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Biology and predatory attributes of a diplogasterid nematode, *Fictor composticola* Khan *et al.*, 2008

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Summary

Biology of *Fictor composticola* has been studied on *Aphelenchus avenae in vitro*. It reproduces by amphimixis, embryonic development is completed in 24 – 27 h and life cycle in 3 – 4 days. Fusion of sperm and egg pronuclei occurs in the uteri. Pulsation of median oesophageal bulb and pressing of lips against egg shell is seen just prior to hatching but teeth seem to play no role in this process. No moulting occurs inside the egg shell and the first stage juvenile hatches out. Female and male undergo mating upon addition of water in the culture plates and continue to swim in copula for a considerable time. A female lays 1.6 – 4.0 eggs in 24 h while feeding upon *A. radicicolus.* Predation and reproduction is affected by the temperature and 25 – 35 °C is the optimum range for these phenomena. Process of feeding as recorded with a CCTV attached to a compound microscope is described. *F. composticola* engulfs small preys; sucks the intestinal contents while holding them or cuts the body wall of large-sized preys and then feeds on prolapsed organs. Two sexes differ in their efficiencies of predation, a female on an average kills 53 *A. avenae* as compared to 11 by a male in 24 h. *F. composticola* feeds and reproduces on mycophagous nematodes and juveniles of root- knot, cyst and citrus nematodes but does not prey upon adult nematodes having coarsely annulated cuticle. Cannibalism in this species is also observed. *F. composticola* and *Seinura paratenuicaudata* prey upon each other. Biocontrol potential of *F. composticola* for managing nematode problems in button mushroom and agricultural crops has also been discussed.
Keywords: *Fictor composticola;* reproduction; feeding preferences; prey range; biology; cannibalism

Introduction

Species of diplogasterid genera, *Butlerius* Goodey, *Mononchoides* Rahm, *Pristionchus* Kreis and *Fictor* Paramonov have been reported to predate upon other nematodes, in addition to feeding upon bacteria, fungi and ciliates (Goodey, 1929; Yeates, 1969; Grootaert *et al*., 1977; Bilgrami & Jairajpuri, 1989; Furst von Lieven & Sudhaus, 2000; Steel *et al*., 2011). However, most of the studies on the predation behavior and biology have been concentrated only on *Mononchoides* species and some of them have been tried for managing plant parasitic nematodes under pot house and field conditions with encouraging results (Small, 1979; Fauzia *et al*., 1998; Osman, 1988; Bilgrami *et al*., 2008). Only meager information is available on *F. composticola* Khan *et al*., 2008 which is prevalent in compost used for cultivating button mushroom (*Agaricus bisporus* (Lange) Singer) in Haryana and Bihar states of India (Khan *et al*., 2008; unpublished data). This prompted us to undertake detailed studies on its biology and predation abilities with an eye to exploit them for managing fungal feeding nematodes (*Aphelenchus* and *Aphelenchoides* species) which are major constraints in successful production of button mushroom in India (Bajaj & Kanwar, 2011).

Material and Methods

F. composticola were extracted from compost used for cultivation of *A. bisporus* in mushroom house of Department of Plant Pathology, CCS Haryana Agricultural University, Hisar by Cobb's sieving and decanting method coupled with modified Baermann funnel technique. They were added in two separate sets of Petri plates (5 cm diameter) containing 4 mm thick 1 % water agar à 10 nema/plate. In one set, 1000 *Aphelenchus avenae* Bastian cultured on *A. bisporus* on PDA were inoculated. Other set received 2 – 3 drops of curd mixed in equal amount of water that

served as stock culture. Curd medium was used to maintain the stock culture because it becomes very difficult to maintain, *F. composticola* on mycophagous nematodes due to very high predation rate. However, predators from curd medium were sub-cultured on *A. avenae*, whenever needed, for further experimentation. *F. composticola* were collected by pouring water into culture plates- nematodes came on agar surface and were hand-picked.

Fungal feeder nematodes (*A. avenae*, *A. radicicolus* (Cobb) Steiner*, Aphelenchoides asterocaudatus* Das, *A. swarupi* Seth and Sharma), whenever needed, were obtained from the culture of these nematodes raised on *A. bisporus* growing on PDA. J2 of cyst, root-knot and citrus nematodes were collected by incubating cysts, egg masses and infected root portions respectively, at 27 ± 1 °C (18 ± 1 °C for *Heterodera avenae* Wollenweber) in a BOD incubator from the cultures maintained at green house of Department of Nematology, CCS HAU, Hisar. Bacteriophagous nematodes were isolated from the culture maintained on 1 % water agar having pinch of baby milk powder. Females of *Seinura paratenuicaudata* Geraert were obtained from culture of this nematode maintained on *A. avenae* in Petri plates containing 1 % water agar. Other nematodes were extracted from the soil using standard techniques from already identified spots.

