Descriptions of Larval *Contracaecum variegatum* (Rudolphi, 1809) and Adult *Contracaecum* sp. (Nematoda: Anisakidae) Collected from Seabirds of the Bering Sea

Kazuya Nagasawa*, Vlastimil Baruš** and Haruo Ogi***

**Abstract.** Third- and fourth-stage larvae of *Contracaecum variegatum* (Rudolphi, 1809) are described from specimens collected from the stomachs of the Thick-billed Murre (*Uria lomvia*), Common Murre (*U. aalge*), and Tufted Puffin (*Lunda cirrhata*) from the Bering Sea. The Tufted Puffin is a new definitive host for *C. variegatum*. Almost all of the seabirds examined were infected with a relatively high intensity with *C. variegatum*. It would therefore appear that this parasite is a very common and abundant nematode of seabirds in the Bering Sea. *Contracaecum yamaguti* (Mawson, 1956) is considered a junior synonym of *C. variegatum*. An adult of *Contracaecum* sp. with an aberrant ventricular appendix is described based on one fragment of a specimen from the stomach of the Common Murre.

**Key words:** *Contracaecum variegatum*, *Contracaecum* sp., Parasitic nematodes, Seabirds, Alcidae, Bering Sea.

Introduction

*Contracaecum variegatum* was originally described as *Ascaris variegata* by Rudolphi (1809) from the type host, Red-throated Dives *Gavia stellata*, in Greifswald, Germany. The nematode had been regarded as a junior synonym of *Ascaris spiculigera* Rudolphi, 1819 (=*Contracaecum rudolphii* Hartwich, 1964) for a long time. However, based on re-examination of the type material, Hartwich (1964) established these nematodes as valid species and transferred them to the genus *Contracaecum* Railliet et Henry, 1912. Hartwich (1964, 1975) also regarded four species of *Contracaecum*, i.e., *C. magnipapillatum* Chapin, 1925 (from Black Noddies *Anous minutus* [as Megalopterus hawaiiensis], Hawaii), *C. torquatum* Yamaguti, 1935 (from Common Gulls *Larus canus*, Japan), *C. oschmarini* Mozgovoy, 1950 (from Thick-billed Murres *Uria lomvia*, Kamchatka), and *C. magnicollare* Johnston et Mawson, 1941 (from Brown Noddies *Anous stolidus*, Queensland), as junior synonyms of *C. variegatum*. However, a new and different view on the synonymy of *C. variegatum* was recently published by Fagerholm et al. (1996), who thought that both *C. magnipapillatum* and *C. magnicollare* are conspecific and differ-
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They also stated that the status of C. torquatum and C. oschmarini remains uncertain.

During examination of a nematode collection from seabirds collected in the Bering Sea, we found adult and larval C. variegatum and adult Contracaecum sp. (fragment only). Adult mature specimens of C. variegatum in our collection are morphometrically identical with a detailed redescription made by Hartwich (1964, 1975). Our larval specimens of C. variegatum included third- and fourth-stage larvae, some of which were found in the molting process. As our knowledge on the life cycle of this species is limited, we here describe the larvae. Morphological information on the larvae, especially that of third-stage larvae, may be useful when larval C. variegatum are found in its intermediate or paratenic hosts. An adult Contracaecum sp. is also briefly described.

**Materials and Methods**

Three species of seabirds, i.e., Thick-billed Murres (*Uria lomvia*), Common Murres (*U. aalge*), and Tufted Puffins (*Lunda cirrhata*), were collected in the Bering Sea (55°00'–64°00'N, 172°00'–175°05'W, Fig. 1) in June and July of 1976 and 1977. The birds were entangled in surface gillnets for salmon research. They were frozen on board and brought to the laboratory, where the stomachs were removed and fixed in 10% formalin. When the stomachs were opened for food analysis, nematodes were taken and preserved in 70% alcohol. Two terms, prevalence and intensity, follow the definitions given by Bush et al. (1997).

For examination in light microscopy, specimens were cleared in glycerin. Drawings

Fig. 1. A map of the Bering Sea, showing locations of seabirds collected in 1976 and 1977. Numerals show the number of seabirds collected.
were made with the aid of a camera lucida. Measurements are given in millimetres. Voucher specimens are deposited in the National Science Museum, Tokyo (for C. variegatum NSMT-As 2834 and 2835 from the Thick-billed Murre; NSMT-As 2832 from the Common Murre; NSMT-As 2836 from the Tufted Puffin; and for Contracaecum sp. NSMT-As 2833 from the Common Murre).

