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A comparative study on the predation by *Allodorylaimus americanus* and *Discolaimus silvicolus* (Nematoda : Dorylaimida) on different species of plant parasitic nematodes

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Summary – Studies on *Allodorylaimus americanus* and *Discolaimus silvicolus* revealed that these predators are similar in their predatory behaviour and requirements. The predator-prey relationship measured for one species strongly supports the observations made for the other predator. The prey catching and feeding mechanisms consist of five phases viz., encounter with prey, attack-response, attack, extra-corporeal digestion/salivation and ingestion/feeding. Predators were not attracted towards live and intact prey but responded positively towards excised prey. Both species of predators preferred second-stage juveniles of *M. incognita, A. tritici, H. mothi* and *T. semipenetrans*. No individual of *Hoplolaimus indicus, Helicotylenchus indicus* and *Hemicycliophora dhirenderi* was either injured or killed. Temperature, agar concentration, age of predators, prey density etc., affected predation but starvation of predators did not show any effect. Both predators achieved maximum success on endo-parasitic nematodes (SR = 90 %). Cortical and epidermal feeders exhibited maximum resistance (PR = 55-65 %). Maximum feeding after wounding occured on endo-parasitic nematodes. *Hoplolaimus indicus, Helicotylenchus indicus* and *H. dhirenderi* were 100 % resistant to predation. A significant correlation was observed between encounters resulting in attack and attack resulting in wounding and feeding after wounding except for endoparasites for *A. americanus* and cortical feeders for *D. silvicolus*. Various physical, chemical and behavioural characteristics are attributed to different degrees of resistance in prey nematodes. Female predators probed their own eggs when they came in contact but attacked, punctured and fed on eggs of prey nematodes (*Rhabditis* sp.). Predators took maximum time to consume an individual of *Longidorus* sp. (FT = 61-68 m) and minimum time to *T. semipenetrans* (FT = 22-25 m).

Résumé – *Étude comparative de la prédation de différentes espèces de nématodes phytoparasites par* Allodorylaimus americanus *et* Discolaimus silvicolus *(Nematoda : Dorylaimida)* – Les études réalisées sur *Allodorylaimus americanus* et *Discolaimus silvicolus* montrent que ces deux prédateurs ont un comportement et des besoins identiques. La relation prédateur-proie notée pour une espèce se compare de très près à celle de l'autre. La capture de la proie et les mécanismes d'ingestion comprennent cinq phases : rencontre avec la proie, essai d'attaque, attaque, digestion extracorporelle (salivation), ingestion. Les prédateurs ne sont pas attirés par des proies vivantes et intactes mais réagissent à des proies blessées. Les deux espèces préfèrent les juvéniles de deuxième stade de *Meloidogyne incognita, Anguina tritici, Heterodera mothi* et *Tylenchulus semipenetrans*. Aucun spécimen d'*Hoplolaimus indicus, Helicotylenchus indicus* ou *Hemicycliophora dhirenderi* n'a été blessé ou tué. La température, la concentration en agar, l'âge des prédateurs, la densité des proies, etc. influencent la prédation mais le jeûne des prédateurs n'a aucun effet. Les deux prédateurs ont la plus grande réussite avec les espèces endoparasites (SR = 90 %). Les nématodes brouteurs ou ectoparasites montrent la meilleure résistance (PR = 55-65 %). La prédation maximale correspond aux nématodes endoparasites blessés. *Hoplolaimus indicus, Helicotylenchus indicus* et *Hemicycliophora dhirenderi* sont à 100 % résistants à la prédation. Une corrélation significative est observée entre rencontres suivies d'attaque et attaques suivies de blessures et ingestion, sauf pour les espèces endoparasites dans le cas de *A. americanus* et ectoparasites dans celui de *D. silvicolus*. Des caractéristiques physiques, chimiques et comportementales sont mises en relation avec les différents degrés de résistance montrée par les proies. Les prédateurs femelles explorent leurs propres œufs si elles viennent à leur contact, mais attaquent, percent et ingèrent les œufs des nématodes – proies (*Rhabditis* sp.). Le temps mis pour l'absorption est le plus long pour *Longidorus* sp. (FT = 61-68 min) et le plus court pour *T. semipenetrans* (FT = 22-25 min).

Key-words : predation, *Allodorylaimus, Discolaimus*.

Linford and Oliviera (1937) reported *Aporcelaimus, Nygolaimus, Sectonema, Labronema, Dorylaimus* and *Actinolaimus* spp. as predaceous. Esser (1963, 1987) also observed species of these genera besides *Carcharolaimus* as predaceous. No detailed studies were made until Wyss and Grootaert (1977) and Bilgrami *et al.* (1985) gave a descriptive account of the predation abilities of a dorylaim and nygolaim predator, *Labronema vulvapapillatum* and *Aquatides thornei* respectively. Small and Grootaert (1983) observed predation by *L.*

vulvapapillatum and Shafqat *et al.* (1987) studied prey catching and feeding mechanisms of *Dorylaimus stagnalis*. Khan *et al.* (1991) used different species of plant parasitic nematodes to study predation by *Aporcelaimellus nivalis*. Jairajpuri and Bilgrami (1990) and Bilgrami (1990) speculated about more species of *Eudorylaimus, Mesodorylaimus, Aporcelaimus, Aporcelaimellus, Laimydorus, Nygolaimus* and *Sectonema* as predaceous. Bilgrami (1993) analysed the relationships between *Aporcelaimellus nivalis* and different prey trophic categories.

