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An Ecotoxicological Investigation on the Effect of Deltamethrin (Insecticide) on Fecundity and Moulting Pattern of the Terrestrial Isopod, *Philoscia muscorum*

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Abstract: Soil is a complex and dynamic ecosystem supporting diverse fauna which constitute an integral component of ecosystem processes. Arthropod population in soil is dynamically involved in global nutrient cycling. This sensitive ecosystem and its components are affected by various chemical stressors added to it. Agrochemicals pose a serious threat to the faunal component of soil system. In this study impact of an insecticide, Deltamethrin, on the pre-adult moulting interval and fecundity of a terrestrial isopod, *Philoscia muscorum* was analyzed. Using standard procedures, bioassay studies were done in laboratory to find out the impact of the agrochemical. Four replicates were used for conducting fecundity studies. When control group was compared with the experimental group treated with deltamethrin, significant difference in fecundity was obtained. Pre-adult moulting interval showed significant difference between control group and experimental group. Ecologically feasible agro practices are to be promoted for sustainability of soil ecosystem.

Keywords: *Philoscia muscorum*, Ecotoxicology, Deltamethrin, Moulting interval, Fecundity

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Introduction

Soil fauna, characterized by numerous species, large number, small movement range and sensitivity to environmental changes (Copley, 2000) constitute an integral part of soil ecosystem by filtering and purifying the soil environment. Soil litter layer constitutes a crucial habitat for many soil organisms. Most of the soil fauna, macro as well as micro-fauna, influence the dynamic nature of soil ecosystem by modifying the habitat through litter decomposition. The process of litter decomposition is quite significant as about 90% of the total biomass in terrestrial systems returns to the soil through litter (Wardle and Bardgett, 2004). Litter layer soil arthropods belong to the group of ecosystem engineers and they facilitate litter decomposition by fragmenting leaf litter (Pinto *et al*., 2005), thus constituting distinctive components of brown food web (Bardgett *et al*., 2005). Yang and Chen (2009) have reported that soil fauna influence nutrient release through litter decomposition directly and indirectly thus altering the nutrient levels and community composition of soil. The soil macrofauna community are important functional groups, maintain the stability of ecosystem as a whole (Kunakh *et al*., 2020) and human interferences adversely affect the structure and function of these systems. Soil isopods are saprophagous invertebrates, with cosmopolitan distribution, often constituting dominant community in soil (David and Handa, 2010). Terrestrial isopods are sensitive to impacts of anthropogenic activities and hence are recommended as bioindicators (Mazzei *et al*., 2013; Agodi *et al*., 2015).

Anthropogenic activities in various dimensions including the alteration of physio-graphical structure and addition of chemicals into soil in the form of fertilizers and pesticides have become detrimental to soil fauna. Chemical additions to the soil disturb the equilibrium of the system as it cause quantitative and qualitative alterations to soil faunal component (Meena *et al*., 2020). It has been reported by Drobne (1997) that terrestrial isopods are appropriate to test the relative toxicity of various chemical additives present in the soil, indicative of their role as ecological indicators.

Considering the load of agrochemical stressors added to ecosystem and their perilous impacts, presently ecotoxicological studies are of much relevance. The present study aims to evaluate the impact of Deltamethrin on the fecundity and duration of moulting in the terrestrial isopod, *Philoscia muscorum.* Deltamethrin is a broad-spectrum pyrethroid insecticide (Tomlin, 2006), widely used for controlling pests in agriculture lands and public health programs (Bhattacharjee and Das, 2011). The present study takes into consideration the fecundity and pre-adult moulting pattern as it may indicate changes in population dynamics of the organism.