Results

Contracaecum variegatum (Rudolphi, 1809)

(Figs. 2–3)

Description of third-stage larvae (based on 15 specimens in the molting phase, from the Thick-billed Murre)

Larval body surrounded by cuticular sheath, distinctly undulated and getting loose in its middle part. Transverse striation of cuticle irregular, with intervals ranging from 0.011 to 0.026. Cephalic end rounded, with three small lips and without distinct interlabia. Cervical collar from transversely striated cuticle not developed. Sex at this stage not
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**Fig. 3.** *Contracaecum variegatum* male fourth-stage larva in the molting phase, from the Thick-billed Murre (*Uria lombia*) in the Bering Sea. A, cephalic end (ventral view); B, stomach region; C, caudal end (ventral view); D, caudal end (lateral view). c, intestinal caecum; co, cloacal opening; cp, cervical papillae; fg, first group of postcloacal papillae; il: ventrolateral lip; n, nerve ring; o, oesophagus; pp, precloacal papillae; sg, second group of postcloacal papillae; v, ventriculus; va, ventricular appendix.

**Fig. 3.** *Contracaecum variegatum* male fourth-stage larva in the molting phase, from the Thick-billed Murre (*Uria lombia*) in the Bering Sea. A, cephalic end (ventral view); B, stomach region; C, caudal end (ventral view); D, caudal end (lateral view). c, intestinal caecum; co, cloacal opening; cp, cervical papillae; fg, first group of postcloacal papillae; il: ventrolateral lip; n, nerve ring; o, oesophagus; pp, precloacal papillae; sg, second group of postcloacal papillae; v, ventriculus; va, ventricular appendix.

**Description of fourth-stage larvae** (based on 10 male and 10 female specimens in the molting phase, from the Thick-billed Murre)

Body 2.21–4.45 in length and 0.10–0.16 in maximum width. Height of lips 0.024–0.033, and maximum width of cephalic end 0.042–0.087. Oesophagus straight, 0.44–0.79 long and 0.035–0.047 wide. Nerve ring and cervical papillae situated 0.16–0.25 and 0.27–0.32, respectively, from anterior extremity. Distinct ventriculus present, 0.032–0.045 long and 0.040–0.057 wide. Intestinal caecum oriented anteriorly, 0.30–0.52 long, and ventricular appendix oriented posteriorly, 0.16–0.36 long. Length ratio of ventricular appendix and intestinal caecum 1: 1.5–1.9. Dark coloured intestine transient to rectum 0.032–0.040. Tail conical, 0.077–0.123 long. Phasmids not located.

Cuticular sheath distinctly separated from larval body, in some specimens already broken on head and cervical parts which are then loose. Cephalic end with three fully formed lips and with three interlabia (their peaks slightly bifurcated). Excretory pore situated at level of lip base. Cervical collar formed by transverse striation of cuticle present. It is formed by 15–18 transverse striae forming the characteristic cuticular denticulation, with peaks oriented anteriorly. Sex differentiation evident. Caudal papillae and spiculae discernible in males, and location of vulva, vagina, and uterus (without eggs as yet) discernible in females. Distinct mucron present in both sexes.
In males, length of body 6.02–8.73, maximum width 0.27–0.35. Height of lips 0.060–0.093, and height of interlabia 0.042–0.058. Maximum width of cephalic end 0.10–0.17. Cervical cuticular collar 0.032–0.041 long. Oesophagus 1.10–1.79 long and 0.072–0.093 wide. Nerve ring and cervical papillae situated 0.27–0.34 and 0.36–0.45, respectively, from anterior extremity. Ventriculus 0.060–0.123 in length and 0.090–0.136 in maximum width. Intestinal caecum 0.60–0.92 long, and ventricular appendix 0.36–0.45 long. Length ratio of ventricular appendix and intestinal caecum 1 : 1.5–2.0. Two spiculae, only weakly sclerotized as yet and situated in spicular sheath. Length of spiculae 1.08–2.70, and maximum width 0.012–0.015. Posterior extremity tapers with conical tail, 0.11–0.17 long. Precloacal papillae of 28–33 pairs situated in two longitudinal rows on ventral body side up to 1.83–2.35 from posterior extremity. Postcloacal papillae of 7 pairs in total. First two pairs situated lateral at small distance below cloacal opening, and other 5 pairs at middle and lower parts of tail (3 pairs more lateral, 2 pairs more median).

In females, length of body 6.05–7.89, maximum width 0.24–0.38. Height of lips 0.060–0.084, and height of interlabia 0.038–0.055. Maximum width of cephalic end 0.081–0.170. Cervical cuticular collar 0.030–0.048 long. Oesophagus 0.96–1.65 long and 0.057–0.132 wide. Ventriculus 0.044–0.092 in length and 0.078–0.107 in maximum width. Intestinal caecum 0.55–0.99 long, and ventricular appendix 0.34–0.45 long. Length ratio of ventricular appendix and intestinal caecum 1 : 1.5–2.2. Vulva shaped in transverse slit, situated on ventral body side at distance 1.68–2.75 from anterior extremity. Vulvar index (cf. Hartwich 1964) 28–38%. Posterior extremity conical, tail 0.12–0.18 long. One pair of phasmids situated close to posterior end, at distance 0.039–0.050 from peak.