For studying embryonic development, eggs were collected by giving an incision near the vulvae of gravid females with a hypodermic needle. Eggs were transferred to hanging drop cultures for further observations under a compound microscope. Observations were also made on a CCTV attached to a compound microscope and development was recorded on a video cassette. The cassette was played back for critical analysis. For confirming the occurrence of first moult inside the egg, 50 eggs with moving juveniles inside egg shell were transferred to small drops of water on glass slides. Each slide was then covered with a cover slip and lightly pressed to release the juvenile inside and observed for the presence of moulting.

For studying the predation and feeding behavior, a small drop of water was placed on to a 22 mm square cover slip. Five females of *F. composticola* and 15 females of *A. avenae* were added to the drop and pushed to the bottom. This cover slip was then placed inverted over the cavity of a cavity slide and sealed with petroleum jelly. Several slides were prepared in this fashion. Nematode behaviour was continuously observed on a CCTV attached to a compound microscope at 400x / 1000x magnifications, and feeding activity was recorded on video cassette. The cassette was played back for studying finer details of feeding and predation.

Studies on other aspects of biology and predation behavior of *F. composticola* were conducted in 5 cm dia. Petri plates containing 4 – 5 mm thick layer of water agar. For each aspect, there were ten replications. Observations on number of nematodes and their life stages were made by blending the agar in 75 ml water after specified period of inoculation and counting them under a stereozoom microscope.

Duration of life cycle: Life cycle duration of *F. composticola* on *A. avenae* was determined by observing life cycle stages at regular interval after 24 h of inoculation for the presence of newly formed adults. In this experiment 5 individuals of both sexes of *F. composticola* were inoculated with 5000 *A. avenae* in each plate.

Fecundity: For recording number of eggs laid by a female of *F. composticola*, Petri plates were inoculated with 20 females of *F. composticola* along with 750 males and females of *Aphelenchus radicicolus*. Observations were recorded after 24 hours of inoculation.

Mode of reproduction: To ascertain the role of male in reproduction, freshly laid eggs were transferred singly to several plates, each containing 500 *A. avenae*. Ten females developing in these plates were then inoculated in Petri plates containing 1000 *A. avenae*. Five individuals each of both sexes inoculated in Petri plates containing 1000 *A. avenae* served as control. Observations were recorded after three days of release of predators.

Mating behaviour: Copulation behavior of *F. composticola* present on the surface of water agar in culture Petri plates was studied under a stereozoom microscope keeping such plates upright. For recording observations on nematodes present at the bottom, plates were kept inverted on the stage of microscope. Observations were also recorded by adding one ml of water in culture plates and transferring mating pairs to water drops placed on a glass slide. To see the position of spicules and gubernaculum during copulation process, mating pairs in copula were transferred to hot 4% formalin and processed to anhydrous glycerin by slow method.

Effect of temperature on the predation and reproduction: For studying effect of temperature on the predation and reproduction of *F. composticola*, 5 females of *F. composticola* were released in Petri plates containing 1000 *A. avenae* and incubated at 0, 5, 10, 15, 20, 25, 30 and 35 °C. Observations were recorded on 4th and 9th day of release on number of individuals of two species present in each plate.

Cannibalism: For studying cannibalism, 200 juveniles and 80 adults (females and males) were added in Petri plates containing 1 % water agar only and observations were recorded under a stereozoom microscope. Number of nematodes present in plates were counted after 24 h.

Predation rate: Rate of predation of *F. composticola* on *A. avenae* was studied in Petri plates containing 10 females and one male of *F. composticola* and 1000 *A. avenae.* Observations were recorded on number of surviving *A. avenae* and *F. composticola* population (eggs+ juveniles + adults) after 24, 48, 72 and 96 h of release.

Predation efficiency of two sexes: Differences in the predation efficiencies of males and females of *F. composticola* were studied with the following treatments: T1- 5 ♀♀ + 5 ♂♂ of *F. composticola* + 1000 *A. radicicolus*, T2- 10 ♀♀ of *F. composticola* + 1000 *A. radicicolus*, T3- 10 ♂♂ of *F. composticola* + 1000 *A. radicicolus*. Observations were recorded after one day of incubation.

Prey range: Prey range of *F. composticola* on different trophic groups of nematodes was studied at room temperature in Petri plates by releasing 10 ♀♀ and 5 ♂♂ per plate. However, the number of prey and duration of experiment varied depending upon the availability of nematodes (Table 3). Predation behaviour on *Zeldia* sp. was studied under a stereozoom microscope by inoculating 10 *F. composticola* in culture plates of *Zeldia* sp.

