Journal of Pharmaceutical Research International

33(51B): 85-89, 2021; Article no.JPRI.76976
ISSN: 2456-9119
(Past name: British Journal of Pharmaceutical Research, Past ISSN: 2231-2919, NLM ID: 101631759)

A Review on Non-target Toxicity of Deltamethrin and Piperonyl Butoxide: Synergist

Mrinmoy Basak [a], Rejwan Ahmed Choudhury [a], Priyanka Goswami [a], Biplab Kumar Dey [a] and Moksood Ahmed Laskar [a*]

[a] Faculty of Pharmaceutical Science, Assam Down Town University, Guwahati-26. Assam, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JPRI/2021/v33i51B33517
Editor(s):
(1) Dr. Takashi Ikeno, National Institute of Mental Health, National Center of Neurology and Psychiatry, Japan.
Reviewers:
(1) Sérgio Thode Filho, Federal Institute of Education, Science and Technology of Rio de Janeiro, Brazil.
(2) Carlos Prosperi, Blas Pascal University, Argentina.
(3) Idris Sherifat Banke, Usmanu DanFodiyo University, Nigeria.
Complete Peer review History, details of the editor(s), Reviewers and additional Reviewers are available here: https://www.sdiarticle5.com/review-history/76976

Mini-review Article

Received 08 September 2021
Accepted 17 November 2021
Published 25 November 2021

ABSTRACT

Deltamethrin and piperonyl butoxide two synthetic pyrethroids, when used in a combination it produces synergistic effect. This two insecticide has found to be widely used in the management of mosquito, housefly and other insects to control the various vector born diseases. In this review we assessed the toxic effect of deltamethrin and piperonyl butoxide on beneficial organisms commonly available in the ecosystem. It was found to be toxic to fish, honey bees the prime pollinators of crop plant; earthworm is also susceptible at a lethal concentration for a particular exposure. As far the birds are concerned, they have a less toxic risk in lower concentration of exposure. The alterations obtained in the hematological, biochemical and histopathological studies, further conclude that it can cause environment hazards and toxic to the non-targeted organisms. This investigation gives an insight into the combined toxicological profile of deltamethrin and PBO for better risk assessment and safe use of pyrethroids and their synergist in non-targeted organisms.

Keywords: Deltamethrin; piperonyl butoxide; fish; earthworm; bird; honey bees; selective toxicity.

**Corresponding author: E-mail: moksoodahmedlaskar@gmail.com;*

1. INTRODUCTION

Pyrethroids are meant for the management of various insects for controlling various vector born diseases or as pest control, by killing or repelling a good range of organisms which are undesirable but these are also capable to harm the other non-target organisms inhabiting to ecological balance. In Ghana, through tropic transfers and run-off water pyrethroids are reaching the aquatic ecosystems, this types of chemicals may cause harmful effect to man based on water bodies. Deltamethrin is one of such insecticides widely used worldwide affecting the aquatic vertebrae [1]. In soil earthworms are most common organisms in the environments, which play a crucial role for the improvement fertility and structure in soil ecosystems. Thus earthworm are consider as an example of non-target organisms in soil as because of their beneficial role, earthworms modify the organic matter in soil by chemical as well as physical means, they mix the plant litter into soil, which improves the soil porosity, stabilization and formation of soil aggregates [2]. Honey bees are the good pollinators of environment acute or chronic exposure pesticides like deltamethrin may kill the honey bees individually, whole colonies within short periods of exposure, exposure for long term may include lethal effects on queen, drones, workers, and brood, which may be kill or altered the fertility. In a honey bee it may alter tissues, gut, enzyme activity, memory and behavioral function and also found to cause reproductive issues like viability of sperm, disruption of ovary [3]. Pyrethroids are also found to affect the birds indirectly which may be due to the threat through the supply of food. Waterfowl, insectivorous birds which are small are mostly susceptible for such kinds of toxicants [4]. In practice of agricultural the people engaged are often face problem in harvest management because of loss which is caused by the various insects pest. In control of such problem farmer have to go for various pesticides to used which may be natural or synthetic ones like pyrethroid and pyrethrins [5]. Thus, while spraying the pesticides in crops or use of insecticides in the management of vector born disease it should be kept in mind regarding their toxic profile and safety margin in terms of concentration. Pesticides which are sprayed on the crops fall on the soil and enter the water via surface runoff from agricultural soils, enter water and affect the earthworm, fish. Hence present study has undertaken for the assessment of safety margins for deltamethrin and piperonyl butoxide in regards to non-target organisms such as honey bees, the earthworm, bird, and fish [6]. The combination form of insecticide has found to be advantageous because some of these are also having the synergistic effect such as PBO (Piperonyl butoxide) which has found to be used with other insecticides because of its synergistic activity infect there are different essential oils which can be used as a synergists when employed with the synthetic pyrethroids like alpha-cypermethrin, beta-cypermethrin etc. [7]. PBO is also toxic substance which may results into short term as well as long term effects, the effects are mostly associated to carcinogenic, hepatic and central nervous system related adverse impacts. PBO is the most widely used synergists by incorporating with various insecticidal products. In case of aerosol containing mosquito repellants PBO is often used as synergist to increase the potency of synthetic pyrethroid [8]. The toxic profile of PBO is moderately toxic to aquatic animals, highly toxic to amphibians, invertebrates and earthworm [9]. Toxicity for Ingested PBO in case of birds is founds to be low [10,11].