In the present work experiments were carried out to study predation by two species of dorylaim predators viz., *Allodorylaimus americanus* (Tjepkema, Ferris & Ferris, 1971) Andrássy, 1986 and *Discolaimus silvicolus* Sauer & Annells, 1985 using plant parasitic nematodes.

Materials and methods

Allodorylaimus americanus and *Discolaimus silvicolus* were cultured in separate Petri dishes containing 1 % water-agar using *Rhabditis* sp. as prey. A small amount (5-10 mg) of infant milk powder (Lactogen) was spread over the surface of agar to grow bacteria which served as food for the prey nematodes. Plant parasitic nematodes (prey) belonging to four trophic categories were collected fresh from different hosts and localities of Aligarh (Table 1). All experiments were made in small cavity-blocks (2.0 × 2.0 × 1 cm) containing 5 mm thick layer of 1 % water-agar at 25 ± 1 °C. Typical experiments were carried out using twenty five individuals of *Hirschmanniella oryzae* which were subjected to predation by five adult individuals of *A. americanus* and *D. silvicolus* in separate cavity blocks. The number of prey killed or injured was counted 24 h after inoculation of predators and prey. Similarly, predation was tested on second-stage juveniles of *M. incognita*. The experiments were replicated five times. All the above-mentioned conditions remained the same for all experiments unless otherwise stated.

Prey catching and feeding mechanisms

Observations on the prey catching and feeding mechanisms of the two predators were made at 60 × magnifications by inverting Petri dishes containing predators and prey over the stage of stereoscopic microscope. To study feeding mechanism in detail observation chambers consisting of a glass slide with 2 × 1.5 × 0.5 cm block of 1 % water-agar were used at more than 100 × magnification (Bilgrami *et al.*, 1985). Twenty specimens of *A. americanus* and *D. silvicolus* were released in observation chambers with 50-75 individuals of *H. oryzae*. The agar blocks were gently covered with a cover-slip. Observations were made after 15 min and continued upto about one hour.

Table 1. *Rate of predation by* Allodorylaimus americanus *and* Discolaimus silvicolus *using one species of prey.*

Prey nematodes and source No. of prey = 25	No. of prey killed by predators	
	A. americanus	*D. silvicolus*
Endo-parasitic nematodes		
1. *Meloidogyne incognita*	15±1.00	14±0.89
(from tomato)	(14-16)	(13-15)
2. *Heterodera mothi*	15±2.07	14±0.08
(from motha grass)	(13-18)	(13-16)
3. *Anguina tritici*	16±2.07	15±1.14
(from wheat gall)	(13-18)	(14-17)
4. *Tylenchulus semipenetrans*	16±1.58	15 ±1.58
(from lemon)	(14-18)	(13-17)
5. *Hirschmanniella oryzae*	11±1.58	9±1.14
(from paddy)	(9-13)	(8-11)
Ecto-parasitic : Epidermal feeders		
1. *Helicotylenchus indicus*	0	0
(from rose bed)		
2. *Hoplolaimus indicus*	0	0
(from palm)		
3. *Tylenchorhynchus mashhoodi*	10±1.14	8±1.58
(from paddy)	(8-11)	(7-10)
4. *Basiria* sp.	13±1.58	11±1.58
(from paddy)	(11-15)	(9-13)
5. *Hemicycliophora dhirenderi*	0	0
(from rose bed)		
Ecto-parasitic : Cortical feeders		
1. *Xiphinema basiri*	6±1.00	4±0.84
(from mulberry)	(5-7)	(3-5)
2. *Longidorus* sp.	6±1.09	4±0.84
(from mulbery)	(4-7)	(3-5)
3. *Trichodorus* sp.	8±0.84	7±1.30
(from rose bed)	(7-9)	(5-8)
Mycophagous		
1. *Aphelenchus avenae*	12±1.14	12±1.14
(from paddy)	(11-14)	(10-13)
2. *Aphelenchoides* sp.	11±1.30	9±0.84
(from paddy)	(10-13)	(8-10)

Attraction of predators towards live and excised prey

Attraction of *A. americanus* and *D. silvicolus* was tested towards live (intact) and excised (cut in two pieces) individuals of *H. oryzae* and *M. incognita* using Petri dish method (Ahmad & Jairajpuri, 1980; Bilgrami & Jairajpuri, 1988 *a*). Petri-dishes 5.5 cm in diameter, were filled with agar and marked at the bottom in three zones – inner, middle and outer – by drawing two concentric circles of 0.5 and 2.5 cm diam. A plastic straw pipe 5 mm high and 5 mm in diam., sealed at one end with a piece of filter paper, was placed vertically at the centre of the inner circle in such a way that the sealed end remained in touch with the bottom of the Petri dish. The straw pipe filled with agar was inoculated with 50 living or excised individuals of *H. oryzae* and *M. incognita* and incubated for 12 h. Five adult individuals of *A. americanus* and *D. silvicolus* were released at various points of the periphery of the middle circle. The distribution of predators was recorded after 2, 4, 6 and 8 h. Scores were obtained by summing up the products of the number of worms in each zone with their corresponding weighting factors. The weighting factors were obtained by dividing the area of the outer zone by that of each of the three zones. Scores were then converted into log scores. Experiments were replicated 20 times. Petri-dishes without prey served as control.

Effect of type of prey

The effect of different species of prey on predation by *A. americanus* or *D. silvicolus* was determined by subjecting each species of prey (Table 1) to predation.

