 61–64 | 61–65 | 63–64 | 61; 58.5 | 59–65 | 58–62 |
| a | 24–30 | 21–29 | 29 | 23–27 | 34–36 | 21–34 | 24–35 | 21–26 | 32–35 | 25; 23 | 21–26 | 27–32 |
| b | 3.9–4.3 | 4 | 4 | 3.9–4.6 | 4.9–5.1 | 3.7–4.8 | 4–4.3 | 4.2–4.5 | 4.1–4.5 | 4.2; 4.2 | 3.6–4.3 | 4.1–4.6 |
| c | 16–21 | 14–19 | 21 | 14–17 | 17–18 | 16–19 | 15–18 | 17–19 | 18–21 | 20; 17 | 13–16 | 15–18 |
| c' | 3.3* | 3.1* | 2.7* | 3.3* | 2.7–3.4 | 2.4–3.2 | 2.7–2.8 | 2–2.5 | 2.3–2.8 | 2.3; 2.5 | 2.6–3.0 | 2.6–3.2 |
| Dorsal tooth apex from the base (%) | 72–75 | 70–75 | 77* | 70–73 | 77 | 71–77 | 73–77 | 73–72 | 70–75 | 76–77 | 66–72 | 72–75 |
| Buccal cavity length (µm) | 32–38 | 40* | 41 | 34–38 | 40 | 38–43 | 36–43 | 38–40 | 41–43 | 39; 41 | 39–43 | 37–42 |
| Buccal cavity width (µm) | 19–23 | 23* | 22* | 16–18 | 16 | 15–20 | 14–16 | 16–21 | 22–23 | 21; 23 | 20–23 | 20–23 |
| Tail length (µm) | 85–108 | 115* | 110 | 100–110 | 127–143 | 110–134 | 96–131 | 98–115 | 89–106 | 92; 124 | 108–169? | 93–118 |

Note: *: Calculated from original drawings.

Oesophagus cylindroid, 365–468 μm long, encircled by the nerve ring at 116–149 μm or approximately 30–35% of its length from anterior end. Secretory-excretory pore conspicuous with a distinctly sclerotized terminal duct; situated just posterior to the nerve ring about 130–163 μm or approximately 35–39% of its length from the anterior end. Oesophago-intestinal junction non-tuberculate. Cardia projecting into intestinal lumen. Rectum straight, thick-walled, 28–40 μm or 0.7–1 times anal body diameter long.

Reproductive system didelphic-amphidelphic with both branches equally developed, 162–254 μm or approximately 8.1–13.5% body length. Ovaries reflexed, 83–135 μm . Sphincter at oviduct-uterus junction poorly developed. Vulva a transverse slit in ventral view. Vagina length 18–24 μm or about one-third to two-fifth of the corresponding body width, *par refringens* drop-shaped, well sclerotized pieces, measuring 4–7 \times 3–4 μm . In two females, uterus with one or two eggs measuring 103–110 \times 45–52 μm .

Tail conoid shape, curved, 93–118 μm long or about 2.6–3.2 anal body diameter. Caudal glands poorly developed without spinneret. Tail tip fine, slightly round with a hyaline portion as 8–10.5 μm long.

Male: Not found.

Remarks: The measurements of the Vietnamese specimens corresponded well with those of holotype female and paratype specimens from California, USA except for having slightly longer length of buccal cavity (37–42 μm vs 32–38 μm after Mulvey, 1967) and completely agreed with previous populations from South Africa (Coetzee, 1968; De Bruin & Heyns, 1992), Mexico (Zullini, 1977), Japan (Khan & Araki, 2002; Ahmad et al., 2010) and India (Jairajpuri & Khan, 1982; Nusrat et al., 2013) (see Table 2).

Locality: four females were found at Bac Me Natural Reserve, Ha Giang province (N = 22°43'5", E = 105°12'4", altitude at 320 m); one female at Van Ban Natural Reserve, Lao

Cai province (N = 22°1'34", E = 103°58'46", altitude 860 m); one female at Vu Quang National Park, Ha Tinh province (N = 18°17'21", E = 105°21'39", altitude 110 m); one female at Kon Chu Rang Natural Reserve, Gia Lai province (N = 14°29'05", E = 108°32'04", altitude 1010 m); one female at Me Linh Biodiversity Station, Vinh Phuc province (N = 21°40'22", E = 105°15'27", altitude 550 m).

Clarkus papillatus (Bastian, 1865) **Jairajpuri, 1970** (Fig. 2)

Materials: seven females in good condition. Measurements: see Table 3.