2. METHODS

2.1 Toxicity Study in Aquatic Animals

Pyrethroids with less than 1.0 part per billion (ppb) LC50 values having toxic effect for invertebrates among the aquatic animals, whereas the similar doses of pyrethroids are employed against mosquito, black fly and their larvae to control the various vector born disease [12]. The insects of surface dwelling category are most sensitive organisms, nymphs, mayfly, large crustaceans, benthic and zooplankton such types of organisms may also get affected with insecticides. Very low concentration which is even non lethal dose, they may show some altered behavioral changes in case of aquatic animal's pyrethroids are having the ability to create tactile stimulus and may affect the survival. Shrimp and lobster are also susceptible to most of the pyrethroids. LC50 values for fish are even less than 1.0 part per billion thus pyrethroids are highly toxic to aquatic vertebrates. The toxic profile for deltamethrin is highly toxic; whereas allethrin having low toxicity; permethrin, cypermethrin and fenvalerate these are moderately toxic pyrethroids [13]. The abnormality in potassium and sodium level with an increase in the urine osmolality is observed due to pyrethroids toxicity. The damage observed into the gill surface obtained from

histopathological studies suggest the accumulation of insecticide in gills, which may associated with decrease oxygen intake efficiency by gill and due to increase secretion of mucus irritation is developed with increase ventilation volume [14]. The toxic effect causes by pyrethroids includes impaired schooling behaviors, inappropriate swimming (try to adhere the water surface), buoyancy loss, seizures, hyperactivity, rate of cough is increased, elevated mucus secretions in gill, gill arches get flared, and before death shaking of head and listlessness is also observed [15].

2.2 Toxicity Study in Honey Bees

Pyrethroids affects the feeding behavior of insects like bees and thus act as a strong repellent [16]. The pyrethroids at starting it leads to knockdown of bees (the normal position of the insects cannot be possible to maintained) which further may result into recovery or death. Pyrethroids having repellency action towards bees, which may result into a decrease in contact of bee's with the surfaces of plant and it is lasts for one day after the administration of pyrethroids [17]. As most of the insects they die in field, thus fewer chances are there to contaminate their hives and brood remains unexposed from insecticides.

2.3 Toxicity Study in Birds

Pyrethroids can produce some indirect affects to the birds; it is due to contaminated food supply. Small insectivorous birds and waterfowl are commonly susceptible towards insecticides [18]. The resistance of pyrethroids is more in case of birds as compared to mammals. Excretion rate of pyrethroids is more rapids in quail, with faster metabolisms and low absorption rate; it is found that >4,000 mg/kg body weight is the LD50 in oral route for quail whereas 450 mg/kg body weight for is the oral LD50 in rat, which is almost 10 times greater in magnitudes [19].

