

Nematode Fauna of High Altitude Avian Hosts in Garhwal Himalayan Ecosystems

I. *Eustrongylides spinispiculum* n. sp. and Revised Key to the Species of Genus *Eustrongylides* Jägerskiöld (1909)

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INTRODUCTION

Very little work has been done in Garhwal Himalayan ecosystem on nematode parasites of avian hosts. In the present investigation *Eustrongylides spinispiculum* n. sp. has been described from the small intestine of one hooded muntjac (*Upupa epops* (L)). Validity of the species of the genus *Eustrongylides* Jägerskiöld (1909) has been discussed and a revised key to the species of genus is proposed.

MATERIALS AND METHODS

The parasitological examination of one infected hooded muntjac, *Upupa epops* (L) yielded eleven interesting round worms. Nematodes were washed in normal saline; fixed in hot 70% alcohol and glycerine (95:5); cleared and mounted in lactophenol. Measurements recorded in millimeters unless otherwise stated, and mentioned as

ranges followed by mean \pm SD/SE in parentheses. Polythetic divisive classificatory system (Malhotra *et al.*, 1981) and analysis of variance (Snedecor and Cochran, 1967) were applied.

RESULTS

Eustrongylides spinispiculum n. sp.
(Figs. 1~6; Tables 1~3)

Male (N=6)

Worms long, thread-like, measure 17~21 (19.167 \pm 1.472/0.601) \times 0.006~0.084 (0.068 \pm 0.01/0.004). Cuticle thick. Head, 0.01~0.014 (0.013 \pm 0.002/0.002) \times 0.007~0.014 (0.012 \pm 0.003/0.001) with 12 head papillae; 6 outer circle papillae measure, 0.007~0.009 (0.008 \pm 0.001/0.001) \times 0.003~0.004 (0.003 \pm 0.001/0.0004) and inner circle papillae measure, 0.005~0.006 (0.006 \pm 0.001/0.0004) \times 0.003~0.0034 (0.003 \pm 0.001/0.0004); lips indistinct. Nerve ring at 0.059~0.101 (0.078 \pm 0.017/0.007) from anterior end (Fig. 1). Oesophagus long, 5.922~7.35 (6.421 \pm 0.638/0.028) \times 0.009/0.019 (0.014 \pm 0.003/0.001) and does not possess a bulb. Caudal papillae scattered to posterior part of the body. Spicule single, long, tubular and enveloped

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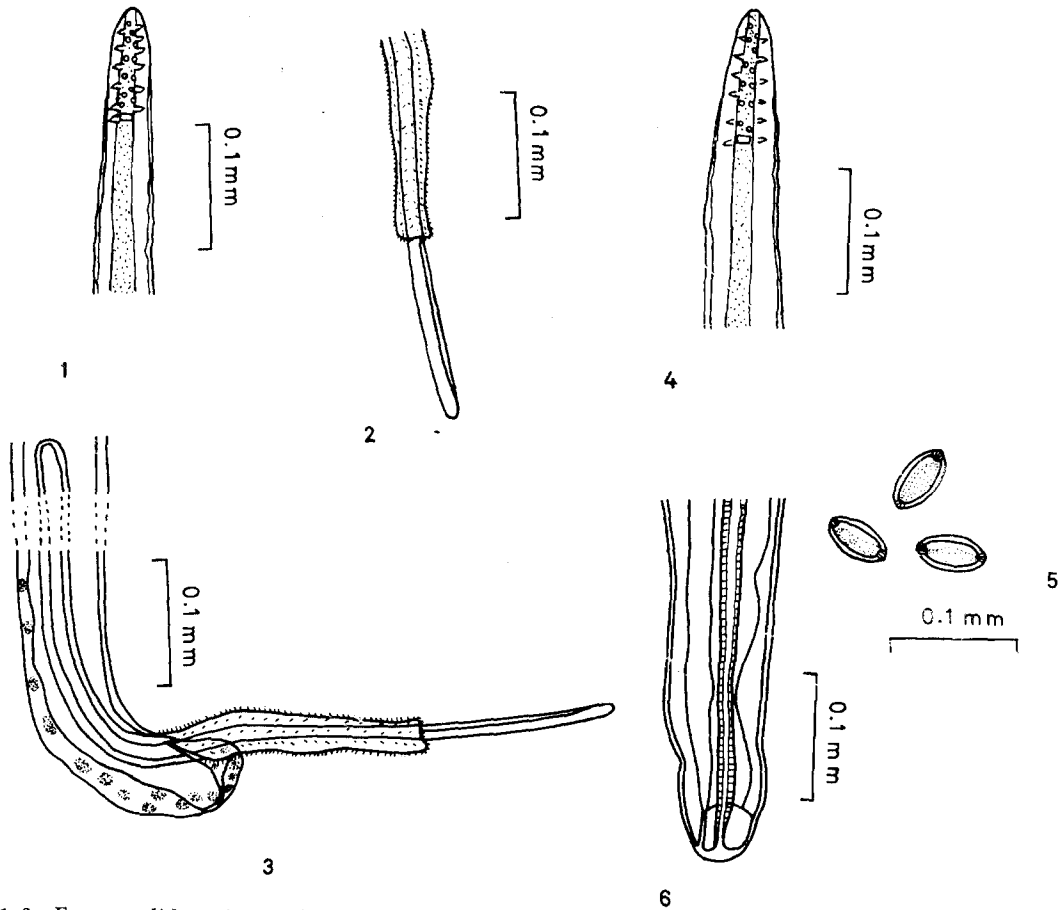