Interaction with S. paratenuicaudata: For studying competitiveness between *F. composticola* and *S. paratenuicaudata*, both predators of *A. avenae*, 10 ♀♀ *F. composticola*, 10 ♀♀ *S. paratenuicaudata* and 5 ♀♀ *S. paratenuicaudata* + 5 ♀♀ *F. com-*

posticola were added to plates containing 1000 *A. avenae* separately. Observations were recorded on 3rd and 5th day of release of predators on the number of predators and preys present in each plate. In another experiment, Petri plates containing ca 1500 *S. paratenuicaudata* in different stages (reared on *A. avenae*) were inoculated with 30 *F. composticola* (both males and females) and examined microscopically to record to the behavior of two species towards each other.
All the experiments except where specified were conducted at room temperature (27 – 32 °C).

Results

Biology
Embryonic development: Cytoplasm of the egg at the time of incision of eggs from the uterus was disorganized with no clear cut nuclear distinction. Within 5 minutes, the cytoplasm constricted in the centre and two pronuclei became very clear in the two halves. In the next five minutes, these pronuclei approached each other and fused together. First cleavage division occurred nearly 20 minutes of the taking out of the egg from the uterus. 16-cell stage was reached after 2 h of first cleavage. It took further three and a half hour to reach gastrula stage. Larva continuously moved inside the egg shell after becoming vermiform. After differentiation of stoma and oesophagus, larva exhibited churning movement. Its median oesophageal bulb pulsated à twice at a one instance at an interval of 3 minutes that later increased to 6 – 13 at a time. Larva frequently pressed its lip region against the egg shell. Pulsation of median oesophageal bulb occurred even when larva did not press the egg shell. Later egg shell became very soft and changed its shape with the movement of larva inside. Ultimately larva came out from one side of the egg. However, frequently it slipped back inside the egg shell two or three times before completely emerging out of the egg shell. No exsheathed cuticle was observed in the emptied egg shell. Total time taken for embryonic development varied from 24 – 27 h.

