Evaluation of the predatory behaviour of *Dorylaimus stagnalis* Dujardin, 1845 (Nematoda : Dorylaimida)

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Summary

Observations on the predatory behaviour of *Dorylaimus stagnalis* Dujardin, 1845 were made in agar-plates. Predation was on chance encounters. Predators were not attracted towards live (non-excised) or excised prey. *D. stagnalis* probed over a short distance along any part of the body of prey and paralysed it by disorganizing its internal body organs with the help of their odontostyle. Ingestion of prey contents was intermittent and duration of feeding lasted for 85 mn (25-180 mn) on *Rhabditis* sp., and 70 mn (15-150 mn) on *Hirschmanniella oryzae. Rhabditis* sp. was prefered most while *Acrobeloides* sp., *Tylenchorhynchus mashhoodi* and *Helicotylenchus indicus* the least. No specimen of *Hoplolaimus indicus* was either injured or killed by the predators. There was no difference in the rate of predation over a period which lasted for ten days. Adults (male and female) preyed more than their younger stages. All factors viz., prey number, temperature and agar concentration influenced predation by *D. stagnalis* except the starvation of predators. Maximum predation took place when predators were placed in a population of 125 individuals of prey. Agar concentrations 1, 2 and 3 % and temperatures 25° and 30° were most suitable for predation by *D. stagnalis.*

Résumé

Évaluation du comportement prédateur de Dorylaimus stagnalis *Dujardin, 1845 (Nematoda : Dorylaimida)*

Des observations sur le comportement prédateur de *Dorylaimus stagnalis* Dujardin, 1845 ont été faites en utilisant des boîtes de Petri contenant de l'agar-agar. La prédation est en relation avec des contacts dus au hasard; le prédateur n'est en effet pas attiré par les proies, que celles-ci soient intactes ou incisées. *D. stagnalis* se nourrit sur une longueur restreinte de n'importe quelle partie du corps de la proie et paralyse celle-ci en désorganisant ses organes internes par action du stylet. L'ingestion du contenu de la proie est intermittente et la prise de nourriture dure 85 mn (20-180) avec *Rhabditis* et 70 mn (15-150) avec *Hirschmanniella oryzae. Rhabditis* est une proie préférée tandis que *Tylenchorhynchus mashhoodi* et *Helicotylenchus indicus* sont les proies les moins attaquées. Aucun individu de *Hoplolaimus indicus* n'a été blessé ou tué par le prédateur. Il n'est apparu, au cours d'une période de dix jours, aucune différence dans le taux de prédation. Les adultes, mâles ou femelles, ont un comportement prédateur plus actif que les juvéniles. Tous les facteurs étudiés (nombre de proie, température, concentration en agar-agar) influencent la prédation de *D. stagnalis,* à l'exception du jeûne du prédateur. La prédation maximale a lieu lorsque les prédateurs sont placés parmi une population de 125 proies. Les concentrations de 1, 2 et 3 % en agar-agar et les températures de 25° et 30° sont les plus favorables à la prédation par *D. stagnalis.*

Thorne (1930; 1939) had suggested that species of many dorylaims and nygolaims may be predatory in habit. Since then species of *Dorylaimus, Labronema, Discolaimus, Carcharolaimus* and *Actinolaimus* have been reported to be predacious (Linford & Oliviera, 1937; Esser, 1963). Detailed account on the feeding mechanism and predation ability of a dorylaim predator, *Labronema vulvapapillatum* Loof & Grootaert, 1981 was given by Wyss and Grootaert (1977) and Small and Grootaert (1983). Very recently, Bilgrami, Ahmad and Jairajpuri (1985*a*) for the first time made detailed observations on the nygolaim predator, *Aquatides thornei* (Schneider, 1937) Ahmad & Jairajpuri, 1979. The dorylaim predators derive their food also from algae and fungi besides feeding on nematodes and hence are considered omnivorous (Hollis, 1957; Ferris, 1968; Wood, 1973).

In the present work a comprehensive study on the predatory behaviour of *Dorylaimus stagnalis* Dujardin, 1845 was made to assess its predatory abilities and to determine the factors affecting predation.