Fig. 1-6. *Eustrongylides spinispiculum* n. sp. 1. Anterior end of male ($\times 225$) 2. Spicule with spiny sheath ($\times 225$) 3. Posterior end of male ($\times 225$) 4. Anterior end of female ($\times 450$); 5. Egg ($\times 225$) 6. Posterior end of female ($\times 225$)

in spiny sheath, 12~13 times shorter than body, measure, 1.456~1.582 ($1.514 \pm 0.052/0.021$) \times 0.012~0.028 ($0.021 \pm 0.007/0.003$) (Fig. 2). Anus terminal. Tail 0.03~0.042 ($0.04 \pm 0.004/0.002$) long. It bears bursa with ventral cleft. Internal margin of bursa fringed and heavily papillated (Fig. 3).

Female (N=5)

Female specimens are long, thread-like, swollen in the middle part of the body, yellowish in colour, measure, 30~34 ($31.8 \pm 1.483/0.663$) \times 0.084~0.112 ($0.094 \pm 0.014/0.006$). Cuticle thick. Head, 0.013~0.019 ($0.014 \pm 0.003/0.001$) \times 0.011~0.021 ($0.015 \pm 0.004/0.002$) with 12 head papillae arranged in two circles. 6 outer circle papillae measure, 0.009~0.011 ($0.01 \pm$

0.001/0.001) \times 0.0034~0.004 ($0.004 \pm 0.001/0.0004$) and 6 inner circle papillae measure, 0.008~0.009 ($0.009 \pm 0.001/0.001$) \times 0.003~0.004 ($0.003 \pm 0.001/0.001$). Lips indistinct. Nerve ring at 0.068~0.108 ($0.092 \pm 0.017/0.008$) from anterior and (Fig. 4). Oesophagus, 7.140~8.136 ($7.73 \pm 0.44/0.197$) \times 0.013~0.021 ($0.016 \pm 0.003/0.002$) without oesophageal bulb. Vulva close to anus. Eggs large, ellipsoidal, measure 0.042~0.056 ($0.052 \pm 0.006/0.003$) \times 0.021~0.035 ($0.029 \pm 0.005/0.002$) and possess polar plugs on both ends (Fig. 5). Anus terminal. Tail rounded, 0.042~0.098 ($0.067 \pm 0.021/0.009$) long. (Fig. 6)

Analysis of variance between measurements of organs of worm and close species revealed

significant taxometric variations (Tables 1~3).