Female: Body medium size, 0.8–1 mm, habitus ventrally curved after fixation, truncated anteriorly and gradually tapering towards posterior end. Under light microscope: cuticle smooth, 1.5–2.5 μm thick at the base of oesophagus. Lip region offset from the body contour, 21–23 μm wide and 9–11 μm high, rounded head with arrangement of labial and cephalic papillae in two circles (6 + 10). Amphideal fovea cup-shaped, oval aperture 2.5–3 μm , located at the level or slightly anterior to dorsal tooth apex. Buccal cavity medium size, 1.8–2 times as long as wide, barrel shaped, narrowing at base; its wall strongly sclerotized. Dorsal tooth medium size, its apex situated at about 81–89% of buccal cavity length from its base and front edge direct forward. The ventral wall of buccal cavity provided with a longitudinal ridge, originating at the point opposite to dorsal tooth apex. Two small but distinct foramina present near the base of buccal cavity.

Oesophagus cylindroid, 250–300 μm long, nerve ring at 88–103 μm or approximately 27–34% of its length from anterior end. Secretory-excretory pore situated just posterior to the nerve ring about 98–118 μm or approximately 37–40% of its length from the anterior end. Oesophago-intestinal junction non-tuberculate. Cardia projecting into intestinal lumen. Intestinal lumen wide. Rectum straight, 16–20 μm or 0.8–1 times anal body diameter long.

Reproductive system didelphic-amphidelphic with both branches equally developed, 88–130 μm or approximately 10–13% body length. Ovaries reflexed, oviduct narrow connected to uterus without apparent sphincter. Vulva a transverse slit in ventral view. Vagina length 11–15 μm or about 30–40% of the corresponding body diameter, *par refringens* small, round-shaped, well sclerotized pieces, measuring 2–3 μm diameter long.

Tail conoid shape, curved, 61–82 μm long or about 2.6–4 anal body diameter. Caudal glands and spinneret absent. Tail tip fine, rounded terminus with a hyaline portion as 5–6.5 μm long.

Male: Not found.

Remarks: The species *C. papillatus* is the most wide distribution of the genus *Clarkus* and have been reported from all continents except Antarctica (Andrássy, 2009). The present specimens show morphological as well as morphometric characteristics similar to specimens of *Clarkus papillatus* described previously (Clark, 1960; Mulvey, 1967; De Bruin & Heyns, 1992; Ahmad et al., 2010) (see Table 3).

Locality: seven females were found at Van Ban Natural Reserve, Lao Cai province (N = 22°1'34", E = 103°58'46", altitude 860 m). Previous localities were recorded at Ha Noi City and other provinces as Lam Dong, Ha Giang, Cao Bang, Vinh Phuc, Ha Tinh, Bac Kan.