Materials and Methods

The impact of the agrochemical, Deltamethrin on fecundity and pre-adult moulting interval of *Philoscia muscorum* was studied using bioassay. For the experimental study, organisms were collected from the field and acclimatized under laboratory conditions. 150 adult organisms grouped as control group and experimental group were kept in culture bottles and fed with decaying jackfruit tree leaves. Deltamethrin was prepared in concentrations, 0.5,1, 1.5, 2, 2.5 and 3 ppm, by dissolving appropriate quantity of the Deltamethrin in 1000 ml distilled water (APHA, 2012). Sublethal concentration and safe concentration were calculated using Probit analysis (Finney, 1971). Five adult males and females each were kept in separate culture chambers-control group and experimental group. The experimental group was fed with jackfruit tree leaves soaked in sublethal concentration of Deltamethrin. Eggs in each oviposition was counted for both the groups. The number of days taken for hatching of eggs and the preadult moulting intervals were observed. The difference in fecundity of the control and experimental group was found out using one way ANOVA. Student's t-test was done to find out the difference in fecundity between broods as well as the difference in fecundity of the organisms treated with Deltamethrin.

Results and Discussion

Fecundity studies in Philoscia muscorum

Fecundity of *Philoscia muscorum* was recorded for the control as well as the experimental groups. Of the four replicates in the study, the second replicate gave the highest mean value of eggs (18) and lowest was recorded for the fourth replicate (13±1.41). Mean fecundity was 18. There was no significant difference in the number of eggs between the broods ($P= 0.63761$, $P> 0.1$).

Regarding the control group treated with sublethal concentration of Deltamethrin, the lowest mean value was for the fourth replicate (12). Here also there was no significant difference in the number of eggs between the broods ($P= 0.213$, $P>0.1$). But there was significant difference in fecundity between the control group and experimental group ($P= 0.006$, $P < 0.05$). Many investigators have reported depletion in isopod population due to application of agrochemicals (Allison, 2010; Adams, 2011; Anderson *et al*., 2012), which substantiates observations of this study.

Pre-adult moulting interval in Philoscia muscorum

Moulting pattern of *Philoscia muscorum* was studied under laboratory conditions. The first moulting occurred at 24.1±0.15 day, second moult at 34.9±0.09 day, third moult at 46.75±0.1 day and at 54.55±0.2 day fourth moulting took place. Pre-adult moulting intervals of *Philoscia muscorum* after treatment with sublethal concentration of Deltamethrin showed difference from the normal moulting pattern of the organism. The experimental group were treated with sublethal concentration of Deltamethrin (1.926 ppm). The eggs hatched after a period of 10.2 days. There was delay in hatching compared to the control group (7.8 days). Moulting intervals also showed increase, the first moulting happened after 14 days, i.e., approximately on the 24th day, second moulting on approximately 35th day, i.e. after 10 days, third moulting occurred on 47th day, i.e., after 13 days and the fourth moult after 14 days, i.e. on the 60th day. Replicates 2, 3, 6, 8 and 10 did not lay eggs while the other groups laid eggs. All the replicates in control group laid eggs. Deltamethrin treated group showed variation in moulting interval at different stages. One way ANOVA indicated that there is no variation in the number of days of each replicates with respect to different stages of moulting ($F=0.000347$, $P>0.05$).

Philoscia muscorum, a litter dwelling isopod is a non-target organism with respect to the insecticide, Deltamethrin. In the present study, it can be seen that exposure to deltamethin can negatively affect the fecundity of the isopod. Agricultural activities- physical such as ploughing or chemical- may affect the soil faunal population adversely. Pereira *et al*. (2009) have indicated that pesticides reaching the soil affect non-target organisms. Chemical stressors adversely affect biodiversity and ecosystem functioning across terrestrial as well as aquatic ecosystems (Beaumelle *et al*., 2020). This is an indication of extensive negative impacts of agro pesticides on soil ecosystems. In the present study it is seen that there is significant difference in fecundity between the control and experimental groups of *Philoscia muscorum*, though the number of eggs deposited in the broods showed no significant difference in both these groups.

