VOLUME 8 ISSUE 2 2022

ISSN 2454-3055

INTERNATIONAL JOURNAL OF ZOOLOGICAL INVESTIGATIONS

Forum for Biological and Environmental Sciences

Published by Saran Publications, India

International Journal of Zoological Investigations Vol. 8, No. 2, 136-140 (2022)

International Journal of Zoological Investigations
Contents available at Journals Home Page: www.ijzi.net
Editor-in-Chief: Prof. Ajai Kumar Srivastav
Published by: Saran Publications, Gorakhpur, India

ISSN: 2454-3055

Impacts of Herbicide Oxadiargyl on the Lifespan, Fecundity and Development of a Detritivore Springtail, *Cyphoderus javanus*

Bhavya L.R.* **and Sanal Kumar M.G.**

P.G. and Research department of Zoology, N.S.S. College, Pandalam, Kerala, India

**Corresponding Author*

Received: 17th June, 2022; **Accepted:** 24th July, 2022; **Published online:** 28th July, 2022

https://doi.org/10.33745/ijzi.2022.v08i02.017

Abstract: Collembolans are tiny ubiquitous apterygote soil arthropods which plays a pivotal role in soil genesis, organic residues disintegration and soil fertility. The present study was focussed to investigate the deleterious effects of commonly used herbicide oxadiargyl on the lifespan, fecundity and development of an ecologically significant detritivore collembolan *Cyphoderus javanus*. Extensive application of herbicides had a significant effect on survival rates, fecundity, longevity and growth of *Cyphoderus javnaus*. The results revealed that rise in the concentration of herbicide negatively affects the survival rates and life history traits of this collembolan. In addition to killing non-target insects, indiscriminate utilization of herbicides in agricultural fields can cause unfavourable changes in the biological balance as well as results in environmental degradation.

Keywords: Detritivore, Biomarker, Fecundity, Herbicide, Ecotoxicity, Collembolans, *Cyphoderus javanus*

Citation: Bhavya L.R. and Sanal Kumar M.G.: Impacts of herbicide oxadiargyl on the lifespan, fecundity and development of a detritivore springtail, *Cyphoderus javanus.* Intern. J. Zool. Invest. 8(2): 136-140, 2022.
https://doi.org/10.33745/ijzi.2022.v08i02.017

Introduction

Soil is one of the most important resources of land which provides a favourable habitat for huge numbers of soil organisms ranging from microscopic creatures to macroscopic forms (Franke, 2003). Among soil fauna, arthropods play a major role in agriculture as they are essential components of the biodiversity of cultivated ecosystems (Fuller *et al.*, 1995; Fraj *et al.*, 2019). Soil microarthropods are well suited as indicator organisms for monitoring the sustainability of natural and agricultural systems because of their high density, species richness and ecological significance (Minor *et al.*, 2000; El Gayer *et al.*, 2009).

According to Rahardjo *et al.* (2019), collembola is the most commonly found organism in various ecosystems, making it easier to assess the soil health status. These detritivore organisms play a key role in soil ecosystem, believed to accelerate aeration and porosity of soil, degradation of organic residues, organic matter mineralization and paedogenesis thereby sustaining the nutrient pool and stability of soil structure (Winter *et al*., 1990). Pfiffner and Luka (2000) and Fraj *et al.* (2019) reported that there is a general trend in agricultural landscape towards a reduction in diversity and abundance of native flora and fauna because of increased landscape uniformity and greater disturbance due to agro-chemicals and tillage. Different environment conditions and chemical stressors may interact and can have negative impacts of soil biota (Morgado *et al*., 2016).

Numerous works have been carried out to determine the impact of widely used different pesticides in agriculture on various soil arthropods including collembolans in India and abroad. Several studies have been conducted regarding effect of selected pesticidal formulations on various collembolans (Amorim *et al*., 2005; Crouau and Moia, 2006; Eijsackers, 2009; Haque *et al.,* 2011; Saha and Joy, 2014; Chakravorty *et al*. 2015; Thomas and Kumar, 2020) and on isopods (Drobne *et al.,* 2008; Kolar *et al*., 2010; Souty-Grosset and Faberi, 2018) and acari (Bhattacharya and Joy, 1980; Ahn *et al.,* 2001; Ghosal and Hati, 2019).

Cyphoderus javanus is considered as a potential bioassay model for toxicity studies because it is very sensitive to the edaphic changes, occurs abundantly in moist and fertile topsoil, and can be reared in the laboratory throughout year (Saha and Joy, 2014). Detailed study on herbicidal effects on life-history, growth, survival, food consumption and reproduction on soil organism especially *Cyphoderus javanus* is still lacking. The present investigation attempted to evaluate the effects of herbicide oxadiargyl on the lifespan, development and fecundity of *C. javanus*, pointing its significant role in environmental degradation.