Contracaecum sp.

Description (based on one fragment of the anterior part of the body, from the Common Murre)

Length of fragment 8.03, maximum width 0.55. Height of lips 0.075, and height of interlabia 0.050 with peaks slightly bifurcated. Excretory pore situated at level of lip base. Cervical cuticular collar 0.033 long, formed by 7–8 transverse striae. Cuticle on body with transverse striation in intervals 0.010–0.016. Oesophagus 1.98 long and 0.14 wide. Nerve ring and cervical papillae situated 0.35 and 0.24, respectively, from anterior extremity. Ventriculus 0.12 in length and 0.15 in maximum width. Ventricular appendix oriented anteriorly, 0.27 long. Intestinal caecum 0.33 long. Length ratio of ventricular appendix and intestinal caecum 1 : 1.2.

Prevalence and intensity of infection

All of 23 (prevalence = 100%) Thick-billed Murres (18 in 1976 and 5 in 1977) were infected with larval and/or adult C. variegatum. Only two (9%) birds harboured both adults and larvae, and the remaining 16 (70%) and five (22%) birds had infection with adults and larvae, respectively. Intensity of infection with adult worms ranged from 1 to 37 (mean 8.9), and females prevailed males in adult specimens (97 females/161 adults,
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Fig. 4. *Contracaecum* sp. adult from the Common Murre (*Uria aalge*) in the Bering Sea. A, cephalic end (dorsal view); B, stomach region. c, intestinal caecum; cc, cervical collar; dl, dorsal lip; e, excretory pore; i, intestine, il, interlabium; o, oesophagus; v, ventriculus; va, ventricular appendix.

60%). Intensity of larval infection ranged from 1 to 6 (mean 3.2) except for one case, in which as many as 181 larvae were found in a single bird. Three of the 18 Thick-billed Murres collected in 1977 were also infected with the acuariid nematode *Stegophorus stellaepolaris* (Nagasawa et al. 1998).

Two Common Murres (1 in 1976 and 1 in 1977) were infected each with 45 larval *C. variegatum* and one adult *Contracaecum* sp. (fragment) (prevalence = 50% for each parasite). All of 13 (100%) Tufted Puffins (all in 1976) were infected with larval *C. variegatum*. Intensity of infection usually ranged from 3 to 73 (mean 24.0), but two birds harbourd 632 and 672 (mean 652.0) larvae, individually. No adult *C. variegatum* was found in these two species of seabirds.

The worms had their extremities embedded in the lining of the host's stomach. Although pathological observations were not for all birds, there were ulcerated nodular lesions in the stomach of a Tuffed Puffin infected with 632 larvae.

Discussion

We identified larval and adult contracaecine nematodes from Bering Sea seabirds as *C. variegatum* based on redescriptions given by Hartwich (1964, 1975) for this species. There was a full conformity in morphological feature, such as in the shape of lips, bifurcated interlabia, cervical collar, intestinal caecum, and ventricular appendix, in the distribution of caudal papillae and sharply pointed distal end of spiculae in males, and in the shape of tail end with a distinct mucron of females. Metrical features, mainly for
fourth-stage larvae in our material, correspond or very close to lower limits of variability reported for mature worms of *C. variegatum*.


Yamaguti (1941) described *Contracaecum* sp. from Goosanders (*Mergus merganser*) collected in Japan. Mawson (1956) found the same nematode parasite in the same host in Canada and described it as a new species, *C. yamaguti*. Since there are no significant morphological differences between *C. yamaguti* and *C. variegatum*, we propose that *C. yamaguti* is a junior synonym of *C. variegatum*.

Fagerholm *et al.* (1996) published a revisional study of contracaecine nematodes from three species of the genus *Anous* from Australia. In comparison of their material with type specimens of *C. magnipapillatum*, they accepted this taxon as a valid species and regarded it as a senior synonym of *C. magnicollare*. This conclusion is different from the opinion of Hartwich (1975) who considered that both species are conspecific and identical with *C. variegatum*. However, we think that Fagerholm *et al.*'s suggestion is acceptable.

Fagerholm *et al.* (1996) examined specimens of *C. variegatum* and confirmed the similarity between this species and *C. magnipapillatum*, especially in the features of the mail tail. However, *C. magnipapillatum* is differentiated from *C. variegatum* based on the morphology of the finger-like interlabia lacking a proximal bifurcation and of the lips having lateral auricles forming inwardly bent hook-like extensions. There is no doubt that our specimens are very close to *C. variegatum*. In addition to the particular and different form of interlabia, *C. variegatum* possesses a distinct mucron on the tail tip in both sexes and the distal end of spicules of males is always sharply pointed (Hartwich 1964, Baruš *et al.* 1978, present study).