Materials and methods

Soil samples containing *Dorylaimus stagnalis,* collected from paddy fields near Jamalpur, Aligarh, were processed by sieving, decantation and Baermann's funnel methods. *D. stagnalis* was cultured in 1 % water-agar at 25 ± 1° using *Rhabditis* sp. as prey. Five milligram of infant milk powder (Lactogen) was spread over the surface of the agar to allow bacteria to grow. This served as the food of prey nematodes. Predators were transferred to fresh culture dishes containing prey after every 10-15 days. *Rhabditis* sp., *Acrobeloides* sp. and *Cephalobus* sp. were cultured in agar plates by spreading the same amount of Lactogen over the surface of agar. Plant-parasitic prey species *Hoplolaimus indicus, Helicotylenchus indicus, Hirschmanniella oryzae* and *Tylenchorhynchus mashhoodi* were isolated fresh from the soil.

Feeding mechanism

Feeding in *D. stagnalis* was studied by observing inverted Petri-dishes containing predators and prey under microscope at 66 × magnification. For higher magnifications 450 × or more, simple observation chambers consisting of a glass slide with a block of 1 % water-agar measuring 2 × 1.5 × 0.5 cm was used (Wyss & Grootaert, 1977; Bilgrami, Ahmad & Jairajpuri, 1985*a*). Ten adult (male and female) specimens of *D. stagnalis* were released together with 100 to 150 prey nematodes in the agar block which was gently covered by a coverslip and kept at 25 ± 1°. Observations were started after one hour. Feeding of *D. stagnalis* was observed on *Rhabditis* sp., and *H. oryzae.*

Prey preference

To determine whether *D. stagnalis* has any preference for prey *Rhabditis* sp., *Acrobeloides* sp., *Cephalobus* sp., *Hoplolaimus indicus, Helicotylenchus indicus, Hirschmanniella oryzae* and *Tylenchorhynchus mashhoodi* were subjected to predation. Five predators were placed with 25 prey nematodes in cavity-blocks containing 1 % water-agar. The number of prey killed or ingested was recorded after 24 h. Each type of prey was tested separately at 25 ± 1°. Experiments were replicated five times.

Attraction towards prey

Attraction of *D. stagnalis* towards prey was studied by the methods of Azmi and Jairajpuri (1977) and Bilgrami, Ahmad and Jairajpuri (1985*b*). Seven zones, each of lcm width, were marked at bottom of 7 cm diameter Petri-dish. A plastic straw pipe 5 mm high and 5 mm in diameter, one end sealed with filter paper, was placed vertically in zone 1 (sealed end remained in contact with the surface of the Petri-dish). Straw pipe and Petri-dish were then filled with 1 % water-agar (0.5 cm thick layer). Twentyfive prey nematodes were placed in straw pipe and whole set was left at 25 ± 1° for 24 h. Twentyfive female predators were then released at different places in zone 4. Number of predators present in each zone was counted after four hours. Attraction was tested separately towards *Rhabditis* sp., live and excised (cut in two pieces) and excised *H. oryzae.* Control was run without prey nematodes.

Rate of predation of adults and juveniles

Rate of predation of male, female and the four juvenile stages (differentiated on the basis of their odontostyle length and body length) of *D. stagnalis* was determined by releasing five specimens of each stage with twentyfive prey nematodes in cavity-blocks containing 1 % water-agar. Predation by each stage was tested separately upon *Rhabditis* sp. and *H. oryzae.* Number of prey killed or ingested was counted after 24 h. Experiments were replicated five times and carried out at 25 ± 1°.

Predatory pattern

To observe predatory pattern over a period of ten days, five female predators were released in cavity blocks containing 1 % water-agar with twentyfive prey nematodes at 25 ± 1°. Observations were made at 24 h intervals. The experiment was replicated five times. Each day after observations the predators were transfered to fresh cavity blocks containing prey of the same type. *Rhabditis* sp. and *H. oryzae* was used separately as prey.