Prey selection in combinations

To determine prey selection all possible paired combinations of plant-parasitic nematodes were subjected to predation by *A. americanus* and *D. silvicolus*. Twenty-five individuals of each prey were used in each combination. Thus each combination had 50 individuals of prey.

Effect of prey density

The effect of prey density on the rate of predation was determined by releasing five predators in cavity-blocks containing 25, 50, 75, 100, 125, 150, 175 and 200 individuals of prey.

Effect of starvation of predators

To study the effect of starvation of predators on their rate of feeding, prey nematodes were subjected to predation by predators starved (kept in water without prey) for times of 0 (fresh) to 10 days in 1-day steps.

Effect of temperature

To determine the influence of temperature, predators were placed in cavity blocks containing prey at various temperatures ranging from 5 to 40 °C (with intervals of 5 °C).

Effect of agar concentrations

To study the effect of agar concentrations predators were released with prey in cavity-blocks containing 1 to 6 % water agar.

Effect of age of predators

To find out the rate of predation by adults and juvenile stages, each stage of the two predators was released in cavity-blocks containing prey nematodes.

Feeding pattern

The number of prey killed by the predators each day was studied over a period of 10 days. Predators and prey were placed together in cavity blocks. The number of preys killed or injured was counted after every 24 h. Each day after observations the predators were transferred to another cavity-block containing fresh agar and prey.

Resistance and susceptibility of prey nematodes to predation and predator strike rate

Fifty encounters (lip contact of predator with the prey at right angles) were observed between predators and prey in Petri dish containing agar. For each encounter fresh individual of predator and prey were used (irrespective of whether the predator failed or succeeded). A prey nematode was placed in front of an active predator with the help of a picking needle without touching (or disturbing) the predator in any manner. Only such observations were recorded where predators behaved as normally as could be ensured. To reduce the effects of satiation and prey habituation 4-6 day-starved adult predators were tested. The strike rate (SR) of *A. americanus* and *D. silvicolus* and prey resistance (PR) and prey susceptibility (PS) of prey nematodes were determined by using the models proposed by Bilgrami and Jairajpuri (1989 *c*). Encounters resulting in attacks (EA), attacks resulting in prey wounding (AW), feeding after wounding (FW) and feeding time (FT) were also determined.

Results

Prey catching and feeding mechanisms

Prey catching and feeding mechanisms of *Allodorylaimus americanus* and *Discolaimus silvicolus* consisted of five recognizable phases : encounters with prey, attack response (probing), attack, extra-corporeal digestion and ingestion/feeding. These have been used to generate quantitative results. Predators and prey moved randomly in agar and made contact with each other (encounter with prey). Predators attacked when a lip contact (at right angles) was established with prey. Predators did not show preference for any particular region of prey. When contact had been established, a predator probed the prey by moving its lips sideways along the body of the prey (searching movements, *attack response*). *A. americanus* probed slightly for a longer duration (3-5 min) than *D. silvicolus* (2-3 min). During probing a few oesophageal pulsations were observed in predators. If the contour and texture of prey cuticle suited the predator the prey was attacked, otherwise predators probed some other region. After selecting a suitable spot, the predator attacked with odontostyle and punctured the prey cuticle *(attack)*. *A. americanus* required eight to eleven odontostyle thrusts compared with *D.*

silvicolus which required nine to fourteen thrusts to puncture the prey cuticle. The predators penetrated odontostyle deep into the body of prey and disorganised body organs in order to render it immobile. The oral disc of *D. silvicolus* also helped in holding prey by suction. During ingestion oesophageal secretions were released in the body of prey through the odontostyle (extra-corporeal digestion). Prey showed considerable shrinkage when their body contents were sucked by the predators. Ingestion was supported by oesophageal pulsations which occurred at regular intervals (18-23 pulsations/min in *A. americanus* and 15-20 pulsations/min in *D. silvicolus;* ingestion/feeding). The ingestion was intermittent (three or four feeding bouts at a time). During feeding, predators often left prey for a while, moved around and reverted back to feed again. Predators punctured prey at more than one place. Only the cuticle of prey was left unconsumed when feeding was finished.

Sometimes prey escaped from the suction " grip " of predator. If an injured prey escaped it became susceptible for future attacks and attracted three to four predators which then aggregated around the prey and fed together. Females of *A. americanus* and *D. silvicolus* probed (by rubbing their lips) around their own eggs but left without initiating feeding. In contrast, predators coming in contact with the eggs of *Rhabditis* sp. attacked, punctured and fed upon them.

ATTRACTION TOWARDS PREY

A. americanus and *D. silvicolus* did not show attraction towards live prey ($p < 0.05$). Both predators were attracted towards excised prey and attraction increased significantly from 2 to 8 h ($p < 0.0.5$).

EFFECT OF TYPE OF PREY (Fig. 1; Table 1)

M. incognita, H. mothi, A. tritici and *T. semipenetrans* were killed most by *A. americanus* and *D. silvicolus*. Mycophagous nematodes and epidermal feeders (ecto-parasitic) were killed in moderate numbers. Cortical feeders (ecto-parasitic) were predated upon the least ($p < 0.05$). No specimen of *Hoplolaimus indicus, Helicotylenchus indicus* and *Hemicycliophora dhirenderi* was either killed or injured by the predators.

When compared, the mean killing of individuals belonging to different prey trophic categories (PTC) endo-parasitic nematodes were killed most by *A. americanus* and *D. silvicolus* and cortical feeders the least ($p < 0.05$) (Fig. 1).