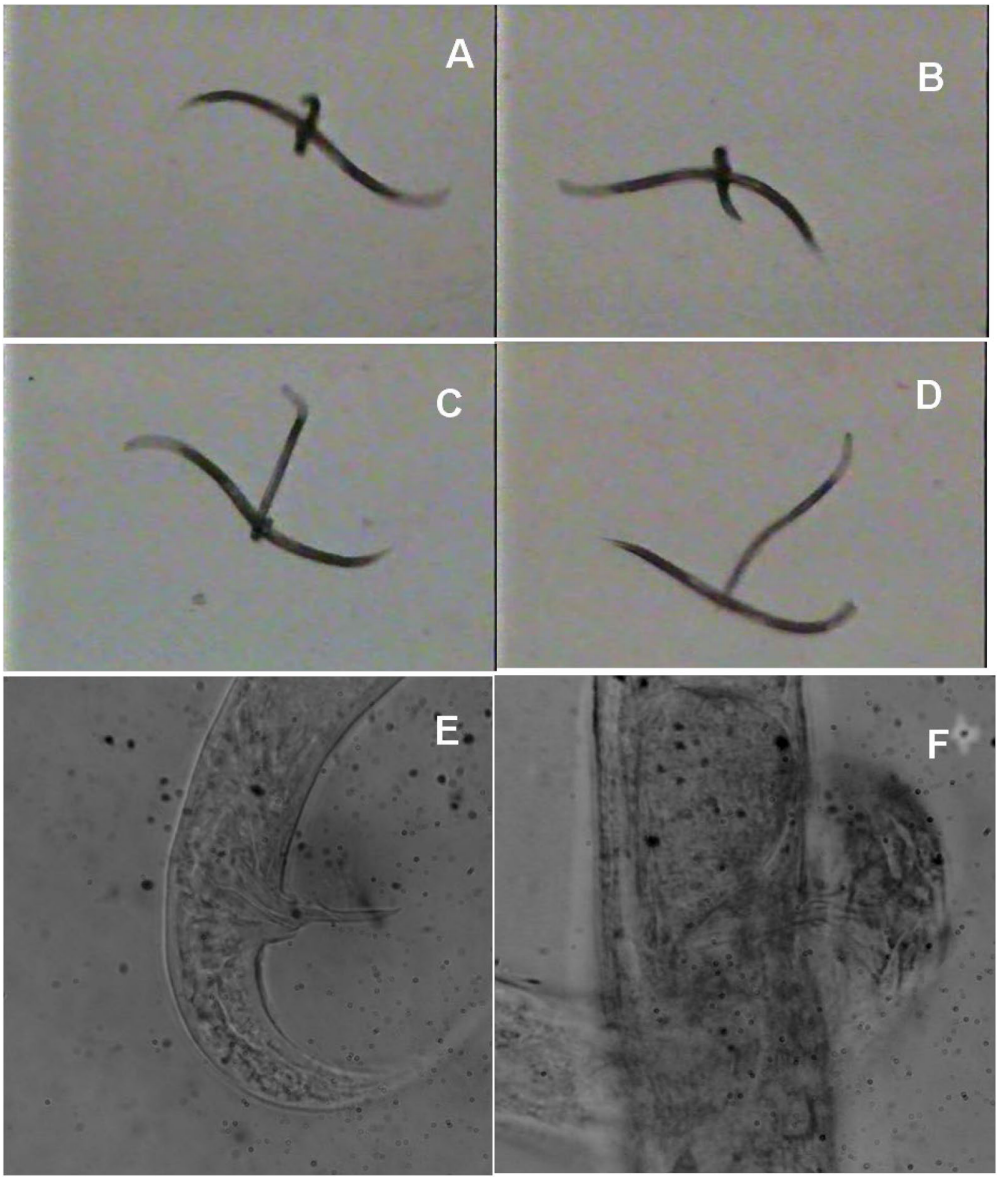

Fig. 1. Copulation in *F. composticola*: A – D - Different stages of mating, E - Spicular region of male just after seaparation from female, F - Position of spicules and gubernaculums in mating during copulation

Table 1. Effect of temperature on reproduction of *Fictor composticola*

Temperature	Number of nematodes on			
	4th day		9th day	
	F. composticola	*A. avenae*	*F. composticola*	*A. avenae*
0 °C	0	1000	0	1000
5 °C	0	1000	0	1000
10 °C	0	1000	0	1000
15 °C	5	1000	5	1000
20 °C	8	40	38	0
25 °C	27	10	66	0
30 °C	74	0	25	0
35 °C	46	0	11	0

Pi : *Fictor composticola*= 5 females, *Aphelenchus avenae* =1000

Life cycle duration: In Petri plates where adults of *F. composticola* were inoculated with *A. avenae*, newly developed males and females of *F. composticola* were recorded after 72 – 96 h of inoculation.

Fecundity: Average number of eggs laid by a female of *F. composticola* in 24 h while preying upon *Aphelenchus radicicolus* varied from 1.6 to 4.0 with a mean of 2.4. *Aphelenchus radicicolus* was used in this experiment *in lieu* of *A. avenae* due to paucity of *A. avenae* culture at the time of experimentation. Nevertheless, it may be mentioned that both *A. avenae* and