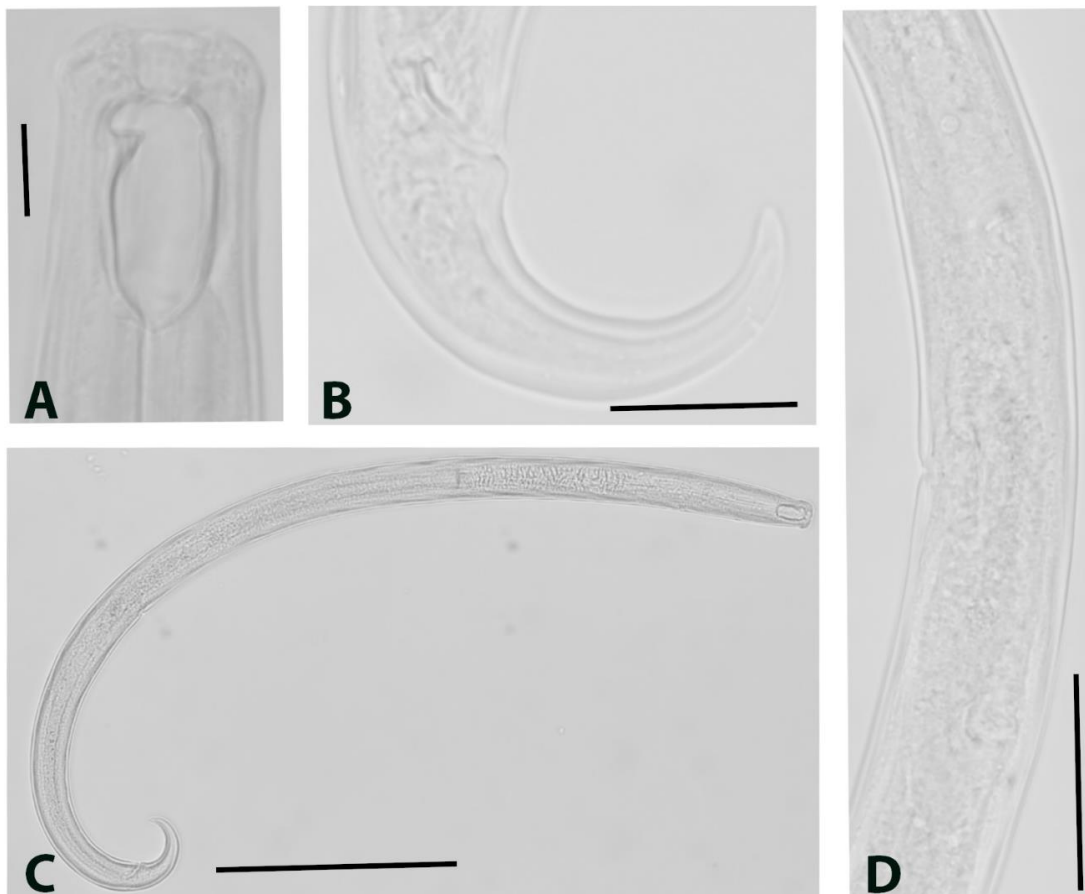


Figure 2. *Clarkus papillatus* (Bastian, 1865) Jairajpuri, 1970, female. A: Head region; B: Tail region; C: Entire body; D: Reproductive systems (scale bars: A = 10 μm ; B = 25 μm ; C = 200 μm ; D = 50 μm)

Table 3. Comparison of morphometric data of *Clarkus papillatus* (Bastian, 1865) Jairajpuri, 1970

| Reference | <i>Clarkus papillatus</i> (Bastian, 1865) Jairajpuri, 1970 | | | | | | | |
|--|--|---------|--------------|---------|------------------------|---------|--------------------|---------------|
| | Clark, 1960 | | Mulvey, 1967 | | De Bruin & Heyns, 1992 | | Ahmad et al., 2010 | Current paper |
| Local | England | | Canada | | South Africa | | Japan | Vietnam |
| Characters | 1 ♀ | 9 ♀♀ | 20 ♀♀ | 3 ♂♂ | 7 ♀♀ | 4 ♀♀ | 10 ♀♀ | 7 ♀♀ |
| L (mm) | 1.3 | 1–1.3 | 0.8–1.4 | 1–1.1 | 1–1.2 | 0.9–1.1 | 0.8–1 | 0.8–1 |
| V (%) | 62 | 60–68 | 60–64 | - | 61–63 | 62–64 | 60–65 | 60–62 |
| a | 29 | 22–29 | 19–26 | 23–26 | 22–27 | 23–27 | 18–26 | 22–28 |
| b | 3.9 | 3.6–3.9 | 3.2–3.8 | 3.2–3.4 | 3.4–3.8 | 3.4–4.8 | 3–3.6 | 3.3–3.6 |
| c | 19 | 14–19 | 14–17 | 14–15 | 13–18 | 14–16 | 10–13 | 12–16 |
| c' | 2.5* | - | - | 2.3* | 2.6–3.6 | 2.8–3.1 | 2.5–3.1 | 2.6–4 |
| Oesophageal length (µm) | - | - | - | - | - | - | 234–313 | 250–300 |
| Position excretory pore of oesophageal region length (%) | - | - | - | - | - | - | - | 37–40 |
| Position nerve-ring of oesophageal length (%) | - | - | - | - | - | - | - | 27–34 |
| Buccal cavity length (µm) | 27* | - | 20–26 | 25–28 | 24–27 | 24 | 25–27 | 23–25 |
| Buccal cavity width (µm) | 13* | - | 10–12 | 13–14 | 9–14 | 9–10 | 14–15 | 12–13 |

| Reference | <i>Clarkus papillatus</i> (Bastian, 1865) Jairajpuri, 1970 | | | | | | | |
|--|--|---|--------------|-------|------------------------|-------|--------------------|---------------|
| | Clark, 1960 | | Mulvey, 1967 | | De Bruin & Heyns, 1992 | | Ahmad et al., 2010 | Current paper |
| Position of dorsal tooth apex (%) from the base of buccal cavity | 86* | - | - | 83* | 84–91 | 83 | - | 81–89 |
| G1 (%) | - | - | - | - | - | - | 9–21 | 10–13 |
| G2 (%) | - | - | - | - | - | - | 9–12 | 10–13 |
| Lip region height (µm) | - | - | - | - | 8–9 | 7–8 | 9–10 | 6.3–8 |
| Lip region width (µm) | 24* | - | - | 24* | 22–25 | 22–26 | 24–26 | 21.5–23 |
| Body width at the base of oesophageal (µm) | - | - | - | - | - | - | 38–44 | 29–35 |
| Maximum body width (µm) | - | - | - | - | - | - | 33–45 | 35–42 |
| Anal body width (µm) | - | - | - | - | - | - | 25–28 | 21–25 |
| Vagina length (µm) | - | - | - | - | - | - | 14–16 | 11–15 |
| Rectum length (µm) | - | - | - | - | - | - | 17–22 | 16–20 |
| Tail length (µm) | 108* | - | 58–85 | 82* | 69–83 | 60–68 | 70–85 | 61–82 |
| Spicule length (µm) | - | - | - | 60 | - | - | - | - |
| Supplements | - | - | - | 10–14 | - | - | - | - |

Notes: *: Calculated from original drawings; -: No information.

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