PREY SELECTION IN MIXTURE OF PREY

Second stage juveniles of *M. incognita, H. mothi* and *A. tritici* were most preferred in all combinations ($p < 0.05$). When tested together they were killed equally and frequently. *X. basiri* and *Longidorus* sp. were preferred the least. No individual of *Hoplolaimus indicus, Helicotylenchus indicus* and *H. dhirenderi* was killed in any combinations.

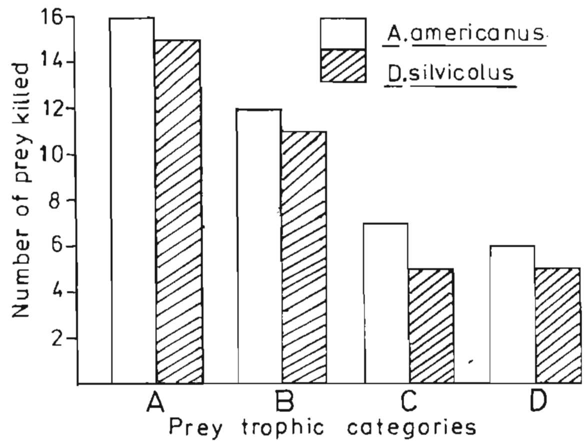

Fig. 1. *Mean killing of prey belonging to different prey trophic categories. A : Endo-parasites; B : Mycophagous; C : Cortical feeders; D : Epidermal feeders.*

EFFECT OF PREY DENSITY (Fig. 2 A, B)

There was a positive correlation between the number of prey killed by *A. americanus* (Fig. 2 A) and *D. silvicolus* (Fig. 2 B) and prey density ($p < 0.05$). Maximum predation occurred in a population of 200 prey and minimum with 25 individuals of prey ($p < 0.05$).

EFFECT OF STARVATION OF PREDATORS (Fig. 2 C, D)

Prey non-availability did not affect predation by *A. americanus* (Fig. 2, C) and *D. silvicolus* (Fig. 2 D). The number of preys killed by fresh and 10-day starved predators did not differ ($p > 0.05$).

EFFECT OF TEMPERATURE (Fig. 2 E, F)

There was a significant increase in predation by *A. americanus* (Fig. 2 E) and *D. silvicolus* (Fig. 2 F) as temperature increased to 25 °C. Both species of prey were killed maximally at 25 and 30 °C ($P < 0.05$). Predation decreased at temperatures lower thant 25 and higher than 30 °C ($P < 0.05$).

EFFECT OF AGAR CONCENTRATIONS (Fig. 3 A, B)

There was a negative correlation between the number of prey killed by *A. americanus* (Fig. 3 A) and *D. silvicolus* (Fig. 3 B) and increasing agar concentrations ($p < 0.05$). Maximum predation occurred at 1 and 2 % agar ($p < 0.05$). Predation declined at concentrations higher than these. *D. silvicolus* did not kill any prey at 5 or 6 % and *A. americanus* failed to kill any prey at 6 % water agar.

EFFECT OF AGE OF PREDATORS (Fig. 3 C, D)

All except first stage juveniles feed on nematodes. Maximum number of prey were killed by adults and the lowest by second-stage juveniles ($p < 0.05$). There was more predation on *M. incognita* than on *H. oryzae.*