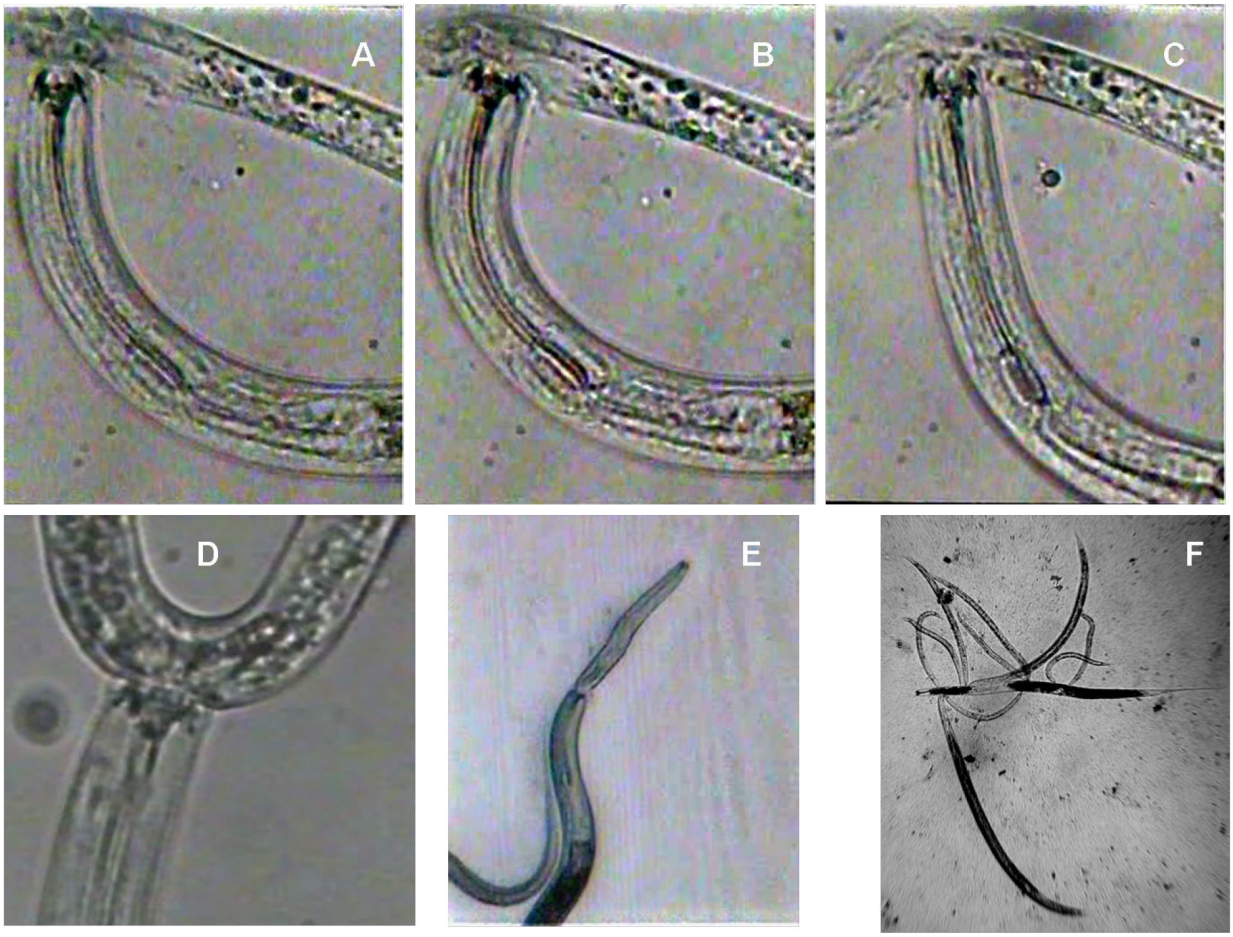

Fig. 2. A-E Feeding of *F. composticola*: A-D- Feeding on *Aphelenchus avenae* - A-C- Stages of feeding upon oozed intestinal contents (note position of teeth, pharyngeal lumen of median bulb and isthmus), D- Holding and ingesting prey contents, E- Cannibalism- Female feeding on its juvenile, F- Several *Seinura paratenuicaudata* feeding upon a female of *F. composticola*

Table 2. Predation and reproduction rate of *Fictor composticola*

Time	*F. composticola*		*Aphelenchus avenae*	
	Adult	Egg + juvenile	Killed	Live
0 h	11*	0	0	1000
24 h	11	28	579	421
48 h	11	62	995	5
72 h	22	82	1000	0
96 h	20	87	1000	0

*= 10 ♀♀ + 1 ♂

A. radicicolus are of almost same size and are predated upon by *F. composticola* at almost equal efficiency (Table 3).

Mode of reproduction: The role of male in reproduction was assessed by releasing *F. composticola* in different combinations in Petri plates containing *A. avenae*. Since no eggs were produced in Petri plates that contained only females, it is inferred that males are essential for reproduction of this species.

Mating behaviour (Fig. 1A – F): When water was added to the culture plates, nematodes came out from the inside the agar, and started swimming fast after some time. However, males present on the surface of agar and coming in contact with female coiled their posterior region to grip female body at any region. On several occasions, 2 – 4 males entangled a single female. The male grip was tight even in the oesophageal region or post vulval region and females were freed at this stage only. However, male only loosely entangled female body in most of the instances and slided towards vulva with the movement of female within the grip. Ultimately vulva was located and spicules were inserted in to vagina. Pair remained motionless for some time and then female became active and carried males on the surface of water and swam. After five minutes male also became active, loosened its grip and anterior region showed movement and tried to free itself but took 10 – 15 minutes to do so. Mating pairs continued to swim even when they were transferred to water drops on a glass slide.

At the bottom of culture plates in which no water added, copulation lasted for hardly two minutes. Males simply loosened their grips and uncoiled allowing inseminated females to wriggle away. When in copula pairs were transferred to hot 4 % formalin, they immediately tried to move apart. In this process, male loosened its grip around female which also twisted its body near the vulval region. They were successful in *ca* 90 % instances to free themselves. Entire blade of spicules remained protruding out of the body when the separated male ultimately died. The movement and extent of protrusion of spicules was guided by a ring like extension of distal end of gubernaculum that encircled the spicules. This ring-like extension could reach up to the level of cloacal lips. In pair that remained in copula upon death, entire blade of spicules was inserted inside the vagina and ring like-extension of gubernaculums touched the vulval lips (Fig. 1F).

Effect of temperature on predation and reproduction (Table 1): At 0, 5, and 10 °C, *F. composticola* could not survive for four days.

Table 3. Prey range of *Fictor composticola* (Initial predator pop.= 10 ♀♀ + 5 ♂♂)

Prey nematode	Duration (Days)	Final *F. composticola* population	Initial prey population	% Prey killed
Aphelenchoides swarupi	8	236	1000	100
A. asterocaudatus	8	184	1000	100
Aphelenchus avenae	8	336	1000	100
A. radicicolus	8	204	1000	100
Helicotylenchus dihystera	8	6	200	0
Hemicriconemoides cocophillus	8	6	200	0
Heterodera avenae J2	8	3	1000	100
H. cajani J2	4	86	1000	81
H. sorghi J2	4	5	1000	100
H. zeae J2	4	222	1000	97.5
Hoplolaimus indicus	8	6	200	0
Meloidogyne incognita J2	8	42	1500	100
Rotylenchulus reniformis, young ♀♀	8	6	200	0
Tylenchorhynchus mashhoodi	4	17	1000	50
Tylenchulus semipenetrans J2	8	12	200	100
Mesorhabditis sp.	4	139	1000	100
Bursilla sp.	4	32	1000	100
Zeldia sp.	4	31	1000	0
Diplogastrellus gracilis	8	6	1000	0
Panagrolaimus sp.	4	93	1000	100