The present study also indicates that Deltamethrin has negative impact on pre-adult moulting of *Philoscia muscorum* (Table 1; Fig. 1). Moulting interval was increased at various stages and fecundity was reduced. It is reported that application of pyrethroid chemicals to agricultural areas can lead to exposure of non-target organisms including soil decomposers to sublethal concentrations of the chemical, which cause alterations in the development pattern, growth and reproduction of these organisms (Palmquist *et al*., 2012), which substantiates the result of the study. Impact of deltamethrin can be through the substrate in addition to the dietary route (Karen *et al*., 1995). In addition to this, Akien-Alli and Otali (2021) reported that deltamethrin application reduced soil pH, soil organic matter content; soil nitrogen and phosphorus content was also reduced. Baskaralingam *et al*. (2019) has reported negative effects of deltamethrin on the physicochemical properties of the soil. It has been reported that agricultural practices decrease the number of species of soil organisms due to ploughing, effect of which last for months or weeks while the influence of persistent chemicals can alter the soil flora and fauna for months or years (Busari *et al*., 2015).

Soil litter dwelling isopods are found at

Table 1: Pre-adult moulting intervals of *Philoscia muscorum* after treatment with sublethal concentration of Deltamethrin

Stage	Sample 1	Sample 2 (Days)	Sample 3 (Days)	Sample 4 (Days)	Sample 5 (Days)	Sample 6 (Days)	Sample 7 (Days)	Sample 8 (Days)	Sample 9 (Days)	Sample 10 (Days)	Group mean (Days±SE)
Rest stage	10	10.5	10.5	10	10	10.5	10.5	10	10	10	10.2±0.07
1st moult	24	23.5	24	25	25	24	24	24	23.5	24	24.1±0.15
2nd moult	35	35	35	35.5	34.5	35	34.5	34.5	35	35	34.9±0.09
3rd moult	47	47	47	46.5	47	47	46	47	46.5	46.5	46.75±0.1
4th moult	59	60	59	59.5	59	60	60	60	59.5	59.5	59.55±0.13

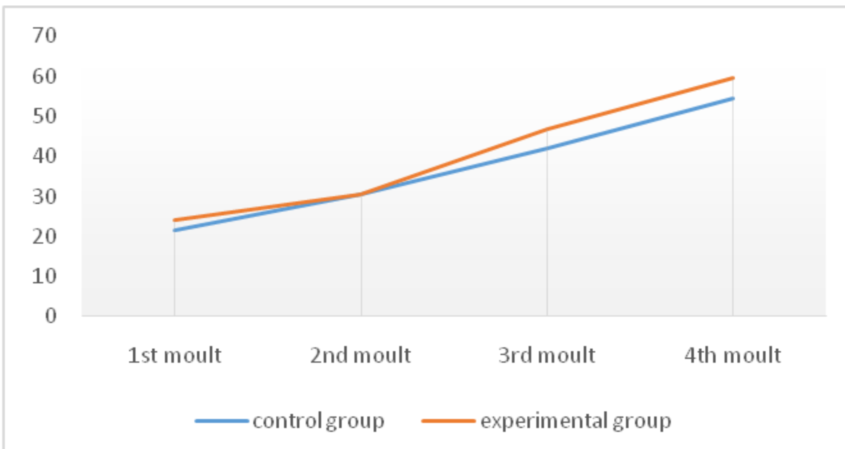

Fig. 1: Graph showing pre-adult moulting intervals of *Philoscia muscorum*- control group and experimental group (+Deltamethrin treated group).

various depths of litter layer and the experimental organism in the present study, *Philoscia muscorum* is an upper layer dweller in the litter. Yang and Li (2020) reported that soil isopods in general and especially those living in 0-1 cm soil layer significantly improve the nutrient content and quality of soil during decomposition of soil litter. Applied agrochemicals come in direct contact with the upper layers of the litter or soil, which may prove detrimental to the organism considered in the present study. Their sensitivity to stressors in the soil ecosystem make them preferable to be used as ecological indicators, reflecting the changes in their habitat. Many isopods are considered as ecological indicators which highlight the impact of intensive agricultural practices and other anthropogenic activities (Paoletti, 1999). Isopods are reported to have roles as bioindicators in bioremediation strategies, indicating the presence of heavy metals (Udovic *et al.*, 2009) as well as in restoration programs (Snyder and Hendrix, 2008). Results of the present study shows that *Philoscia muscorum* can be an indicator for chemical stressors in soil.