DISCUSSION

A total of 18 species of genus *Eustrongylides* have been considered valid till date (Yamaguti, 1961; Fastzkie and Crites, 1977). These are *E. africanus* (Jägerskiöld), *E. elegans* (Olfers) Jägerskiöld, *E. excisus* (Jägerskiöld), *E. excisus* var *amoyensis* (Hoeppli and Hsu), *E. formosensis* (Sugimoto), *E. gadopsis* (Johnston and Mawson) Syn. *E. galaxias* (Johnston *et al.*), *E. indicus* (Ali), *E. ingotus* (Jägerskiöld), *E. linstowi* (Chitwood), *E. mergorum* (Rudolphi) Cram, *E. papillosus* (Rudolphi), *E. perpapillatus* (Jägeskiöld), *E. phalacrocoracis* (Johnston and Mowson), *E. plotinus* (Johnston and Mawson), *E. sinicus* (Wu and Liu), *E. tricolor* (Sugimoto), *E. tubifex* (Jägerskiöld), and *E. wenrichi* (Canavan). The new species resembles closely with *E. elegans*, *E. indicus*, *E. mergorum*, *E. papillosus*, *E. tricolor*

and *E. tubifex*. However, the new form differs from the close species in combination of various characters. These significant differences have been statistically tested and presented in tables (Table 1~3).

Male: Male specimens of the new species possess smaller body than *E. elegans*, *E. indicus*, *E. mergorum*, *E. papillosus*, *E. tricolor* and *E. tubifex*; narrower head than *E. indicus*; smaller outer papillae than *E. mergorum*, *E. tricolor*, *E. tubifex*; smaller inner circle papillae than *E. tubifex*, shorter oesophagus than *E. indicus* and *E. tricolor*; narrower oesophagus than *E. elegans*; greater distance of nerve ring than *E. tricolor*; lesser distance of nerve ring than *E. tubifex*; smaller spicule than *E. tricolor*.

Female: Female specimens of the new species differ in possessing smaller body than *E. elegans*, *E. indicus*, *E. tricolor* and *E. tubifex*; narrower body than *E. mergorum*, narrower head than *E. indicus*; smaller outer circle papillae than *E.*

Table 1. Taxometric analysis of observations of *Eustrongylides elegans*, *E. indicus*, *E. mergorum* vis-a-vis *E. spinispiculum* n. sp.

Character	<i>E. elegans</i>		<i>E. indicus</i>			<i>E. mergorum</i>				
		C.D.	C.D.	C.Dis	C.S.	M.C.D.	C.D.	C. Dis	C.S.	M.C.D.
Body										
Male	L.	2.078	2.469	—	—	—	2.165	0.235	0.765	0.342
	W.	2.709	2.866	—	—	—	2.925	0.145	0.855	0.292
Female	L.	2.218	2.172	—	—	—	2.021	0.12	0.88	0.212
	W.	2.865	2.881	—	—	—	2.923	0.157	0.843	0.264
Head Diameter										
Male		—	2.901	—	—	—	—	—	—	—
Female		—	2.861	—	—	—	—	—	—	—
Head papillae										
Outer papillae										
Male	L.	—	—	—	—	—	2.667	0.102	0.898	0.191
Nerve ring distance										
Male		—	2.509	—	—	—	—	—	—	—
Female		—	2.171	—	—	—	—	—	—	—
Oesophagus										
Male	L.	2.094	2.332	—	—	—	2.109	0.185	0.815	0.297
	W.	2.793	—	—	—	—	—	—	—	—
Female	L.	2.171	2.225	—	—	—	2.128	0.142	0.858	0.228
Egg	L.	—	2.181	0.097	0.903	0.105	2.111	0.105	0.895	0.197
	W.	—	2.115	0.132	0.868	0.239	2.101	0.15	0.85	0.266
Spicule	L.	—	2.669	—	—	—	2.682	—	—	—

Table 2. Taxometric analysis of observations of *Eustrongylides papillosus*, *E. tricolor*, *E. tubifex* vis-a-vis *E. spinispiculum* n. sp.

