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Effect of *Mermis* spp. infection on the fecundity of insect pests of grasshoppers

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Abstract

Grasshoppers are subjected to attack by a wide range of predators and parasites at all stages of their life cycle. Fecundity of these predators and parasites of the insects was affected when grasshoppers were contaminated with *Mermis* spp. Mostly, the females laid fewer eggs than normal. The numbers of eggs produced were 17.5±3.0, 11.2±5.3 and 8.6±4.3 for *Poekilocerus pictus, Oxya velox* and *O. hylahyla*, respectively, for infested insects, whereas, it was 43.3±5.2, 37.8±6.30 and 39.34±5.2 in uninfected grasshoppers. Beside this, it was also noticed that insect infected with *Mermis* spp. did not survive for long. Dissection examination showed that there was significant suppression of oocytes and testis development in infected individuals.

Keywords: Survival, oocyte, fecundity, pathology, *Poekilocerus pictus, Oxya velox, Oxya hylahyla*

Grasshoppers are responsible for causing great loss to valued agronomic crops. They are subject to attack by a wide range of predators and parasites during all stages of their life cycle. *Mermis* spp. also parasitize grasshoppers and locusts in the field. *Mermis nigrescens* Dujardin, 1842 plays a vital role in suppressing the insect population inhibiting their reproductive and immune systems (Christie, 1937).

Numerous publications are available on different aspect of grasshoppers regarding their systematics, ecology and biology (Roberts, 1941; Joyce, 1952, Dirsh, 1961; 1975; Grunshaw, 1991; Riffat & Wagan, 2015); but details about the natural enemies of grasshoppers are missing, with exceptions of Irshad (1977); Hamid & Aslam (1985); Riffat *et al*., (2012). Mulkern *et al*., (1969) stated that coating of mermithid eggs with insect food enhances the percentage of infection. Further, Christie (1937) highlighted the living habitat of *Mermis* spp., he suggested that they prefer to live under soil and their eggs remain viable for several months and can be easily be shipped anywhere. These eggs can be utilized against insect pests. As a bio-control agent, *Mermis* spp. may have a long lasting effect and reduce the environmental problem caused by toxic pesticides. Biocontrol is one of the best solutions to overcome pest problems. Unfortunately, there is little awareness amongst farmers and other stakeholders; the utility of biocontrol should be made more public.

Materials and Methods

Sampling: Different habitats in the district of Badin in Sindh, Pakistan were inspected at various times in different months during 2015-2016. Collections were made from rice (*Oryza sativa* L.), maize (*Zea mays* L.) and sugarcane (*Saccharum officinarum* L.) including the surrounding vegetation with an insect net and

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large samples were picked with forceps or they were hand-picked. The samples were stored in plastic bottles. All of the collected material was sorted out into different species groups.

Culturing of host species: Species of insects were identified by identification keys of Riffat & Wagan (2015) along with photographs and illustrations. After identification, all the material was maintained under laboratory condition in wooden cages (length=17.2 cm, width=14.2 cm). However, in order to have a clear view of all activities of the insects, some were reared in ordinary glass-jars at room temperature (28-38±2° C), with a relative humidity of 30-50±5%. Fresh rice leaves were served to the insects daily and maintained by adding water onto the leaves. The cages and jars were placed in sunlight for 15 to 20 min., daily, to maintain insect health and to prevent diseases.

Collection of host species egg-masses: Egg-masses that were examined during this study were obtained from specimens that were cultured in different cages, and about 40% were collected from insects reared in culture media. Females deposited eggs in a cup filled with sand placed in their cages. Those reared in jars deposited eggs on leaves that were placed vertically in the jars. Cups that were placed in the cages were examined in order to obtain eggs and egg-masses. The eggs were counted by the method described by Pradhan & Peshwani (1961).

Dissection of insect host species: Insects cultured under laboratory condition were thoroughly examined and cut ventrally with a scalpel. When the abdomen was opened and visible for examination, a large number of insects were found infected with *Mermis* spp. Small juvenile nematodes were seen in the host body with evidence of several physiological changes, such as depletion in fat, reduction and immature size of ovaries and testes. *Mermis* spp. were collected and preserved in glycerine and lacto-phenol.

Identification of *Mermis* spp.: The terminology used by Nickle (1971, 1973); and Baker & Capinera (1997) for *Mermis nigrescens* were used in this present study.

Statistical analysis: For the comparison of different mean values of experimental groups ANOVA SPSS 16.0 was used and LSD (least significant different test) was also used in comparison of different variances.

Results

Nematodes parasitizing the grasshopper species belonged to family Mermithidae; this family also infests the spiders, leeches, and crustaceans throughout the world, including Pakistan. It was noted that *Mermis nigrescens* infects grasshoppers (Orthoptera; Caelifera). Infection reduces survival and fecundity of host insects. High infection of grasshopper, i.e., 64.05%, was reported from those samples collected from rice crops and lowest in species collected from dry lands. Infection percentage, i.e., 64%, was significantly higher in grasshopper samples collected from paddy fields, perhaps due to high moisture levels in this crop whereas insects from dry habitats were less infected. Fecundity was 23.5±3.2 in insects cultured in the lab. Insects infected with *Mermis* spp. lived shorter spans that may be caused by damage to many vital organs.