Factors influencing predation by *D. stagnalis*

Observations on the effect of different factors viz., prey number, temperature, agar concentration and starvation of predators on the rate of predation were made. Five female *D. stagnalis* were placed with twentyfive specimens of prey nematodes in small cavity blocks containing 1 % water-agar at 25 ± 1°. Number of prey killed or ingested was counted after 24 h. In all the experiments *Rhabditis* sp. and *H. oryzae* were used separately as prey. Each experiment was repeated five times. The above conditions remained same during all experiments unless mentioned otherwise. Effect of prey number on predation was observed by placing predators with 25, 50, 75, 100, 125, 150, 175 and 200 prey nematodes in separate cavity blocks. To observe the effect of different temperatures, prey nematodes were subjected to predation at 5, 10, 15, 20, 25, 30, 35 and 40°. To determine the effect of starvation, the predators were kept without prey for 0, 2, 4, 6, 8, 10, 12 and 14 days. Predators of each group were tested in separate cavity blocks. Six concentrations of water-agar viz., 1, 2, 3, 4, 5 and 6 % were made to study their effect on the predation of *D. stagnalis.*

Results and discussion

Feeding mechanism

Observations show that *D. stagnalis* feeds by predation. Predation depended on chance encounters with the prey (Nelmes, 1974; Grootaert & Maertens, 1976; Wyss & Grootaert, 1977; Bilgrami, Ahmad & Jairajpuri, 1984; 1985*a*). *D. stagnalis* attacked prey only if it made lip contact and there was no preference shown for attacking any particular part of the body of prey. Probing before attack was reported by Wyss and Grootaert (1977) and Bilgrami, Ahmad and Jairajpuri (1985*a*) in *Labronema vulvapapillatum* and *Aquatides thornei* respectively. *D. stagnalis* also probed any part of the body of prey over a short distance before thrusting its stylet so as to puncture the cuticle of the prey. During probing a few weak oesophageal pulsations were also observed in predators. Probing by *D. stagnalis* was, however, not as vigorous as that of *L. vulvapapillatum* (Wyss & Grootaert, 1977). Stylet thrusting was also not of the same intensity with which *L. vulvapapillatum* aimed to perforate the cuticle of its prey. It was more like that of *A. thornei* where gradual and intermittent stylet thrusting was observed (Bilgrami, Ahmad & Jairajpuri, 1985*a*). Normally six to eight stylet thrusts were enough to puncture the cuticle but some times the prey escaped from the grip of the predator if the later failed to penetrate its odontostyle into the body of prey.

Aphelenchid predators (*Seinura* spp.) are known to paralyse their prey by injecting salivary and eosophageal secretions into the prey (Linford & Oliviera, 1937; Hechler, 1963). *D. stagnalis* also paralysed its prey probably by disorganizing internal body parts of the prey with its odontostyle similar to other dorylaim predators (Hollis, 1957; Wyss & Grootaert, 1977; Bilgrami, Ahmad & Jairajpuri, 1985*a*). However, if predators injected secretions into the prey, these might have been used for extra-corporeal digestion. After penetration, thrusting and side ways movements of the odontostyle began and during ingestion odontostyle remained within the body of the prey. The ingestion was intermittent involving short periods of sucking activity. The body contents of prey could be seen passing through the lumen of odontostyle and oesophagus of the predators. *D. stagnalis* explored and fed at different spots of the same prey to ingest all the body contents. Only the cuticle was not consumed when the feeding was completed. The rest of the sequenses of prey catching and feeding mechanisms did not differ much from those reported by Wyss and Grootaert (1977) and Bilgrami, Ahmad and Jairajpuri (1985*a*) for *Labronema vulvapapillatum* and *A. thornei*. The rate of predation by *D. stagnalis* was, however, more than the above two predators. This differential rate of predation could be due to different nematodes used as prey for the above predators. The duration of feeding on *Rhabditis* sp. (85 mn : 25-180 mn) was slightly more than that on *H. oryzae* (70 mn : 15-150 mn).

Often two to four predators were seen feeding together on a single prey which was injured or killed earlier by another predator. *D. stagnalis* readily fed on the eggs of *Rhabditis* sp. it had contacted but not on its own eggs. They rubbed them with lips few times before moving away. In the presence of eggs of free-living nematodes, affinity of *D. stagnalis* (both male and female) for their own eggs suggests some form of recognition of their own chemical attractants (Esser, 1963; Bilgrami, Ahmad & Jairajpuri, 1985*a*).