Character	<i>E. papillosus</i>				<i>E. tricolor</i>				<i>E. tubifex</i>				
	C.D.	C.Dis	C.S.	M.C.D.	C.D.	C.Dis	C.S.	M.C.D.	C.D.	C.Dis	C.S.	M.C.D.	
Body													
Male	L.	2.122	0.172	0.828	0.279	2.536	0.127	0.873	0.213	2.616	0.189	0.811	0.269
	W.	2.913	—	—	—	2.88	0.125	0.875	0.274	2.873	0.059	0.941	0.218
Female	L.	2.04	0.076	0.924	0.309	2.405	0.048	0.952	0.099	2.471	0.227	0.763	0.288
	W.	2.93	—	—	—	2.863	0.072	0.928	0.158	2.921	0.436	0.564	0.433
Head papillae													
Outer papillae													
Male	L.	—	—	—	—	2.434	0.05	0.95	0.125	2.636	0.111	0.889	0.2
	W.	—	—	—	—	—	—	—	—	2.867	0.058	0.942	0.168
Female	L.	—	—	—	—	—	—	—	—	2.68	0.391	0.609	0.414
	W.	—	—	—	—	—	—	—	—	2.682	0.171	0.829	0.25
Inner papillae													
Male	L.	—	—	—	—	2.690	0.04	0.96	0.104	2.586	0.205	0.795	0.264
	W.	—	—	—	—	—	—	—	—	2.786	0.336	0.664	0.383
Nerve ring distance													
Male		—	—	—	—	2.672	—	—	—	2.376	0.24	0.76	0.395
Female		—	—	—	—	—	—	—	—	2.412	0.306	0.694	0.434
Oesophagus													
Male	L.	—	—	—	—	2.395	—	—	—	—	—	—	—
Female	L.	—	—	—	—	2.394	0.023	0.977	0.066	2.417	0.339	0.661	0.383
Egg:	L.	2.133	—	—	—	2.133	0.111	0.889	0.206	2.063	0.128	0.872	0.228
	W.	2.108	—	—	—	2.165	0.124	0.876	0.236	2.108	0.177	0.823	0.306
Spicule	L.	—	—	—	—	2.717	0.071	0.929	0.078	2.717	0.079	0.921	0.118
	W.	—	—	—	—	2.209	0.209	0.781	0.366	—	—	—	—

Table 3. Analysis of variance between characters of *Eustrongylides spinispiculum* n. sp. vis-a-vis close species

Characters		<i>E. mergorum</i>	<i>E. papillosus</i>	<i>E. tricolor</i>	<i>E. tubifex</i>
Body	Male	$F_{1;6}=203.031(L)^X$	$F_{1;6}=36.895(L)^X$	$F_{1;6}=113.878^X$ $\times F_{1;6}=270.162^X$	$F_{1;6}=53.203^X$ $\times F_{1;6}=7.498^{XX}$
	Female	$F_{1;5}=131.183(L)^X$	—	$F_{1;5}=497.399^X$ $\times F_{1;5}=655.892^X$	$F_{1;5}=15.751(L)^{XX}$
Head					
Outer papillae:					
Male		$F_{1;2}=62.286(L)^{XX}$	—	$F_{1;2}=140.4(L)^{++}$	$F_{1;2}=48.12^{XX}$ $\times F_{1;2}=275.806^X$
Female		—	—	—	$F_{1;2}=28.315(L)^{XX}$
Inner papillae					
Male		—	—	$F_{1;2}=499.333(L)^X$	$F_{1;2}=9.546(L)^+$
Oesophagus					
Female		$F_{1;5}=4.191(L)^+$	—	$F_{1;5}=912.964(L)^X$	—
Nerve ring distance					
Male		—	—	—	$F_{1;6}=18.194^{++}$
Female		—	—	—	$F_{1;5}=11.941^{XX}$
Spicule	Male	—	—	$F_{1;6}=535.269^X$ $\times F_{1;6}=4.32^+$	$F_{1;6}=432.776(L)^X$
Egg	Female	$F_{1;5}=6.025(L)^+$	—	$F_{1;5}=7.998^{XX}$ $\times F_{1;5}=8.884^{XX}$	—

X: significant at 0.5%, XX: significant at 5%, +: significant at 10%, ++: significant at 1%, L., length

tubifex; smaller oesophagus than *E. elegans*; shorter oesophagus than *E. indicus*, *E. mergorum*, *E. tricolor* and *E. tubifex*; lesser distance of nerve ring from anterior end than *E. tubifex*; smaller eggs than *E. indicus*, *E. mergorum* and *E. tricolor*.