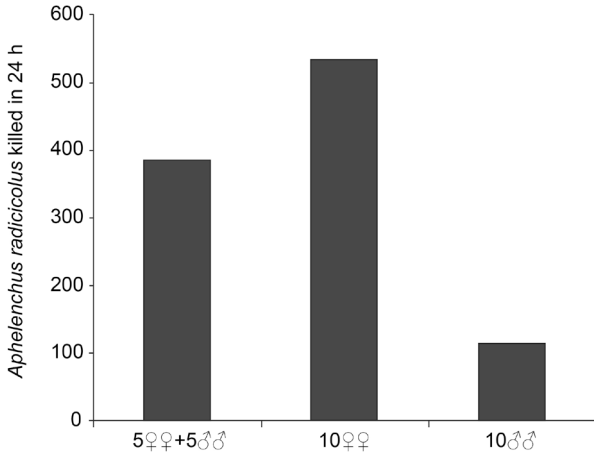

Fig. 3. Predation efficiency of two sexes of *Fictor composticola*

At 15 °C, it survived but failed to predate or reproduce on *A. avenae* up to 9 days of inoculation. At 20 °C feeding and multiplication of *F. composticola* were minimum. However at 25 °C and above temperatures, it fed and reproduced on *A. avenae* very well. Decline in number of *F. composticola* on 9th day of observation can be attributed to cannibalism as discussed below.

Cannibalism: In Petri plates containing 1 % water agar only and receiving 200 juveniles and 80 adults of *F. composticola,* number of predator declined to 63 juveniles and 23 adults within 24 h confirming cannibalism in this species. Cannibalism was noticed between male and female, female and female, male and male, adults and juveniles (Fig. 2E). In many instances a single individual was predated and fed by 5 – 6 individuals. In old cultures, copulating pairs at the bottom of culture plates become easy preys.

Predatory Attributes

Feeding: F. composticola may feed at any region of *A. avenae*. Though no rubbing of the lip region was noticed, it bounced over the prey with its mouth. Cheilostomal rugae may help in holding the prey along with suction caused by stoma and oesophageal region. Teeth are pushed forward due to suction of stoma and came in contact with the body of prey. Dorsal as well as subventral teeth moved in opposite direction and pierced the body wall and intestine. Nematode fed in two ways: i. Holding and ingesting the prey contents. In this method rugae were involved in holding the prey that became 'U' shaped. With each bounce of *F. composticola*, intestinal contents of prey continued to flow inside predator's alimentary canal. *F. composticola* used its teeth repeatedly to push backward the food inside its alimentary canal which may flow backward. Frequency of bites was 32 bites per 42 sec while feeding upon a live prey.

Many a times *F. composticola* wounded a prey in a attack and moved away. Food (intestinal contents) in such cases oozed out and did not flow continuously. Same or other predator attacked the injured portion or took bites from other intact portion of the prey. If injured portion was attacked, predator was able to feed on the intestinal contents without the barrier of body wall. Same or other predator(s) now fed upon the oozing intestine or fed upon intact body parts.

During each bite, the contents of prey were cut with teeth and food was pushed towards the isthmus by suction created by widening of lumen of procorpus and opening of valves of median bulb. Movement of teeth usually synchronized with the opening of valves. Some food (evidenced by bubbles) also moved forward after the stoppage of pulsation but was forced inside with the next bout of median bulb contraction. However, only contraction occurred to ingest the food already present in stoma that could also be broken in to pieces with the help of teeth. Predator also leaving the prey after a bite, frequently moved its teeth/ contracted oesophageal region to push food backward. During each bite median bulb valves did not open completely. Incomplete opening of median bulb pushed the food only up to the base of median bulb, walls of procorpus widening with each bout of median bulb activity. However, to push food into the intestine, valves opened completely along with widening of procorpus's lumen that was followed by the widening of lumen of isthmus and basal bulb lumen. Numbers of bites were 15 half + 18 full in 32 sec in *F. composticola* when fed upon previously killed worm.

Feeding on *Zeldia* sp.: *F. composticola* moved inside the agar plate though enough moisture was present on the surface. *Zeldia* sp. adults and juveniles when probed by *F. composticola* moved away very fast. However, some of the juveniles were wounded and then ingested in pieces or were engulfed *in toto*. Eggs (comparatively larger than those of *F. composticola*) of cephalobids were also punctured. Oozing contents of the attacked eggs then attracted other *F. composticola* to feed.

Predation rate: *A. avenae* population was reduced to nearly half in 24 h after the introduction of 10 females plus one male of *F. composticola* and was completely eliminated within 72 h. Almost no reproduction of *F. composticola* occurred after 72 h in the absence of prey (Table 2).