Species infested with *Mermis* spp. deposited fewer eggs, i.e., *Hieroglyphus perpolita* Uvarov, 1933 with 11.2±3.2 eggs, *H. nigrorepletus* Bolivar, 1912 with 8.6±4.3 eggs, and *Poekilocerus pictus* with17.5±3.0 eggs as compared to its normal fecundity rate of 43.3±5.2, 20.9±4.5 and 43.3±5.2, respectively. The fecundity of Oxyinae family was also reduced due to *Mermis* spp. attack, the fecundity rate in *Oxya* spp. was 16.4±3.4 and 14.5±3.2 for *Oxya velox* (Fabricius, 1787) Serville, 1831 and *O. hyla hyla*, Serville, 1831, respectively. *Truxalis exmia exmia* Eichwald, 1830 deposit 9.5±3.2 eggs if they were infected with *Mermis* spp., however, its normal fecundity rate was 23.5±3.5 under laboratory conditions. When

parasitized, they lived shorter lives (Table 1) due to severe damage to their vital organs Pathological changes were observed in dissections which included suppressed testes development, slow growth rate in both sexes, and sluggish movement. During the present study, it was noted that infections of immature juveniles did not affect the behavior of the host in high moisture areas such as in paddy fields. Similarly, insect contaminated with *Mermis* spp. reduced many important activities of the infected insects. *Truxalis exmia exmia* deposited fewer eggs, i.e., 9.5±3.2 when infected with *Mermis* spp.; however, normally it laid 23.5±3.5 under laboratory conditions.

Survival was also reduced due to major damage to vital organs function. Testes and oocyte development was significantly restrained by parasitic attack (Table 2).

There was no significant effect on the behavior of nymphal stages of the insects when infected with *Mermis* spp. juveniles; however, nymphal development was slowed and the size of the *Mermis* spp. was reduced in the nymph.

The adult host developed faster during the first fifteen days when infected with *Mermis* spp., but the wings development was reduced and deformed, curved in shape.

Table 1. Fecundity of six species of grasshoppers uninfected compared with infected with *Mermis* spp.

Species	No. of eggs deposited by grasshopper	
	Uninfected (days)	Infected (days)
Hieroglyphus perpolita Uvarov, 1933	23.2±5.3d*	11.2±3.2d
H.nigrorepletus I. Bolivar, 1912	20.9±4.5e	8.6±4.3e
Poekilocerus pictus Fab.,	43.3±5.2a	17.5 ±3.0a
Oxya velox Fab.,	37.8±6.3c	16.4±3.4b
O.hylahyla Serville,	39.3±5.2b	14.5±3.2c
Truxalis exmia exmia Eichwald,	23.5±3.5d	9.5±3.2e
($F^{0.05}$)	$_{(31.36)}5.498$	$_{(12.97)}2.356$

Note: *The letter indicate a significant difference (P<0.01) according to LSD test.

Table 2. Longevity of six species of grasshoppers uninfected and infected with *Mermis* spp.

Species	Survival of grasshoppers	
	Uninfected (days)	Infected (days)
Hieroglyphus perpolita Uvarov, 1933	19.9±2.1f*	9.3±3.45e
H .nigrorepletus Bolivar, 1912	35.1±7.8e	21.3±4.2b
Poekilocerus pictus Fab.,	57.6 ±5.3a	19.4±1.2c
Oxya velox Fab.,	41.8 ±8.3c	19.6±7.2c
O. hylahyla Serville,	37.3±5.2d	16.2±5.2d
Truxalis exmia exmia Eichwald,	46.2 ±4.2b	23.5±3.1a
($F^{0.05}$)	$_{(39.66)}7.069$	$_{(14.96)}2.531$

Note: *The letter indicates a significant difference (P<0.01) according to LSD test.

Discussion

Denner (1968) observed that populations of *Hesperotettix viridis* were also infected with *M. nigrescens*. *H. viridis* completely lost its fecundity ability. Beside this, *Melanoplus bivittatus* produced less eggs as compared to its normal range. During these investigations it was observed that *Oxya* spp. were infected more with *Mermis* spp. than others. Perhaps the wet habitat of *Oxya*, (basically a rice pest) may be one of the reasons for this; however, infection of *Mermis* spp. was found to be at its maximum during the monsoon (June to July) season. Earlier, similar findings were reported by Blickenstaff & Shariffullah, 1962. Rubtsov (1964) also recommended that moist habitats enhance the infection of *Mermis* spp. During this study, it was noticed that ovaries in the females infected with *Mermis* spp. were not completely destroyed, as earlier reported by Christie (1936) however, it was also reported that testes were destroyed, males remained immature and ovaries failed to develop (Gordon *et al*., 1979).

Linstow (1899) stated that *Mermis* spp. significantly affected the population of earwig (*Forticula auricularis* L., 1758) and grasshopper. Bailey & Gordon (1973) reported that *R. culicivorax* depleted the metabolic activities of host species by accumulating the storage material in their trophosomes which prevent the development of imaginal disks in the host species. Schmidt & Platzer (1978) reported that when insects are infected with parasites its haemolymph protein was significantly depleted. Gordon (1981) reported that *M. nigrescens* obtained all dietary amino acids of host species by stimulating the catabolism of protein from host body. Further, he also reported reduction in glucose level in black flies. During this investigation, it was noted that grasshopper development became reduced when infected with *Mermis* spp. *Mermis* spp. may become commercialized for the management of grasshoppers in agricultural fields.

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