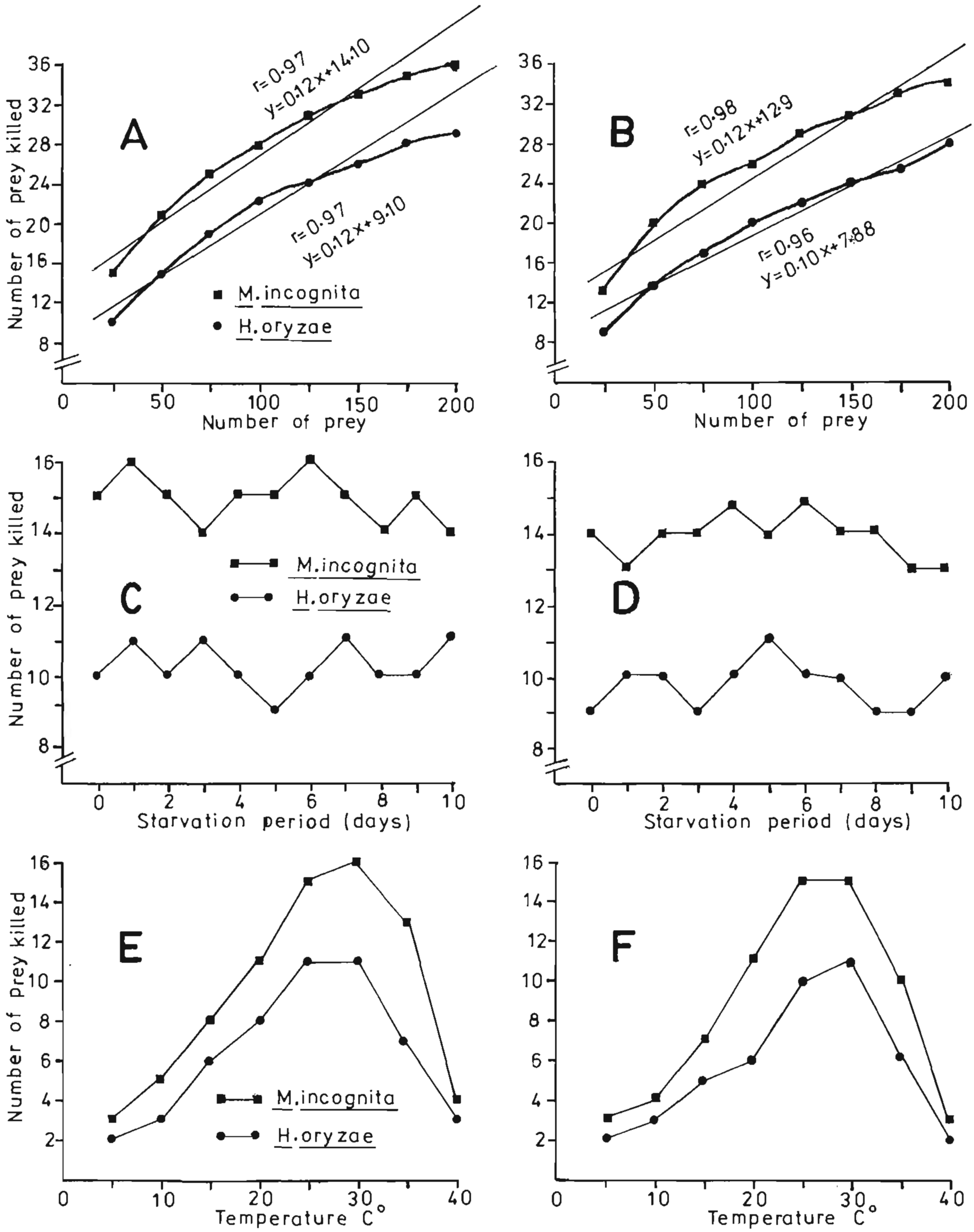

Fig. 2. *A : Effect of number of prey on the rate of predation by* Allodorylaimus americanus; *B : Effect of number of prey on the rate of predation by* Discolaimus silvicolus; *C : Effect of starvation on the rate of predation by* A. americanus; *D : Effect of starvation on the rate of predation by* D. silvicolus; *E : Effect of temperature on the rate of predation by* A. americanus; *F : Effect of temperature on the rate of predation by* D. silvicolus.