Predation efficiency of two sexes: Females of *F. composticola* killed more number of *A. radicicolus* (avg. 53 per female) than males (avg. 11 per male) within 24 hours (Fig. 3). When individuals of both sexes were present, number of preys killed by a predator was 38.5 during the same period.

Table 4. Interaction of *Fictor composticola* and *Seinura paratenuicaudata* in the presence of *Aphelenchus avenae*

Treatment	**No. of nematodes (juveniles and adults)**					
	F. composticola		***S. paratenuicaudata***		***A. avenae***	
	3rd day	**5th day**	**3rd day**	**5th day**	**3rd day**	**5th day**
F. composticola 10 ♀♀	33	34	-	-	54	0
S. paratenuicaudata 10 ♀♀	-	-	52	56	143	0
F. composticola 5 ♀♀ + *S. paratenuicaudata* 5 ♀♀	18	25	5	3	145	17

Prey range (Table 3): *F. composticola* predated and reproduced on all the fungivorous nematodes (*A. avenae, A. radicicolus, Aphelenchoides asterocaudatus, A. swarupi*) that are common in mushroom houses of northern India, and were tested in the present investigations. It also killed and reproduced on second stage juveniles of *Meloidogyne incognita* (Kofoid and White) Chitwood, *Heterodera avenae*, *H. cajani* Koshy, *H. sorghi* Jain *et al., H. zeae* Koshy *et al*., *Tylenchorhynchus mashhoodi* Siddiqi and Basir and *Tylenchulus semipenetrans* Cobb. However, it failed to multiply or feed on other tylenchids- *Rotylenchulus reniformis* Linford and Oliveira (immature females), *Hoplolaimus indicu*s Sher, *Helicotylenchus dihystera* (Cobb) Sher and *Hemicriconemoides cocophillus* (Loos) Chitwood and Birchfield. Amongst other nematodes frequently encountered in button mushroom houses, it preyed and multiplied on all of them except for adults of *Zeldia* sp. and *Diplogastrellus gracilis* (Butschli) Paramonov.

Interaction between F. composticola and S. paratenuicaudata: In an experiment where *F. composticola* and *Seinura paratenuicaudata* were released separately in Petri plates containing 1000 *A. avenae*, *F. composticola* killed about 94.6 % *A. avenae* as compared to 85.7 % by *S. paratenuicaudata* within three days (Table 4). Both the predators eliminated entire population of *A. avenae* in 5 days. However, when both were added together, they could kill 98 % *A. avenae* within 5 days. Multiplication of both, *F. composticola* and *S. paratenuicaudata*, was adversely affected by their predation on each other.

F. composticola when introduced in plates containing around 1500 *Seinura paratenuicaudata* cultured on *A. avenae*, killed and fed upon aphelenchid predator, specially its larvae. *S. paratenuicaudata* adults and larvae also attacked *F. composticola* but latter species escaped by moving very fast in most of the cases. However, in other instances, *S. paratenuicaudata* adults and larvae were successful in inserting their stylets in to the body of *F. composticola* and paralyzing them, particularly when they were feeding. Once paralyzed, *F. composticola* became easy prey of other *S. paratenuicaudata* (Fig. 2F) as well as members of its own species.

Discussion

Most of the eggs collected from the uteri of gravid females were still unfertilized though the sperm had penetrated inside the egg shell. Sperm and egg pronucleus when decondenssed, were of almost of equal size and fusion occurred within 15 minutes of their transfer to water. However, no attempts were made to study the distribution of P granules as reported by Riddle *et al*. (1997) or Goldstein *et al*. (1998). Since some of the eggs excised from the uteri underwent cleavage without pronuclei fusion, it appears that fusion of pronuclei occurs prior to egg laying.

The other point of interest was hatching behavior. The movement of larva inside the egg shell and softening of egg shell is similar that described in a number of nematode species including *Seinura paratenuicaudata* (Vats *et al*., 2004). During each bout of oesophageal activity, pulsation of valves of median bulb, wall of corpus and movement of teeth were observed. However, median bulb valve plates were never fully open, and no movement of any particle inside the isthmus was noticed indicating that such activities were associated with the release of oesophageal gland secretions inside the egg shell that may ultimately help in break down and softening of egg shell. Though rubbing of lips against the egg shell was frequently seen but stomatal teeth were never observed cutting the egg shell. Cheilostomal rugae may be involved in producing minute holes in the egg shell during rubbing of the lips that needs to be verified.