Sustainablity of global ecological systems is crucial with respect to food security and maintenance of habitable spaces in the biosphere. Regarding soil ecosytems, existence and maintenance of a healthy population of these soil isopods is of utmost importance with respect to their key ecological role as litter decomposers thus forming a salient component of global carbon budget (Berg and Mcclaugherty, 2014). This scenario necessitates the popularisation of soil-faunal friendly approaches in agro-ecosystems.

Conclusion

Synthetic agrochemicals have invaded all kinds of biosystems. Soil systems are of special emphasis regarding the effect of chemical stressors as the impact stands for a longer duration in the soil than any other type of ecosystem. The rejuvenation time of soil ecosystems is much higher compared to other systems, aggravating the negative effects. Production and application of synthetic agrochemicals have long lasting and far-reaching consequences in the biosphere. In this study it is found that the application of the pesticide, Deltamethrin adversely affects fecundity as well as pre-adult moulting interval of the soil isopod, *Philoscia muscorum*. This may affect population dynamics of this organism in the soil and the ecological services done by organism. Such changes may have global impacts, especially on biogeochemical cycles. Though there is no total protection against the deleterious effects of these chemical stressors, sustainable agricultural practices with lesser chemical additions are to be formulated and practiced for long term survival of the soil ecosystem.

Ethical Statement

The authors confirm that all ethical issues have been dealt with the research ethics guidelines provided by the NSS College, Pandalam, Kerala 689501, India.

Author Contributions

Each author has contributed equally to the study's planning, analysis, writing, and editing. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

The authors declare no conflicts of interest.

References

Adams ECG. (2011) Ecological studies of micro-arthropods in a New Zealand pasture soil with special reference to Collembola. Pedobiologia 11: 321-337.

Agodi A, Conti GO, Barchitta M, Quattrocchi A, Lombardo BM, Montesanto GE and Ferrante M. (2015) Validation of *Armadillo officinalis* Dumèril, 1816 (Crustacea, Isopoda, Oniscidea) as a bioindicator: in vivo study of air benzene exposure. Ecotoxicol Environ Saf. 114: 171-178.

Akien-Alli I and Otali CC. (2021) Impact of different doses of deltamethrine on soil microbial density and crop growth. GSC Adv Res Rev. 8(3): 36-42.

Allison FE. (2010) Soil organic matter and its role in crop production. Elsevier Scientific Publishing Company. New York, pp. 210.

Anderson RV, Elliot ET, Mc Clellan JF, Coleman DC and Cole CV. (2012) Trophic interaction in soil fauna as they affect energy and nutrient dynamics. Biotic interactions of bacteria, amoeba and nematodes. Microb Ecol. 4: 361-371.

APHA. (2012) Standard methods for the examination of water and waste water. American Public Health Association, American Water Works Association, Water Environment Federation.

Bardgett RD, Usher MB and Hopkins DW. (2005) Biological diversity and function in soils. Ecological Reviews. Cambridge University Press, Cambridge.

Baskaralingam P, Madhurantakam C and Gopalakrishnan C. (2019) Effects of deltamethrin on earthworm population and soil fertility. Int J Environl Sci Technol. 16(3):1295-1302

Beaumelle L, De Laender F and Eisenhauer N. (2020) Biodiversity mediates the effects of stressors but not nutrients on litter decomposition. Elife 9: e55659.

Berg B and McClaugherty C (2014) Plant litter: Decomposition, humus formation, carbon sequestration. Springer Berlin Heidelberg.

Bhattacharjee P and Das S. (2011) Toxicity of pesticide deltamethrin to fish. Indian J Appl Res. 4(5): 19-21.

Busari MA, Kukal SS, Kaur A, Bhatt R and Dulazi AA. (2015) Conservation tillage impacts on soil, crop and the environment. Int Soil Water Conserv Res. 3(2):119-129.