Hence, on the basis of above morphological and taxometric variations the present lot of worms are proposed to be regarded as a new species *Eustrongylides spinispiculum* n. sp. after the spiny character of muscular sheath enveloping spicule.

Karmanova (1968) provided key to the species of *Eustrongylides* which was later modified by Fastzkie and Crites (1977). These authors did not include *E. gadopsis*, *E. galaxias*, *E. indicus*, *E. papillosus*, *E. plotinus*, *E. sinicus* and *E. wernrichi* mainly because of these species being either larval forms or their descriptions were considered insufficient. In the present account with the addition of a new species *E. spinispiculum* n. sp. the key to genus *Eustrongylides* given by Fastzkie and Crites (1977) has been revised as under:

A revised key to species of genus *Eustrongylides* Jägerskiöld (1909)

1. Cephalic papillae 18 in number.....2
Cephalic papillae 12 in number.....3
2. Papillae of inner circle much smaller than outer circle papillae. Inner circle papillae end sharp pin-like spine. Male bursa with two ventral clefts
.....*E. perpapillatus*
Papillae of inner circle larger than papillae of outer circle. Inner circle papillae end with blunt rivet-like spines. Male bursa without ventral clefts
.....*E. phalacrocoracis*
3. Male bursa with deep cleft on ventral side.....4
Male bursa without deep cleft on ventral side.....6
4. Papillae of inner circle small, barely noticeable with blunt spines*E. plotinus*
Papillae of inner circle relatively large with sharp spines.....5

5. Mouth cavity short but wide. Its depth equal to or less than half diameter of anterior end of body at the level where oesophagus begins. Spicule long, 3~4 times shorter than body length of male
..... *E. excisus*
Mouth cavity relatively larger and narrower. Its depth exceeds half the diameter of head and of body at the level oesophagus begins. Spicule, 6~7 time shorter than body length of male
..... *E. formosensis*
6. Outer circle papillae larger than inner circle papillae7
Outer circle papillae smaller than inner circle papillae or differ from them in size.....9
7. Inner circle papillae with long oval shaped bending spines. Spicule 3~4 times shorter than body length of male; spicule not located in muscular sheath*E. mergorum*
Inner circle papillae with straight cone shaped spines. Spicule may be over 7~13 times shorter than body length of male; part of spicule enveloped in muscular sheath8
8. Outer circle papillae digitiform. Edge of male bursa without cuticular fringed border. Numerous spines on muscular sheath of spicule. Eggs with polar plugs.....*E. spinispiculum* n. sp.
Outer circle papillae with a wider base. Edge of male bursa with a cuticular fringed border. Spines on muscular sheath of spicule absent. Eggs without polar plugs.....*E. tubifex*
9. Inner circle papillae larger than outer circle papillae. Papillae of inner circle with relatively long sharp spines10
Papillae of inner and outer circles close in size and form; widening to middle and narrowing to their base
..... *E. africanus*
10. Spicule not longer than 6 mm. Egg

shell with fairly sparsely scattered
depressions*E. ingotus*
Spicule longer than 8 mm. Egg shell
with numerous scattered depressions
not far from one another*E. tricolor*

Host : *Upupa epops* (L)
Habitat : Small intestine
Locality : Kotdwara (395 mASL) Dist.,
Pauri-Garhwal, U.P., India
Type
Specimens : Holotype no. PNL 025/82 and
paratype no. PNL 026/82 de-
posited with Parasitological Col-
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ABSTRACT

Analysis of variance has been applied as a new tool for precise substantiation of taxometric differences between *Eustrongylides spinispiculum* n. sp. and close species, as indicated by the polythetic divisive classificatory system. A revised key to the species of genus *Eustrongylides* Jäger-

skiöld (1909) has been presented.

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