PREY PREFERENCE (Fig. 1)

D. stagnalis showed some degree of preference. *Rhabditis* sp. were killed in greater numbers ($p < 0.05$), while *Acrobeloides* sp., *T. mashhoodi* and *Helicotylenchus indicus* were prefered least. Other prey nematodes viz., *Hirschmanniella oryzae* and *Cephalobus* sp. were killed in moderate numbers. No specimen of *Hoplolaimus indicus* was either injured or killed by the predators. This disparity in the rate of predation by *D. stagnalis* upon different nematodes that were used as prey may be attributed to the size and behaviour of prey and the texture of their cuticle. *Hoplolaimus indicus* and *Helicotylenchus indicus* seemed to resist predation probably due to the toughness and thickness of their cuticle and secretion of toxic chemicals as was suggested by Esser (1963) for other species of *Hoplolaimus* and *Helicotylenchus* respectively.

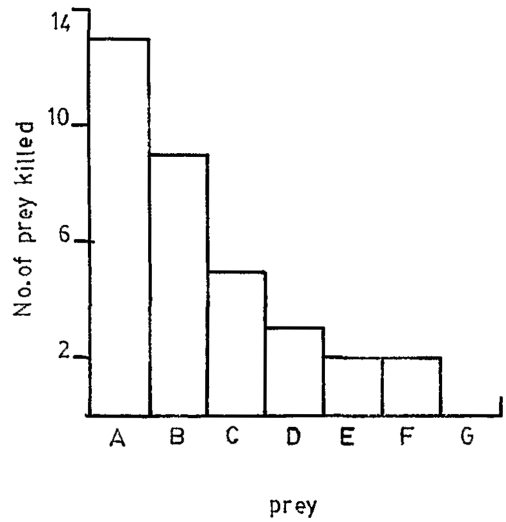

Fig. 1. Prey preference in *D. stagnalis*. A : *Rhabditis* sp.; B : *Hirschmanniella oryzae;* C : *Cephalobus* sp.; D : *Helicotylenchus indicus;* E : *Acrobeloides* sp.; F : *Tylenchorhynchus mashhoodi;* G : *Hoplolaimus indicus.*

ATTRACTION TOWARDS PREY (Fig. 2)

The predacious nematodes were unable to detect their prey even from short distances (Esser, 1963). This