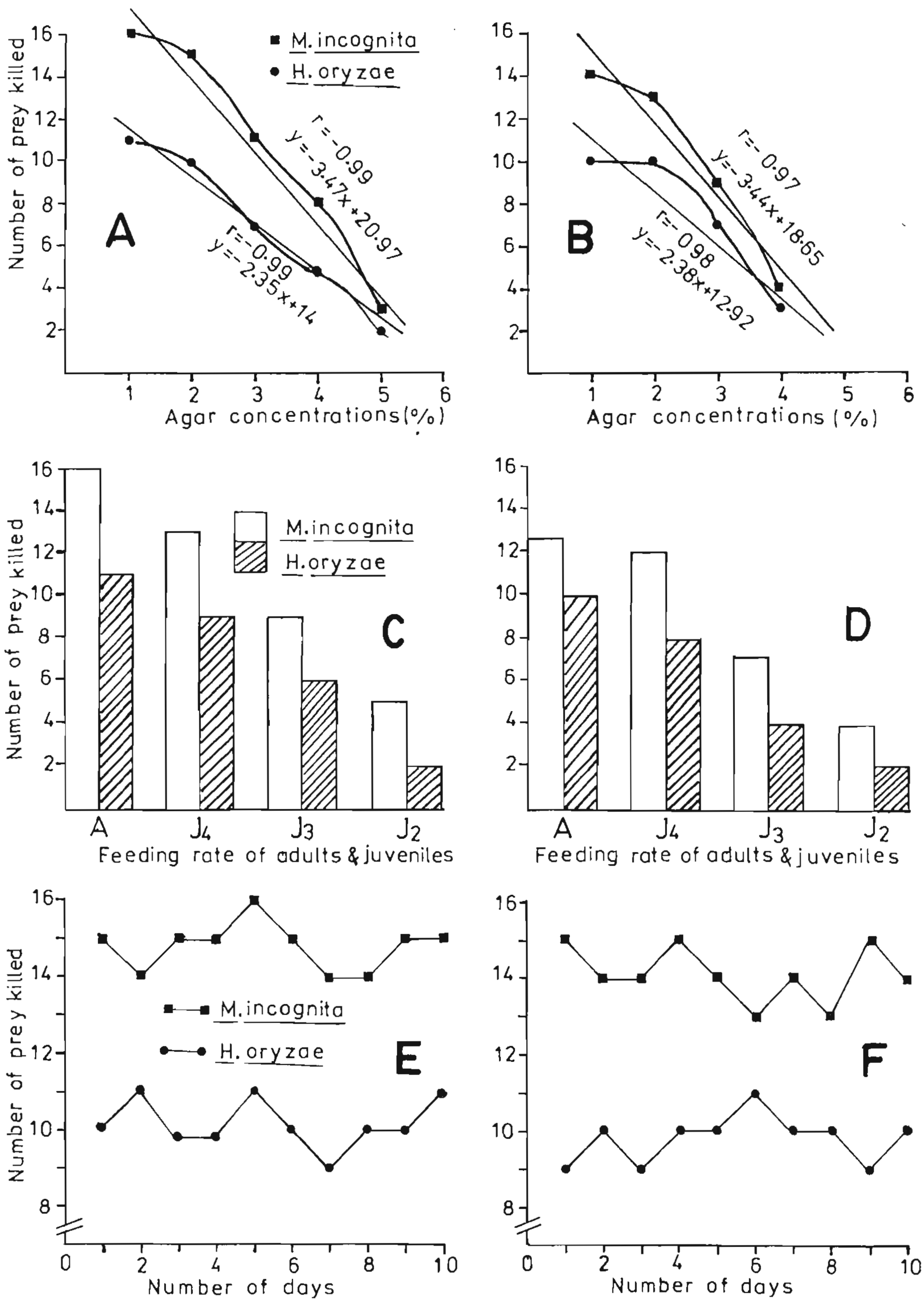

Fig. 3. *A : Effect of agar concentrations on the rate of predation by* Allodorylaimus americanus; *B : Effect of agar concentrations on the rate of predation by* Discolaimus silvicolus; *C : Rate of predation by different stages of* A. americanus; *D : Rate of predation by different stages of* D. silvicolus; *E : Predatory pattern of* A. americanus *over a period of 10 days; F : Predatory pattern of* D. silvicolus *over a period of 10 days.*

FEEDING PATTERN (Fig. 3 E, F)

A. americanus and *D. silvicolus* did not show any consistent predatory behaviour over a period of ten days ($p > 0.05$).

RESISTANCE AND SUSCEPTIBILITY OF PREY TO PREDATION AND STRIKE RATE OF THE PREDATORS (Tables 2, 3)

A significant correlation was observed between encounters resulting in attacks and attacks resulting in wounding ($r = +0.70 - 1.00$; $p < 0.05$) for all PTCs. Similar correlations were obtained between attacks resulting in wounding and feeding after wounding ($r = +0.86 - 1.00$; $p < 0.05$) except endoparasites for *A. americanus* ($r = +0.28$; $P > 0.05$) and cortical feeders for *D. silvicolus* ($r = +0.34$; $p > 0.05$) where the relationships were insignificant.

ENDOPARASITES (Table 2, A)

A. americanus and *D. silvicolus* achieved maximum success on *T. semipenetrans* (SR = 92 %). *A. americanus* wounded *H. mothi* and *A. tritici* maximally (AW = 93 %) while *D. silvicolus* wounded *M. incognita* and *T. semipenetrans* (AW = 90 & 91 %). Maximum feeding occurred on *M. incognita* by *D. silvicolus* (FW = 90 %) and *A. tritici* by *D. silvicolus* (FW = 88 %). Both predators took maximum time to consume *A. tritici* and minimum to *H. mothi.* All prey species were highly susceptible to predation by *A. americanus* and *D. silvicolus* (PR = 7-13 %) except *H. oryzae* which showed a higher degree of resistance (PR = 26-27 %).

EPIDERMAL FEEDERS (ECTO-PARASITES) (Table 2, B)

Hoplolaimus indicus, Helicotylenchus indicus and *H. dhirenderi* exhibited 100 % resistance against predation. *A. americanus* and *D. silvicolus* attacked prey (SR = 72-80 %) and fed most upon *Basiria* sp. (FW = 76 & 67 %). Both predators took maximum time (FT = 46 min and 45 min) to consume *T. mashhoodi* and minimum (FT = 35 and 39 min) to finish *Basiria* sp.

CORTICAL FEEDERS (ECTO-PARASITES) (Table 2, C)

Cortical feeding plant nematodes showed high degree of resistance (PR = 51-67 %) with low strike rate (SR = 60-70 %) and wounding (FW = 33-49 %). Both predators fed more on *Trichodorus* sp. (FW = 46 & 47 %). *A. americanus* took maximum time to finish *X. basiri* (FT = 62 min) and *D. silvicolus* took longest (FT = 68 m) to consume *Longidorus* sp.

MYCOPHAGOUS (Table 2, D)

A. avenae and *Aphelenchoides* sp. were more vulnerable to predation by *A. americanus* and *D. silvicolus* (PS = 75 – 83 %). The former fed more on these prey (FW = 78-79 %) than the latter (FW = 70-74 %). Predators took more time to consume *A. avenae* (FT = 38 min and 41 min) than *Aphelenchoides* sp (FT = 34 min and 37 min).

NUMERICAL ANALYSIS OF PREY TROPHIC CATEGORIES (PTC) (Table 3)

Strike rate of the predators : A. americanus and *D. silvicolus* were most successful predators on endoparasites. Comparatively fewer encounters resulted in attacks when cortical and epidermal feeders were subjected to predation by *A. americanus* and *D. silvicolus.*

Attacks resulting in wounding : Attacks with migratory juveniles resulted in maximum wounding with low degree of variation. Fewer encounters on cortical and epidermal feeders resulted in attacks.

Prey resistance : Maximum resistance against predation was observed in epidermal feeders. The endoparasites were the most susceptible trophic group. Mycophagous nematodes also showed a comparatively high degree of susceptibility.

Feeding after wounding : A. americanus and *D. silvicolus* fed the maximum on migratory juveniles with a low degree of variation. Feeding after wounding on epidermal feeders was least with a high degree of variation.

Feeding time : Both the predators took a minimum of 28-31 min to consume an individual of a migratory juvenile and a maximum of 58-60 min to finish a cortical feeder.