2.4 Toxicity Study in Earthworms

Application of pyrethroids in soil has founds to reduce earthworms population predatory mites counts [20]. Deltamethrin decrease the body weight of earthworm's initially in 4 weeks but afterwards it get increased. The enzyme P450activity is stimulated in earthworms by a low concentration of deltamethrin [21]. The time of exposure, concentration, environmental matrix and selected end points are the factors that influence the deltamethrin toxicity identification. Deltamethrin toxicity profile has been found to be as moderate towards earthworms as compared to other pyrethroids. However, through filter paper test it is observed that deltamethrin have both cytotoxic and chronic toxicity even at low doses (2.0 mg kg−1) [22,23].

3. DISCUSSION

This study was carried out to analyze any toxicological, physiological and pathological changes on non target species such as earthworm, honey bee, aquatic vertebrates, birds which is caused by the use of some common environmental toxicants inducing pesticides and also to create an awareness of pesticide pollution in ecological resources. The alteration in constantly swimming sideways, losing equilibrium, slowing their motion, hanging vertically in the water, increased operculum movement, lordosis, and motionlessness gaping their mouth for air with lamellar thickening on gill and fusion. Fish are mostly sensitive to the environmental fluctuation takes place within internal milieu. Therefore water quality is a major factor, in terms of hematological variation in fish. Deltamethrin and its synergist piperonyl butoxide is a highly toxic pesticide widely used in agriculture which in contacts with honey bees causes an altered feeding behavior and also may lead to death. As honey bees are the natural pollinators therefore, special attention is drawn to its heavy use in mosquito control programs which necessitates in-depth subchronic and chronic toxicity tests in honey bees. Pyrethroids used in agriculture also decrease the population of earthworms therefore special consideration has to be taken to retain the ecological balance of earthworm which is also essential for soil biota. Birds are found to be as less susceptible towards the pyrethroids in low concentration for short period of exposure.

4. CONCLUSION

The toxic effects of deltamethrin and its known synergistic effects with PBO exposure to non-target species like honeybees, earthworms, birds and aquatic organisms (fish) is the most significant as these organisms are essential for maintaining the ecological balance. Aquatic organisms, particularly fish, are highly sensitive to deltamethrin even at low concentration also they can cause toxic effects. It has been found to be toxic to honey bees the prime pollinators of crop plant; earthworm is also susceptible at a

lethal concentration for a particular exposure, as far the birds are concerned, they are having a low toxicity in terms of lower concentration for short period of exposure. It is therefore, posses a great environmental risk and there is an utmost necessity to carry out their subchronic and chronic toxicity studies on the toxic effects of deltamethrin and PBO exposure to fish, honeybees, earthworms and birds which may attribute towards the prediction of a safe concentration of deltamethrin and PBO for further insecticides management techniques. This study confirms the potential risk of deltamethrin and PBO, which should be accounted in the assessment of pyrethroids induced ecological risks in non target organisms.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