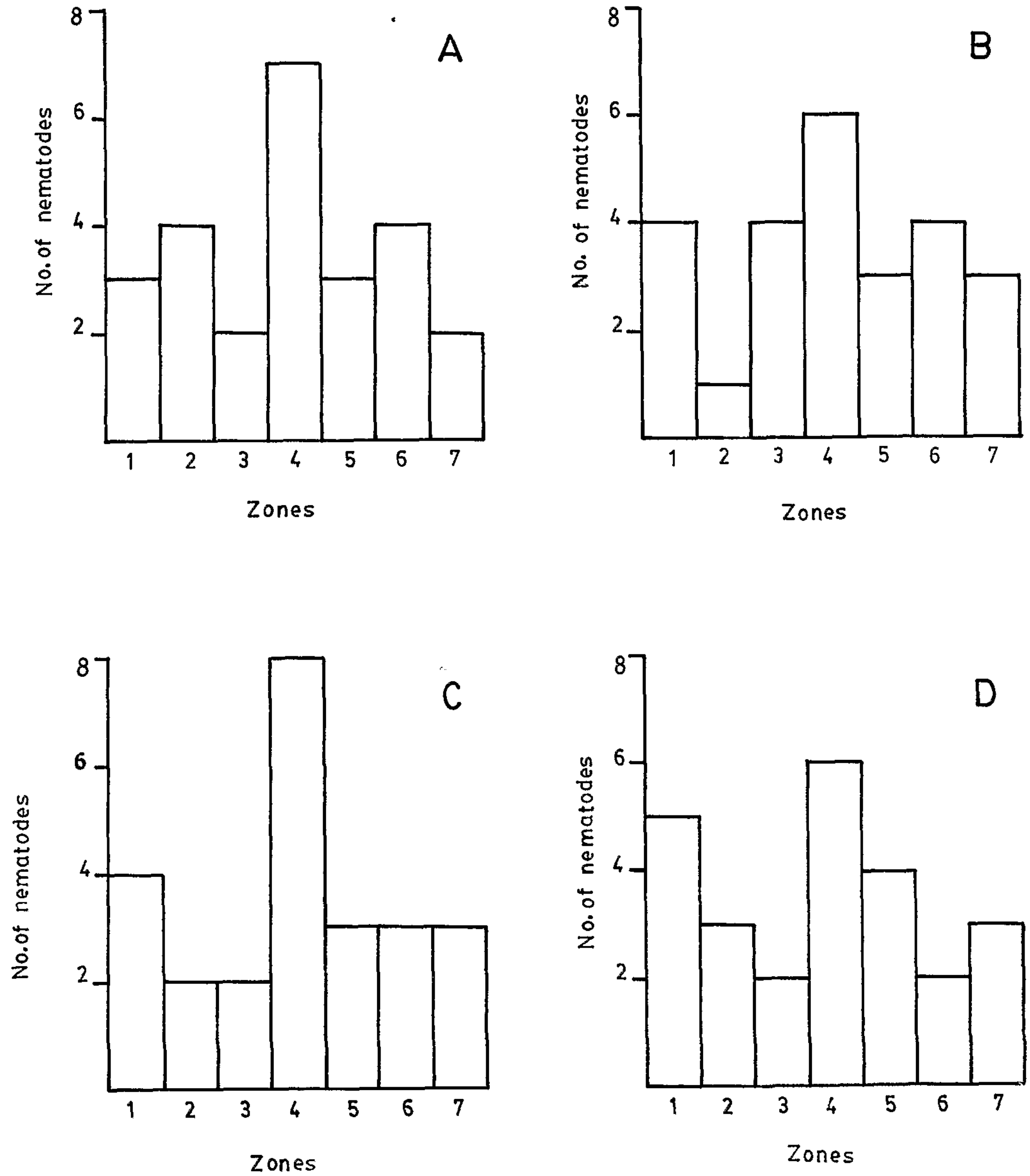

Fig. 2. Attraction of *D. stagnalis* towards A : without prey; B : *Rhabditis* sp. (whole); C : *Rhabditis* sp. (excised); D : *Hirschmanniella oryzae* (excised).

opinion was supported by Grootaert and Maertens (1976); Wyss and Grootaert (1977) and Bilgrami, Ahmad and Jairajpuri (1984; 1985*a*) on their studies on *Mononchus aquaticus*, *L. vulvapapillatum* and *A. thornei*. Esser (1963) was also of the opinion that live prey cut in two halves attracted several dorylaim predators. During present observations on *D. stagnalis* such a phenomenon was not observed either towards excised *Rhabditis* sp. or *H. oryzae* as the number of predators present in zones 1, 2 and 3 in the presence and absence of prey were not significantly different ($p > 0.05$). However, aggregation of *D. stagnalis* around an injured prey suggests some kind of attraction (Wyss & Grootaert, 1977; Bilgrami, Ahmad & Jairajpuri, 1985*a*).

RATE OF PREDATION OF ADULTS AND JUVENILES (Fig. 3)

All except the first stage juveniles preyed upon *Rhabditis* sp. and *H. oryzae*. First stage juveniles did not

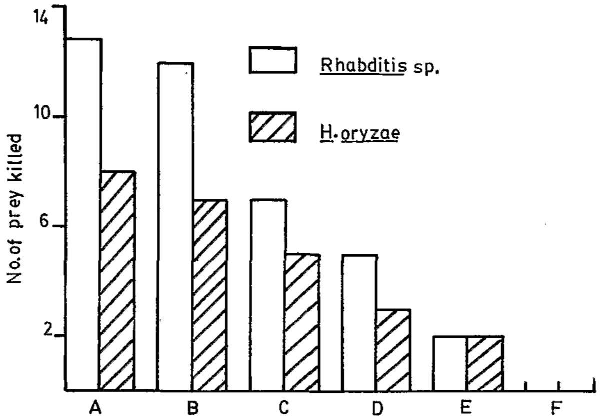

Fig. 3. Rate of predation of adult and juvenile stages : A : Female; B : Male; C : Fourth stage; D : Third stage; E : Second stage; F : First stage juveniles.