Copley, J. (2000). Ecology goes underground. Nature 406(6795): 452-455.

David JF and Handa IT. (2010) The ecology of saprophagous macroarthropods (millipedes, woodlice) in the context of global change. Biol Rev. 85(4): 881-895.

Dick RP. (1992) A review: long-term effects of agricultural systems on soil biochemical and microbial parameters. Agricult Ecosystems Environ. 40(1-4): 25-36.

Drobne D. (1997) Terrestrial isopods—a good choice for toxicity testing of pollutants in the terrestrial environment. Environ Toxicol Chem. 16(6): 1159-1164.

Finney DJ. (1971) Probit analysis, Statistics for Biologists. Cambridge University Press, pp. 216.

Karen V, Anouk T, Maartje H, Nico M van Straalen, Istiana D and Jack B. (1995) The importance of the exposure route when testing the toxicity of pesticides to saprotrophic isopods. Environ Toxicol Chem. 14 (7): 1225-1232.

Kunakh OM, Yorkina NV, Zhukova YO and Malasay AS. (2020) Environmental impact assessment: possible application of the ectomorphic approach. Agrology 3(3): 133-144.

Mazzei V, Longo G, Brundo MV, Copat C, Conti GO and Ferrante M. (2013) Effects of heavy metal accumulation on some reproductive characters in *Armadillidium granulatum* Brandt (Crustacea, Isopoda, Oniscidea). Ecotoxicol Environ Saf. 98: 66-73.

Meena RS, Kumar S, Datta R, Lal R, Vijayakumar V, Brtnicky M and Marfo TD. (2020) Impact of agrochemicals on soil microbiota and management: a review. Land 9(2): 34.

Palmquist K, Salatas J and Fairbrother A. (2012) Pyrethroid insecticides: use, environmental fate, and ecotoxicology. In: Insecticides- advances in integrated pest management, (ed.) Farzana P., Intech Open. doi: 10.5772/29495

Paoletti MG. (1999) Using bioindicators based on biodiversity to assess landscape sustainability. Agricult Ecosystems Environ. 74(1–3): 1-18.

Pinto AP, Serrano C, Pires T, Mestrinh, E, Dias L, Teixeira DM and Caldeira AT. (2012) Degradation of terbuthylazine, difenoconazole and pendimethalin pesticides by selected fungi cultures. Sci Total Environ. 435: 402-410.

Snyder BA and Hendrix PF. (2008) Current and potential roles of soil macroinvertebrates (earthworms, millipedes, and isopods) in ecological restoration. Restoration Ecology 16(4): 629-636.

Tomlin CD. (2006) The pesticides manual: a world compendium. British Crop Protection Council 14: 351.

Udovic M, Drobne D and Lestan D. (2009) Bioaccumulation in *Porcellio scaber* (Crustacea, Isopoda) as a measure of the EDTA remediation efficiency of metal-polluted soil. Environ Pollut. 157(10): 2822-2829.

Wardle DA and Bardgett RD. (2004) Indirect effects of invertebrate herbivory on the decomposer subsystem. In: Insects and ecosystem function, Springer Berlin Heidelberg, pp. 53-69.

Xin WD, Yin XQ and Song, B. (2012) Contribution of soil fauna to litter decomposition in Songnen sandy lands in northeastern China. J Arid Environs. 77: 90-95.

Yang X and Chen J. (2009) Plant litter quality influences the contribution of soil fauna to litter decomposition in humid tropical forests, southwestern China. Soil Biol Biochem. 41(5): 910-918.

Yang X and Li T. (2020) Effects of terrestrial isopods on soil nutrients during litter decomposition. Geoderma. 376(2): 114546.

Zhang LZ, Khan SU, Akhtar MH and Ivarson KC. (1984) Persistence, degradation and distribution of deltamethrin in an organic soil under laboratory conditions. J Agricult Food Chem. 32: 1207-1211.