Materials and Methods

Live organism *Cyphoderus javanus* were randomly collected from different sites of Thiruvananthapuram district (Neyyar, Vithura and Agastyavanam Biological Park) and cultivated in special plastic chambers containing a mixture of plaster of paris and activated charcoal in the ratio 5:2 and distilled water, fed weekly with Baker's yeast pellets.The culture vessels were maintained in a controlled environment with a temperature of 28.7 ± 5 °C with photoperiod of 12:12 h (light: dark). For bioassay investigations**,** 1000 ppm stock solution of oxadiargyl was prepared by dissolving adequate amount of chemical in 1000 ml of distilled water (APHA, 2012). From this stock solution different concentrations of 2, 5, 7, 9, 11 and 13 ppm were used for toxicity study. Three replicates of *Cyphoderus javanus* and a control were taken for each concentration of this herbicide formulations. The mortality was recorded at every 12, 24, 48, 72 and 96 h. Probit Analysis (Finney, 1971) was used for the calculation of lethal concentration LC_{50}, LC_{100}, sub lethal and safe concentration of oxadiargyl. The total fecundity, hatching success and lifespan were also recorded. To find out significance between number of eggs and oviposition for normal and oxadiargyl treated individual, two-way ANOVA was used.

Results and Discussion

As shown in Table 1, collembolan's mortality rate was increased with rise in the concentration of herbicide oxadiargyl. The morality rate of *Cyphoderus javanus* on exposure with various concentrations of oxadiargyl (2 ppm, 5 ppm, 7 ppm, 9 ppm, 11 ppm and 13 ppm) were studied for various groups of 100 organisms during different time intervals. The mortality at 96 h after exposure to 2, 5, 7, 9, 11 and 13 ppm of oxadiargyl was 39.7, 43.7, 57.2, 78.1, 91.9 and 100%, respectively. No mortality was recorded in control groups. This is in accordance with the results of Vinod *et al.* (2017) who observed that the agrochemicals (Glyphosate and Indofil) have a profound effect in reducing the fecundity of *Cryptopygus thermophilus.*

LC_{100} value for herbicide oxadiargyl was computed as 25.1 ppm at 12 h, 22.48 ppm at 24 h, 19.04 ppm at 48 h, 14.06 at 72h and 12.71 at 96 h (Table 2). The LC_{50} value was calculated as 13.66

Table 1: Mortality rate (%) of Oxadiargyl on *Cyphoderus javanus*

Concentration	12 h	24 h	48 h	72 h	96 h
2 ppm	9.1	16.8	25.2	29.8	39.7
5 ppm	15.4	19.3	27.8	39.5	43.7
7 ppm	16.2	22.8	33.6	43.8	57.2
9 ppm	17.4	36.6	42.8	57.8	78.1
11 ppm	41.0	51.2	61.8	80.1	91.9
13 ppm	47.5	57.3	71.9	97.3	100

Table 2: LC_{100}, LC_{50}, safe and sublethal concentrations of Oxadiargyl on *C. javanus*

LC_{100}	**12 h**	25.1
	24 h	22.48
	48 h	19.04
	72 h	14.06
	96 h	12.71
LC_{50}	**12 h**	13.66
	24 h	11.38
	48 h	9.05
	72 h	6.63
	96 h	4.9
Safe Concentration (ppm)		0.79
Sub-lethal Concentration (ppm)		0.19

ppm at 12 h, 11.38 ppm at 24h, 9.05 ppm at 48 h, 6.63 ppm at 72 h and 4.9 ppm at 96 h (Table 2). The safe level and sublethal concentration of oxadiargyl was calculated as 0.79 ppm and 0.19 ppm, respectively (Table 2). Haque *et al.* (2011) determined LC_{50} and LT_{50} values of two herbicide formulations (pendimethalin and pretilachlor) for *Xenylla welchi* and found that at sublethal concentrations both the herbicides adversely affected the life cycle of this organism indicating their potential role in damaging the soil ecosystem.