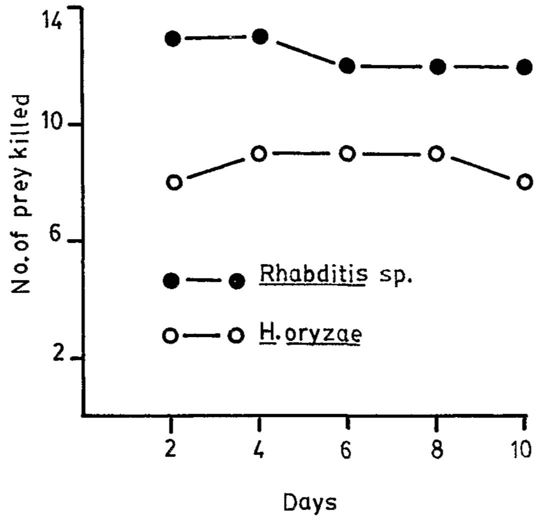

Fig. 4. Predatory pattern in *D. stagnalis.*

kill or injure any prey but fed on prey killed by elder stages. Adults (male and female), fourth and third stage juveniles killed more *Rhabditis* sp. than *H. oryzae.* Second stage juveniles preyed equally upon both the prey. There was no significant difference in the number of prey killed by male and female *D. stagnalis* ($p > 0.05$). Fourth and third stage juveniles killed lesser number of *Rhabditis* sp. and *H. oryzae* than their adults. Differences in the rate of predation by various stages of *D. stagnalis* reflect their predatory potentials. Adults being stronger predators than their younger stages.

Predatory pattern (Fig. 4)

D. stagnalis showed little variation in its predation on *Rhabditis* sp. and *H. oryzae* over a period lasting ten days. Number of prey killed by predators after 2nd and 10th day was not significantly different ($p > 0.05$). *Mononchus aquaticus* also showed a consistent predatory pattern over the same period (Bilgrami, Ahmad & Jairajpuri, 1984).

Factors influencing predation by *D. stagnalis* (Fig. 5)

The increase in prey number increased the predation by *Diplenteron potohikus, Prionchulus punctatus* and *A. thornei* (Yeates, 1969; Nelmes, 1974; Bilgrami, Ahmad & Jairajpuri, 1985*a*) but predation by *Mononchus aquaticus* remained unchanged in varying prey populations (Bilgrami, Ahmad & Jairajpuri, 1984). Observations on *D. stagnalis* revealed that predation increased significantly upto a population of 125 prey nematodes ($p < 0.05$, Fig. 5, A). Prey number more than this did not affect predation and the rate of killing per day was same ($p > 0.05$). This suggests a certain ration between predators and prey for maximum predation at which *D. stagnalis* might have been satiated and did not attack or kill any prey thereafter. The increase in predation was perhaps the outcome of improved chances of encounters between predators and prey which, however, did not alter predation beyond an optimum level of prey population.

Predation was also influenced by different temperatures. Maximum number of *Rhabditis* sp. and *H. oryzae* were killed at 25 and 30° (Fig. 5, B). Temperatures lower (5-15°) and higher (40°) declined predation markedly ($p < 0.05$). At 20 and 35° moderate number of *Rhabditis* sp. and *H. oryzae* were killed. At different temperatures the rate of predation by *D. stagnalis* may be different because of the activity of predators and prey which might have been influenced by the change in temperature (Bilgrami, Ahmad & Jairajpuri, 1983).

The starvation of predators was the only factor which did not alter the number of prey killed per day by *D. stagnalis* (Fig. 5, C). Differences in predation after 0 and 14 days were insignificant ($p > 0.05$). Bilgrami, Ahmad and Jairajpuri (1984) also found similar results in *M. aquaticus.*

The rate of predation by *D. stagnalis* was also altered by the change in agar concentrations as was also observed by Bilgrami, Ahmad and Jairajpuri (1983) in *M. aquaticus.* Maximum killing was recorded in 1, 2 and 3 % water-agar ($p < 0.05$, Fig. 5, D). Concentrations higher than these declined the rate of feeding significantly ($p < 0.05$). In 6 % no specimen of *H. oryzae* was either killed or ingested but predators succeeded in killing a few *Rhabditis* sp. at this concentration. It seems that similar to temperature, agar concentrations also governed the activity of prey and predators which affected the rate of predation by *D. stagnalis.*