Discussion

A. americanus and *D. silvicolus* are very similar in their predatory behaviour and requirements. The predator-prey relationships measured for one species were very similar to those made for other predator. Predation depended on physical contacts with the prey. Excised or injured prey attracted predators (Yeates, 1969; Bilgrami *et al.,* 1985; Shafgat *et al.,* 1987) and a similar phenomenon was observed during the present investigations. The pre- and post-feeding attraction and aggregation of *A. americanus* and *D. silvicolus* is similar to that described by Bilgrami and Jairajpuri (1988 *b*) in *M. fortidens* and *M. longicaudatus.* In the presence of eggs of free-living nematodes the affinity of *A. americanus* and *D. silvicolus* for their own eggs suggests a recognition of their own chemical attractants (Esser, 1963; Bilgrami *et al.,* 1985; Shafqat *et al.,* 1987; Khan *et al.,* 1992).

The prey catching and feeding mechanisms of *A. americanus* and *D. silvicolus* conforms to the five phases as described by Bilgrami and Jairajpuri (1989 *a*). *Aquatides thornei* required 8-10 thrusts (Bilgrami *et al.,* 1985) and *Dorylaimus stagnalis* 6-8 (Shafqat *et al.,* 1987) to puncture the cuticle of prey. *D. silvicolus* required more stylet thrusts (9-14) than *A. americanus* (8-11) and only probed for short durations. Aphelenchid predators paralysed their prey by injecting saliva (Linford & Oliviera, 1937; Hechler, 1963), Diplogasterids hold their prey with the oesophageal suction and buccal armature (Bilgrami & Jairajpuri, 1989 *a*), nygolaim predators paralysed prey by disorganizing internal

Table 2. *Trophic categorisation of prey, resistance and susceptibility of prey to predation and strike rate of* Allodorylaimus americanus *and* Discolaimus silvicolus.

Prey nematodes		No. of encounters resulting in attacks (EA)	Strike Rate of predators (SR %)	No. of attacks resulting in wounding (AW %)	Prey Resistance (PR %)	Prey susceptibility (PS)	Feeding after wounding (FW)	Duration of feeding on single prey (FT m)
Endo-parasites								
M. incognita	AA	45	90	91	9	91	90	26 (19-33 m)
	DS	42	84	90	10	90	86	25 (20-37 m)
H. mothi	AA	45	90	93	7	93	88	24 (16-32 m)
	DS	46	92	87	13	87	86	21 (15-35 m)
A. tritici	AA	44	88	93	7	93	88	31 (25-38 m)
	DS	45	90	89	11	89	88	28 (20-40 m)
T. semipenetrans	AA	46	92	91	9	91	83	25 (20-29 m)
	DS	46	92	91	9	91	83	22 (18-34 m)
H. oryzae	AA	39	78	74	26	74	69	48 (35-52 m)
	DS	40	80	73	27	73	66	46 (33-55 m)
Epidermal feeders (ectoparasites)								
Basiria sp.	AA	39	78	79	21	79	76	35 (29-50 m)
	DS	38	76	71	29	71	67	39 (34-47 m)
T. mashhoodi	AA	38	76	71	29	71	59	46 (40-56 m)
	DS	36	72	69	31	69	55	45 (42-54 m)
Hoplaimus indicus	AA	29	58	00	100	00	00	00
	DS	27	54	00	100	00	00	00
Helicotylenchus indicus	AA	25	50	00	100	00	00	00
	DS	24	48	00	100	00	00	00
Hemicycliophora dhirenderi	AA	30	60	00	100	00	00	00
	DS	28	56	00	100	00	00	00
Cortical feeders (ectoparasites)								
Trichodorus sp.	AA	35	70	49	51	49	47	51 (30-57 m)
	DS	32	64	44	56	44	46	46 (36-61 m)
X. basiri	AA	32	64	44	56	44	41	62 (52-73 m)
	DS	30	60	33	67	33	35	66 (56-81 m)
Longidorus sp.	AA	31	62	42	58	42	39	61 (47-70 m)
	DS	33	66	33	67	33	33	68 (55-77 m)
Mycophagous								
A. avenae	AA	40	80	80	20	80	78	41 (31-54 m)
	DS	39	78	77	23	77	70	38 (34-50 m)
Aphelenchoides sp.	AA	41	82	83	17	83	79	34 (28-40 m)
	DS	40	80	75	25	75	74	37 (30-54 m)

Total number of encounters = 50; Figures in paranthesis indicate the range of feeding time.

body organs (Bilgrami *et al.*, 1985). Both species of predators paralysed prey similar to nygolaim and dorylaim predators (Shafqat *et al.*, 1987; Khan *et al.*, 1991). The movement of œsophageal secretions through the lumen of odontostyle suggests the occurrence of extra-corporeal digestion in *A. americanus* and *D. silvicolus* (Grootaert *et al.*, 1977; Bilgrami & Jairajpuri, 1989 *a*; Khan *et al.*, 1991).

The rate of predation by both the predators increased when the number of prey increased as is the case with *Diplenteron colobocercus* (Yeates, 1969), *Prionchulus punctatus* (Nelmes, 1974), *A. thornei* (Bilgrami *et al.*, 1985), *Mononchoides longicaudatus* and *M. fortidens* (Bilgrami & Jairajpuri, 1989 *a*) and *Aporcelaimellus nivalis*