Furst von Lieven (2005) reported that first moult occurs inside the egg in diplogasterids (*Diplogasteroides magnus* Volk, *Koerneria paramata* (Schneider), *Neodiplogaster tropica* Cobb, *Oigolemella* sp., *Pristionchus pacificus* Sommer *et al*. and *Pseudodiplogasteroides* sp. and J2 hatches out of the egg shell except for *P. pacificus* where hatched J2 is ensheathed within cuticle of J1. First stage cuticle in these species is represented by a cap like structure and cuticle of J1 persists in the emptied egg shell. However, in the present studies on *F. composticola* no first moult was observed inside the egg shell, nor the exsheathed cuticle of J1 was ever seen in a number of eggs that were examined just after hatching. Bilgrami and Jairajpuri (1989) also reported the occurrence and predation by J1 of *M. longicaudatus* (Khera) Andrassy and *M. fortidens* (Sch. Stek) Taylor and Hechler.

Cuticle lining between stoma and median bulb in diplogasterids appear as set of several longitudinal ridges (Furst von Lieven and Sudhaus, 2000) and the lumen of corpus region is much wider than that of isthmus and basal bulb. During feeding, when lumen of corpus widens along with nearly half opening of valves of median oesophageal bulb, food is stored in corpus and median bulb. Food is forced into intestine through lumen of isthmus, basal bulb and cardia only with the complete opening of valves median bulb. In *F. composticola* only little contraction and relaxation of oesophageal region occurs during each bite as compared to *Pristionchus pacificus* where there is considerable such activity with each bout (Bumberger, 2013).

Prey range of *F. composticola* is somewhat similar to those described for other diplogasterid predators (Bilgrami & Jairajpuri, 1989; Grootaert *et al*., 1977; Small, 1987). However, it remains to be seen if these also do not feed upon juveniles of non prey hosts (*H. indicus*, *H. dihystera*, *H. cocophillus*, *R. reniformis* immature females) which have coarse annuli/ sheath on their body cuticle. In the present study, *F. composticola* was able to predate upon juveniles of *Zeldia* sp.

As with other diplogasterids, the life cycle of *F. composticola* is short and has high fecundity and is affected by temperature. It is a voracious feeder and its predation rate is much higher than reported for other diplogasterids (Yeates, 1969; Steel *et al*., 2011; Bilgrami *et al.,* 2005). Earlier worker, have offered only limited number of preys (25 – 50) in their experimentation that might have affected their results. They have also reported that the predation rate is affected by prey density (Yeates, 1969; Bilgrami & Jairajpuri, 1989; Bilgrami *et al*., 2005).

Since *F. composticola* has high predation rate for both plant parasitic and fungivorous nematodes, biological potential of this nematode may be exploited for their management. As regards the management of fungivorous nematodes of button mushroom, all the species of *Aphelenchus* and *Aphelenchoides* tested in the present studies were predated by *F. composticola*. For cultivation of button mushroom, the optimum temperature of 22 – 25 °C is maintained for spawn run (mycelial growth) after which mycelial

network is covered with casing soil for allowing pin head formation for which optimum temperature is 16 – 18 °C. *F. composticola* should be more effective if introduced at the time of spawning that will take care of myceliophagous nematodes present in compost since high temperature is conducive for fast multiplication of predator as observed in the present studies. This nematode may not be so effective against nematodes getting entry along with casing materials the temperature of 16 – 18 °C or less is not congenial for *F. composticola* predation and multiplication. However, its population will go up again at the end of cropping season (mid February onward in northern India) when the temperature starts rising. Since *F. composticola* and *S. paratenuicaudata* predate upon each other, their combine release to manage nematode problems in button mushroom is unlikely to give desired results in the light of the present studies.

Bilgrami *et al*. (2008) made first release of a diplogasterid nematode, *M. gaugleri* in field and observed significant decrease in nematode population in treatments where *M. gaugleri* were added. Since *F. composticola* predates upon agriculturally important nematodes (*Meloidogyne incognita*, *Heterodera avenae*, *H. cajani*, *H. sorghi*, *Tylenchulus semipenetrans*, etc.) it may be possible to exploit this predator for managing nematode problems in crops. However, further studies are needed to know the adaptability and survival of *F. composticola* in agricultural soils, effect of different agricultural practices etc. Addition of Farm Yard Manure is most likely to enhance *F. composticola* population as it feeds upon bacteria and nematodes of cp value of 1 or 2. It will be interesting to see if organic amendments create conducive environment for the multiplication of diplogasterid predators like *F. composticola* that in turn suppress the populations of plant parasitic nematodes as speculated by Linford *et al*. (1938).

The unique phenomenon of *F. composticola* to go for mating just after the addition of water in culture plates, and the pair to swim on the surface for a considerable time, may be an adaptation of this species for dispersal so that both sexes are carried together to a new locality. This tendency is apparently similar to animal parasitic nematode genus, *Syngamus*, in which two sexes remain in copula (Chapin, 1925) inside the host body.

We reared females from single egg in isolation. Such female failed to reproduce when provided with prey nematodes, ruling out the possibility of uniparental reproduction *in F. composticola*. Details of reproductive system have been given by Khan *et a*l. (2008).

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