The results of adverse effects of herbicide oxadiargyl on life history stages of *Cyphoderus javanus* are shown in Table 3. When compared to the control groups, the experimental group showed a sharp decrease in the number of eggs laid. In control group, mean number of eggs laid was found to be 71.7 and in experimental group it was 42.4. The average number of juveniles hatched was 65.2 in control groups and 31.83 in experimental groups. The hatching success was obtained to be 90.93 in control groups and 75.07% in experimental groups. The mean number of exuvia was noticed as 5.27 in control and 1.33 in herbicide treated groups. The average life span showed a drastic reduction from 105 days in control to 25 days in test groups. The results of two-way ANOVA showed that there is no significant difference in the number of eggs laid

Table 3: Toxic effects of Oxadiargyl on life history stages of *Cyphoderus javanus*

Treatment	Mean number of eggs laid	Mean number of juveniles	Hatching success (%)	Mean number of exuvia	Average lifespan (in days)
Control	71.7	65.2	90.93	5.27	105
Oxadiargyl	42.4	31.83	75.07	1.33	25

in each replicate during different oviposition ($P<0.05$) and having significant difference between number of eggs laid during different ovipositions ($P<0.05$).

Insect growth regulator pesticides produced significant ill effects like chitin synthesis inhibition, mortality of adults and juveniles, decreased fecundity, etc. on *Folosomia candida* at environmentally relevant concentrations (Campiche *et al.*, 2006), which is in conformity with results of present study. Significant reduction in hatching success due to exposure to these herbicides on *Cyphoderus javanus* was also reported previously by Chakravorty *et al.* (2015); which strengthens the observations of the present investigation. According to Odendaal and Reinecke (1998) the mortality rates are increased which may be due to the fact that toxin accumulation in the hepatopancreas become saturated after a certain period, which may cause the excess toxins to pass into the blood and interfere with biochemical reactions in other tissues (Jones and Hopkin, 1996). Pesticides interfere with enzymes either by inhibition of a cholinesterase which usually breaks down the neurotransmitter acetylcholine at synapses or inhibition of sulfhydral group enzymes and uncoupling of oxidative phosphorylation as in herbicides and fungicides (Brown, 1978). Liu *et al.* (2018) reported that adult survival, growth and reproduction of *Folosomia candida* differed significantly among Cu concentrations in soils and were negatively correlated with the copper concentrations, suggesting that the species was sensitive to contaminated soils, which is consistent with the results of the present investigation. Adult organism's survival rate, growth and fecundity were found to be negatively proportionate with oxadiargyl concentrations.

Conclusion

From the results of the present investigation, it can be concluded that the herbicide oxadiargyl treated *Cyphoderus javanus* showed a sharp reduction in longevity, fecundity, incubation, hatching and exuvium deposition. Negligible mortality of *Cyphoderus javanus* were recorded in control groups and higher mortality rate in test organisms due to continuous exposure of oxadiargyl could seriously influences the health of soil collembolans and hence, ecosystem stability. This in turn, can negatively affect the processes of soil aggregation, porosity, infiltration and paedogenesis. For better knowledge, further studies are recommended to know the ill effects of this herbicide on the physiological and histological aspects of *Cyphoderus javanus.*

Acknowledgements

The authors would like to acknowledge DST-FIST, for providing essential facilities at the research centre.

References

Ahn Y, Kim Y and Yoo J. (2001) Toxicity of the herbicide glufosinate-ammonium to predatory insects and mites of *Tetranychus urticae* (Acari: Tetranychidae) under laboratory conditions. J Economic Entomol. 94(1):157-161.

Amorim MJ, Rombke J, Scheffczyk A, Nogueira AJ and Soares AM. (2005) Effects of different soil types on the collembolans *Folsomia candida* and *Hypogastrura assimili* using the herbicide Phenmedipham. Arch Environ Contam Toxicol. 49: 343-352.

APHA. (2012) Standard methods for the examination of water and waste water, American Public Health Association, 22nd ed. Washington DC, pp. 948.

Bhattacharya T and Joy VC. (1980) Changes in the abundance of soil inhabiting Acari of paddy field in response to the application of two herbicides. In: Pesticide residue in the environment in India, (eds.) Edwards C.A., Veeresh G.K. and Krueger H.R., UAS Technical Services, 32: 505-513.

Brown AWA. (1978) Ecology of pesticides. New York: John Wiley and Sons. Pp.525.

Campiche S, Becker-van SK, Ridreau C and Tarradellas J. (2006) Effects of insect growth regulators on the non-target soil arthropod *Folsomia candida* (Collembola). Ecotoxicol Environ Saf. 63(2): 216-225.

Chakravorty PP, Haque A, Sanayal S and Dasgupta R. (2015) Effect of herbicides on *Cyphoderus javanus* (Hexapoda: Collembola) under laboratory conditions. J Entomol Zool Stud. 3(1): 220-223.

Crouau Y and Moia C. (2006) The relative sensitivity of growth and reproduction in the springtail *Folsomia candida*, exposed to xenobiotics in the laboratory, an indicator of soil toxicity. Ecoloxicol Environ Saf. 64: 115-121.