Table 3. *Characterization and comparison of different prey trophic categories.*

Prey trophic categories		EA M±SD	SR (%) M±SD	AW (%) M±SD	PR (%) M±SD	PS (%) M±SD	FW (%) M±SD	FT (m) M±SD
Endo-parasitic nematodes	AA	44±3.0 (6)	88±6.0 (6)	89±8.0 (9)	12±8.0 (70)	88±8.0 (9)	83±9.0 (10)	31±10.0 (32)
	DS	44±3.0 (6)	88±5.0 (6)	86±7.0 (9)	14±7.0 (54)	86±7.0 (9)	82±9.0 (11)	28±10.0 (36)
Cortical feeders (ecto-parasites)	AA	33±2.0 (6)	66±4.0 (6)	45±3.0 (8)	55±3.0 (7)	45±4.0 (8)	42±4.0 (10)	58±6.1 (10)
	DS	32±2.0 (5)	64±3.0 (5)	37±6.0 (17)	63±6.0 (10)	37±6.0 (17)	38±7.0 (18)	60±10.9 (18)
Epidermal feeders (ecto-parasites)	AA	32±6.0 (19)	64±12.0 (19)	30±41.0 (137)	70±41.0 (59)	30±41.0 (137)	27±38.0 (139)	42±8.0 (19)
	DS	31±6.0 (20)	61±12.0 (20)	20±38.0 (191)	72±38.0 (53)	28±38.0 (136)	24±34.0 (140)	42±4.0 (10)
Mycoph-agous	AA	41±1.0 (2)	82±1.0 (2)	82±1.0 (1)	19±2.0 (11)	82±2.0 (3)	79±1.0 (1)	38±4.9 (13)
	DS	40±1.0 (2)	80±1.0 (2)	78±1.0 (1)	24±1.0 (6)	76±2.0 (3)	72±3.0 (4)	38±0.7 (2)

Figures in paranthesis indicate coefficient of variation. All figures are nearest to whole numbers. M±SD = Mean Standard Deviation; EA = Encounters resulting in attacks; SR = strike rate of predators; AW = Attacks resulting in wounding; PR = Prey resistance; PS = Prey susceptibility; FW = Feeding after wounding; FT = Feeding time.

(Khan *et al.*, 1991). For *Mononchus aquaticus* it remained unaltered (Bilgrami *et al.*, 1984). Shafqat *et al.* (1987) obtained an optimum ratio between the predator and prey number for maximum predation. During the present observations the increase in predation may be attributed to improved predator-prey encounters. Wallace (1963) found lower (5-10 °C) and higher temperatures (40° or more) unfavourable for nematodes. Bilgrami *et al.* (1983) found temperatures influencing activity and predation by *M. aquaticus*. The decrease in predation by the two species of predators at temperatures lower than 25° and higher than 30 °C may be attributed to their activity which might be inhibited by the unfavourable temperatures. Agar-concentrations also govern activity (Wallace, 1969; Azmi & Jairajpuri, 1979; Bilgrami *et al.*, 1983) and predation by nematodes (Bilgrami *et al.*, 1983; Shafqat *et al.*, 1987; Bilgrami & Jairajpuri, 1989 *b*). During the present studies the negative correlation between predation and agar concentration suggest that the activity of predators and prey was affected by higher concentrations of agar above which predation declined. More predation by adults than juveniles reflects their predatory potentials (Bilgrami & Jairajpuri, 1985, 1989 *a*).

A. americanus and *D. silvicolus* preferred endoparasitic nematodes most when tested singly or in combinations. No predation on *Helicotylenchus indicus, Hoplolaimus indicus* and *H. dhirenderi* could be attributed to factors such as the activity of prey, type of prey, contour and texture of cuticle, cuticle thickness and body annulations etc. (Bilgrami & Jairajpuri, 1989 *c*).

Various factors provide resistance to prey nematodes against predation (Esser, 1963; Small & Grootaert, 1983; Jairajpuri & Bilgrami, 1990). Wounding determines predation and degree of prey susceptibility. The wound may result in the loss of hydrostatic pressure of the body, affect locomotion, make prey individuals more vulnerable to predation and allow secondary infections (Bilgrami, 1993). Esser (1987) also suggested loss of resistance in a wounded or weakened prey. During the present observations a thick body cuticle (e.g. *Hoplolaimus indicus*) and body annulations *(H. dhirenderi)* might have provided 100 % resistance against *A. americanus* and *D. silvicolus* as was observed for other predators (Esser, 1963; Small & Grootaert, 1983; Bilgrami & Jairajpuri, 1989 *c*). Esser (1963) suggested that resistance to predation in *Helicotylenchus indicus* was chemical which was later supported by Bilgrami and Jairajpuri (1988 *a*, 1989 *c*)and Bilgrami (1993). *A. americanus* and *D. silvicolus* exhibited similar behaviour towards *Helicotylenchus indicus*. The high degree of susceptibility of endo-parasites may be attributed to their relatively soft and smooth cuticle which is easily pierced (Bilgrami *et al.*, 1983; Jairajpuri & Bilgrami, 1990), their activity (Bilgrami *et al.*, 1983) and lack of their anti-predation characteristics such as thick body cuticle annulations, cuticular folds, gelatinous matrix, rapid escape response, etc. (Bilgrami & Jairajpuri, 1989 *c*).

The characterization of prey trophic categories (PTCs) has revealed that migratory juveniles of sedentory endoparasites were most vulnerable to predation as they appeared to lack anti-predation characteristics (Esser, 1963; Grootaert *et al.,* 1977; Small & Grootaert, 1983; Bilgrami & Jairajpuri, 1989 *c*). The ectoparasitic nematodes (cortical) possess physical characteristics which resisted predation better than other PTCs. The reason why cortical feeders were more susceptible to predation could be their inactivity, large size and inability to take evasive actions when attacked (Bilgrami, 1993).

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