In the connection with the richness in species of the genus *Contracaecum*, we think it necessary to pay attention to the presence of the cuticular collar posterior to the base of lips. The presence or absence of this feature enables to distinguish two different groups of species within this genus. We assume that this character may have a higher taxonomic importance.

As to *Contracaecum* sp. described above, the exact species identification was impossible because we had only one fragment specimen of the anterior body. However, the specimen had the unique morphological feature which was the anterior orientation of the ventricular appendix. This is a very rare feature in species of the genus *Contracaecum*. Only two similar cases exist in the literature: Karokhin (1949) and Berland (1981) found the aberrant anterior orientation of the ventricular appendix in an adult specimen of *C. ovale* (Linstow 1907) and a third-stage larva of *Contracaecum* sp., respectively. Moreover, Deardorff (1982) reported a case of the posteriorly directed intestinal caecum in *Contracaecum* sp.

The reciprocal length ratio of ventricular appendix and intestinal caecum may be
useful in distinguishing larval forms of the genus *Contracaecum* parasitic in intermediate or paratenic hosts. Since this feature is found in the third larval stage soon after infection of definitive hosts, we think that it may be present as early as in third-stage larvae. For example, for third-stage larvae of *C. microcephalum* (Rudolphi, 1809), *C. micropapillatum* (Stossich, 1890), *C. osculatum* (Rudolphi, 1802), and *C. ovale*, the ventricular appendix is longer than the intestinal caecum, and the length ratio is thus lower than 1:1 (Moravec 1994). For third-stage larvae of *C. rudolphii*, the length ratio is about 1:3, ranging from 1:2.9–3.5 (Moravec 1994), and for those of *C. variegatum*, the ratio is 1:1.5–1.9 (present study). Thus, *C. variegatum* third-stage larvae can be distinguishable from those of other species based on the length ratio of ventricular appendix and intestinal caecum. There are also differences in the shape of cephalic end between third-stage larvae of both *C. variegatum* and *C. rudolphii*.

It has been reported that nematodes of the genus *Contracaecum* infecting the stomach of seabirds induce various pathological lesions (Fagerholm 1996). We actually found ulcerations in the heavily infected stomach of a Tuffed Puffin. Similar observations were made by Fagerholm *et al.* (1996) for Black Noddies infected with *C. magnipapillatum* from the Great Barrier Reef, Australia. As our knowledge is very limited about the pathogenicity of seabird-infecting nematodes (Fagerholm 1996), more study is needed to assess their impact on the host at both individual and population levels.

Our study shows that all of the seabirds examined, except for one Common Murre, were infected with a relatively high intensity with *C. variegatum*. This indicates that the parasite is a common and abundant nematode of seabirds in the Bering Sea. In addition, larvae of *C. variegatum* were frequent and sometimes abundant in our samples. The seabirds were collected in June and July, which suggests that these months are the parasite's major recruitment season to definitive seabird hosts from intermediate or paratenic hosts. If this is true, it seems that seasonal changes in feeding intensity and food composition of the seabirds are related to seasonal variations in the parasite's recruitment. Parasitological examination of food animals of the seabirds, such as planktonic invertebrates and epipelagic fishes, should be made in order to elucidate the life history of *C. variegatum*.

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**References**


**べーリング海の海鳥類から得られた線虫**

 CONTRACAECUM VARIEGATUM と CONTRACAECUM SP. の記載

べーリング海で表層流し網によって捕獲された海鳥類3種（ハイブトウミガラス、ウミガラス、エトビリカ）の胃から線虫 CONTRACAECUM VARIEGATUM の第3期幼虫と第4期幼虫を見出し、その形態を記載した。エトビリカは C. variegatum の新宿主である。調べた海鳥はほとんどすべて個体が C. variegatum の寄生を比較的多数受けていた。他の海鳥類から記載された CONTRACAECUM YAMAGUTI は C. variegatum の同種異名と考えられる。また、胃盲囊部の形態が異常な CONTRACAECUM SP. の成虫をウミガラスの胃から採集し、その形態を記載した。

長澤和也：遠洋水産研究所，〒424–8633 静岡県清水市折戸5–7–1. E-mail: ornatus@ss.enyo.affrc.go.jp

Vlastimil Baruš：景観生態学研究所，チェコ共和国ブルノ市. E-mail: kozena@brno.cas.cz

小城春雄：北海道大学水産学部，〒041–0821 北海道函館市港町3–1–1