ACKNOWLEDGEMENT

Authors take this opportunity to acknowledge DEAN of Pharmaceutical science, Assam down town University and Principal, NEF College of Pharmacy, Guwahati, Assam, India to encourage me and providing me all the facilities I have been needed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Extoxnet, Pesticide information profiles; 2015. Available:http://ace.orst.edu/info/extoxnet/pips/deltamet.htm
2. Nasr HM, Badawy MEI, Biomark Response and Biomass Toxicity of Earthworms *Aporrectodea caliginosa*. 2015;5:6.
3. Ellis JD, Klopchin J, Buss E, Minimizing Honey Bee Exposure to Pesticides, IFAS Extension University of Florida. ENY-162. 2017;1-13.
4. Peter JV, John G, Cherian AM. Pyrethroid poisoning. Journal of the Association of Physicians of India. 1996;44:343-344.
5. Naydar PM, Adeyemi TA, Laikova KV, A short history of insecticides, Journal of plant protection Research. 2015;55(3).
6. Stanley J, Chandrasekaran S, Preetha G. Selective toxicity of Diafenthiuron to non-target organisms: Honey bees, coccinellids, chelonus, earthworms, silkworms, and fish. Journal of Plant Protection Research. 2016;56(1).
7. Fazolin M, Silva IMD, Gomes LP, potential of dillapiole-rich essential oil with synthetic pyrethroids insecticides against fall armyworm, Ciencia Rural, Santa Maria. 2016;46(3):382-388.
8. Cox, Caroline. Insecticide Synergist Factsheet: Piperonyl Butoxide. Journal of Pesticide Reform. 2002;22:12-20.
9. Osimitz TG, Hobson JF. An ecological risk assessment of piperonyl butoxide. In D.G. Jones, ed. Piperonyl butoxide: The Insecticide synergist. San Deigo: Academic Press. 1998;122-135.
10. Roberts, BL, and Dorough HW, Relative toxicities of chemicals to the earthworm Eisenia foetida. Environ. Toxicol. Chem. 1984;3:67-78.
11. Josephine OB, Acute Toxic Effects of Deltamethrin on Tilapia, *Oreochromis niloticus* (Linnaeus, 1758) West Africa Journal of Applied Ecology. 2006;9(7): 0855-4307.
12. Sayeed S, Parvez S, Pandey B, Hafeez R, Haque S. Rai suddin. Oxidative stress biomarkers of exposure to deltamethrin in freshwater fish, *Channa punctatus* Bloch. Ecotoxicology & Environmental Safety. 2003;56:295-301.
13. Kallaji M. Mosquito/black fly adulticide (Brand Name Scourge) proposed for aerial spray applications in the Adirondack Park. Memorandum, New York Department of Law and Environmental Protection Bureau. 1990;I 6761.
14. Bradbury SP, Coats JR. Comparative toxicology of the pyrethroid insecticides. Reviews of Environmental Contamination and Toxicology. 1989;108:133-177.
15. Zuzana Richterová, Jana Máchová, Alžběta Stará et al. Effects of Cyhalothrin-Based Pesticide on Early Life Stages of Common Carp (*Cyprinus carpio* L.). Bio Med Research International; 2014. Article ID 107373, 7 pages. DOI: 10.1155/2014/107373.
16. Mueller-Beilschmidt D. Toxicology and environmental fate of synthetic pyrethroids. Journal of Pesticide Reform. 1990;10:3.

17. Sayeed S, Parvez S, Pandey B, Hafeez R, Haque S. Rai suddin. Oxidative stress biomarkers of exposure to deltamethrin in freshwater fish, Channa punctatus Bloch. Ecotoxicology & Environmental Safety. 2003;56:295-301.
18. Peter JV, John G, Cherian AM. Pyrethroid poisoning. Journal of the Association of Physicians of India. 1996;44:343-344.
19. Dayal M, Parmar D, Dhawan A, Ali M, Dwivedi UN, Seth PK. Effect of pretreatment of cytochrome P450 (P450) modifiers on neurobehavioral toxicity induced by deltamethrin. Food and Chemical Toxicology. 2003;41:431-437.
20. Lukowicz-Ratajczak J, Krechniak J. Effects of deltamethrin on the immune system in mice. Environmental Research. 1992;59: 467-475.
21. Zhang W, Song YF, Gong P, Earthworm cytochrome P450 determination and application as a biomarker for diagnosing PAH exposure. J. Environ. 2006;8: 963.
22. Song Y, Kai J, Long-term toxic effects of deltamethrin and fenvalerante in soil. Journal of Hazardous Materials. 2015; 289:158–164.
23. Rehman H, Sagga S, Mohan A, Systemic review on pyrethroid toxicity with special reference to deltamethrin, Journal of Entomology and Zoology Studies. 2014; 2(6):60-70.

© 2021 Basak et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/76976