Drobne D, Blazic M, van Gestel CAM, Leser V, Zidar P, Jemec A and Trebse P. (2008) Toxicity of imidacloprid to the terrestrial isopod *Porcellio scaber* (Isopoda, Crustacea). Chemosphere 71: 1326-1334.

Eijsackers H. (2009) Side effects of herbicide 2, 4, 5-T on reproduction, food consumption and moulting of the springtail *Onychiurus quadriocellatus* Gisin (Collembola). J Appl Entomol 85(1-4): 341-360.

El-Gayyar EA, Al-Assiuty ANIM and Al-Korashy MM. (2009) Abundance and species diversity of soil microarthropods as influenced by different types of fertilizers in greenhouse biotopes. Egypt J Exp Biol (Zool) 5: 67-75.

Finney DJ. (1971) Probit Analysis. Cambridge University Press, Cambridge, pp. 333.

Fraj M, Charfi-Cheikhrouha F and Souty-Grosset C. (2019) Spatio-temporal variations of terrestrial isopod diversity in the Bizerte agroecosystems (North East of Tunisia). Vie Milieu. 69(1): 53-60.

Franke B. (2003) Arthropod fauna of soils. Newsletter of the Biological survey of Canada, pp. 20-35.

Fuller RJ, Gregory BD, Gibbons DW, Marchant JH, Wilson JD and Baillie SR. (1995) Population declines and range contractions among lowland farm birds in Britain. Conserv Biol. 9: 1425-1441.

Ghosal A and Hati A. (2019) Impact of some new generation insecticides on soil arthropods in rice maizecropping system. J Basic Appl Zool. 80: 6.

Haque A, Das Gupta R and Chakravorty PP. (2011) Effect of two herbicides on *Xenylla welchi* (Hexapoda: Collembola) under laboratory conditions. Environ Contam Toxicol. 86: 583-586.

Jones DT and Hopkin SP. (1996) Reproductive allocation in the terrestrial isopods *Porcellio scaber* and *Oniscus asellus* in a metal-polluted environment. Functional Ecol. 10: 741-750.

Liu M, Xu J, Krogh PH, Song J, Wu L, Luo Y and Ke X. (2018) Assessment of toxicity of heavy metal-contaminated soils toward Collembola in the paddy fields supported by laboratory tests. Environ Sci Poll Res. 25: 16969-16978.

Minor M, Norton RA, Volk TA, Abrahamson LP and White EH. (2000) Impact of willow/popular biomass crops on soil microarthropods. Interim Prog. Report. Prepared for the USA. Dep. Energy, pp. 1-10.

Morgado RG, Gomes PAD, Ferreira NGC, Diogo NC, Santos, Miguel JGS, Amadeu MVM and Loureiro S. (2016) Toxicity interaction between chlorpyrifos, mancozeb and soil moisture to the terrestrial isopod *Porcellionides pruinosus*. Chemosphere 144: 1845-1853.

Odendaal JP and Reinecke AJ. (1998) The effect of high lead concentrations on the mortality, mass and behaviour of *Porcellio laevis* Latr. (Crustacea, Isopoda) in laboratory tests. South African J Zool. 33(3): 143-146.

Pfiffner L and Luka H. (2000) Overwintering of arthropods in soils of arable fields and adjacent semi-natural habitats. Agricult Ecosys Environ. 3: 215-222.

Rahardjo BT, Rachmawati R and Soetjipto D. (2019) Sugarcane leaf litter as soil amendment to stimulate collembolan diversity. Agrivita J Agricult Sci. 41(2): 295-301.

Saha I and Joy VC. (2014) Potential ill effects of IGR pesticides on life-history parameters in ecologically important soil collembolan *Cyphoderus javanus* Borner. Int J Sci Environ Technol. 3(2): 365-373.

Souty-Grosset C and Faberi A. (2018) Effect of agricultural practices on terrestrial isopods: a review. Zookeys 801: 63-96.

Thomas N and Kumar MGS. (2020) Effect of feed on life history of *Bilobella branuera* (Dhervang-1981)-(Collembola:Neanuridae). J Xidian Univ. 14(12): 485-492.

Vinod P and Sanalkumar MG. (2017) Study on the Effect of two agrochemicals on the fecundity of a soil collembolan *Cryptopygus thermophilus*. Int J Pure

Appl Res. 4(1): 34-41.

Winter JP, Voroney RP and Ainsworth DA. (1990) Soil microarthropods in long-term no-tillage and conventional tillage corn production. CanJ Soil Sci. 70: 641-653.