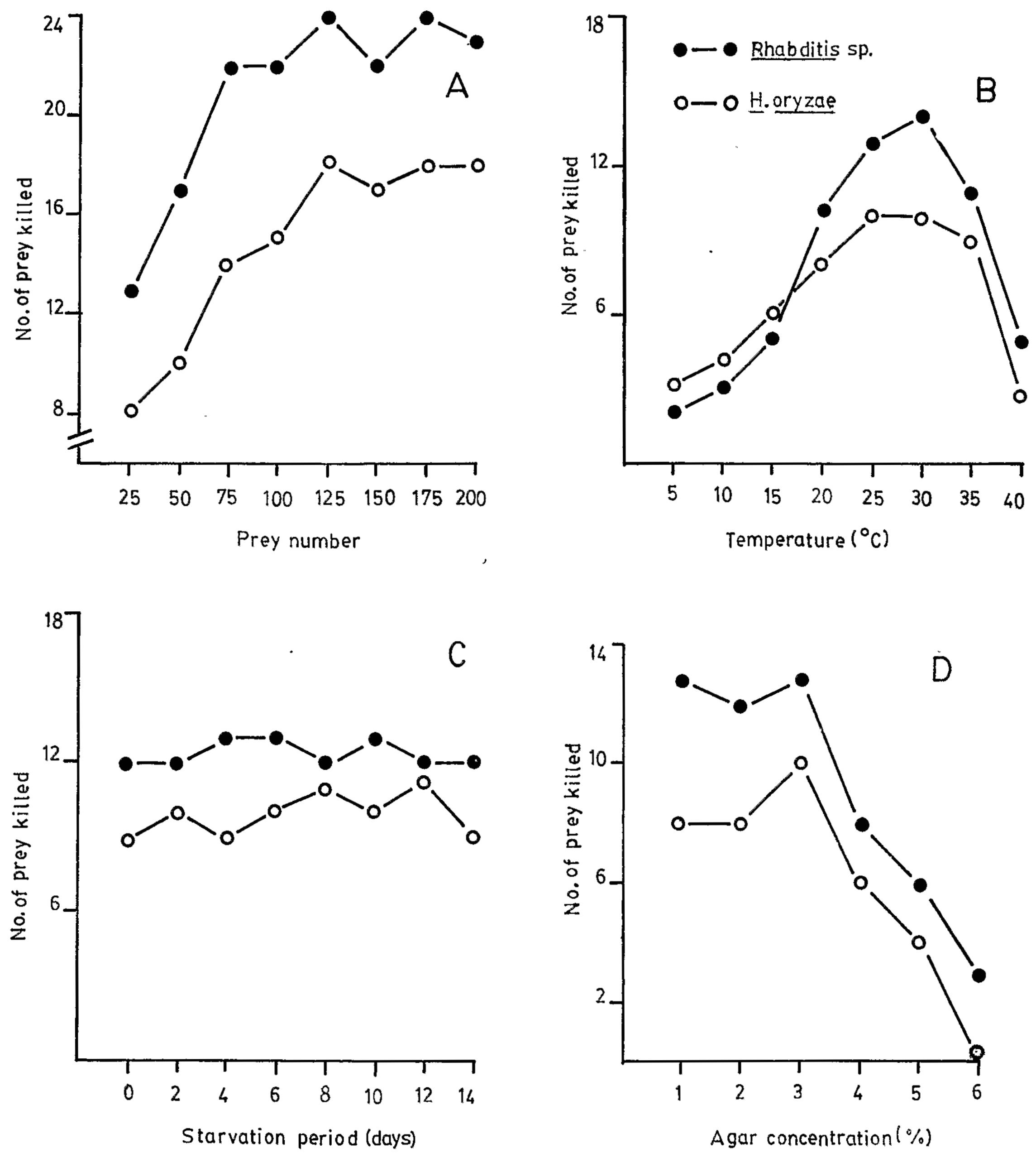

Fig. 5. Factors influencing predation by *D. stagnalis*. A : Prey number; B : Temperature; C : Starvation of predators; D : Agar concentration.

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