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A COMPREHENSIVE REVIEW WITH EMPHASIS ON HISTOPATHOLOGICAL EFFECTS

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ABSTRACT

Biopesticides offer a sustainable and eco-friendly alternative to conventional chemical pesticides, with the potential to reduce resistance in insect populations. As environmental concerns and pesticide resistance rise, there is growing scientific and industrial interest in the discovery and development of novel bioinsecticides. These biocontrol agents are being increasingly integrated, rotated, or combined within pest management programs as part of ecologically sound practices. Current market trends indicate a 15% annual growth in the biopesticide sector, reflecting the global shift toward environmentally conscious agricultural solutions. This trajectory aligns with the principles of Integrated Pest Management (IPM), promoting reduced chemical dependency. Recent research has expanded the use of microbial agents, particularly novel bacterial species, as effective alternatives to synthetic insecticides. Histopathological studies play a critical role in understanding the mode of action and safety of these biopesticides on target and non-target organisms.

INTRODUCTION

MOSQUITOES: MEDICALLY SIGNIFICANT VECTORS

Worldwide mosquitoes are a serious concern of public health and have an estimated disease transmission to more than 700 million people per year, and are now projected to lead to roughly 1 in 17 deaths[1]. The threat of mosquitoes is particularly severe in nations in Southeast Asia, and global warming has resulted in the expansion of mosquitoes in temperate and high altitude countries in recent years[2]. India's ecologically favoured illness is endemic to mosquitoes. The main vector of malaria in India, Anopheles stephensi, has an annual incidence of between three and one hundred million clinically manifested cases and a mortality toll of between one and one million. Today, over 40% of people worldwide live in endemic areas of malaria. Approximately two million cases of malaria are recorded every year in India[3]. Of the 53 Anopheles in India, 9 are malaria vectors. In the metropolitan parts of India[4], malaria is transmitted by Anopheles stephensi.

Culex quinquefasciatus, is also a widely spread mosquito in India as a possible vector for Bancroftian filariasis. It functions as a vector of the filariasis in the Indian subcontinent of Wuchereriabancrofti. Aedes aegypti are main carriers of denga fever, dengue hemorrhagic fever, and yellow fever viruses which have been known to spread across broad regions of the tropics or subtropics and cause significant mortality[4]. According to WHO[6], it is possible to have about 50 million dengue illnesses yearly, which have developed as an important international health test.

Nature of active ingredients responsible for larval toxicity

The alternative sources for traditional biocides include plant secondary metabolites (PSM)[7]. This method is very intriguing because it represents a possible supply of bioactive compounds which the general population has seen as reasonably safe and less environmental and low health hazards. Secondary plant metabolites are active at several new target locations, decreasing resistance potential[8].

The majority of plants have chemicals meant to inhibit plant-eating (phytophageal) insect attacks. These substances come into several categories, including repellents, food dissuasions, poisons and growth regulators. Most of the chemical groups may be classified into five main chemical categories: (1) nitrogen compounds, (2) terpenoids, (3). While defence of phytophagous insects is the major function of many chemicals, several are also effective against mosquitoes and other biting dipteran insects[9].

HISTOPATHOLOGICAL EFFECTS

Generally, secondary herbivorous metabolite protective metabolites are active harmful components for plant extracts [10]. The injects that feed on the secondary metabolites have non-specific actions for a broad variety of molecular targets, including proteins and nucleic acids. The active components of plants have key objectives, including the enzymes, hormones, protein kinases and other objectives which yet to be found and which play an essential part in cellular functions[11].

Histopathological effects on C. quinquefasciatus have been examined for plant extracts or their active compounds[12]. Histopathological alterations have been previously studied and assessed with botanical pesticides in treated insects using alternative insect control[13]. Histopathological investigations have shown that plant extracts permanently influence midgut epithelium and are depending upon the concentration, time and the mosquito species employed in plant preparations and plant metabolites in some aquatic dipteran larvae.The tasks for medicinal epithelium include ionic and osmotic management, lipid and carbohydrate storage, lumen pH control, digestive enzyme secretions and nutrient absorption[14].

Changes in the anterior and back areas of the treated larvae's midgut are noticed. Epitholic cells are severely injured from the basement membrane and from the peritrophic membrane. The combination of intestinal contents with the hemolymph has been shown to induce larval death. The midgut column cells display a vacuolated cytoplasm and some become unconscious, sluggish and detached[14].

The impact of orange peel extracts has also been established [15] in the treated larvae of Anopheles stephensi on the epithelial cellulose midgut, stomach caeca and brushbroad cells. Matrichoriachamomella has historopathological effects on the epithelial midgut cells of the Culex quinquefasciatus third instar larvae[16]. After 48 hours of exposure to M. chamonella, the transversal midgut slice revealed discrepancies in the appearance of columnar cells, a swelling, or extruded cellular mass in Midgut and disintegrations.

The larva has suffered significant damage in the midgut with the hypertrophic cells, with most cells lyse and the rejection of the cytoplasmic material in the lumen gut, and between the peritrophic membrane and the epithelium midgut, after anopheles gambiae has been treated with aquousPersea americana extract. [17] [18] The study demonstrated severe damage to epithelial columnar cells in Simuliumpertinax larvae being treated with Bacillus thuringiensis. Midgut vacuolisation of columnar cells, damage to microvilli, epithel content flowing into the midgut lumen and cell death [18] were most typical consequences [18].

The way in which biocompounds are produced and the mechanism of operation of them have practical significance as they offer important information on the formulation that is most suited and adaptable to future marketing and vector administration[19].

CONCLUSION

Vector-borne mosquito illnesses in all nations represent a significant human health concern. In order to address the challenges of using synthetic combinations in the mosquito control programme, there has been a change in plant pesticides. Both larvae and adult mosquitoes can be killed using botanicals. Only very few botanicals have gone from the laboratories to the field, which is owing to phytochemicals as contrasted with synthetic pesticides' light and heat unpredictability.These botanicals were further studied widely, but only relatively few patents with the continuing regulation of the formulations for use with mosquito species on the field level have been submitted. Thus, this study gathers significant plant extract information together with its active compounds as agents that alter the physiology and behaviour of dangerous mosquito vectors. Collective efforts are now required to draw on the collected knowledge of the plant chemistry of mosquitoes in order for their use to be integrated into integrated pesticide control programmes.

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