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The influence of pyrethrum extract on the developmental stages of the rice-moth, *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae)

Snehlata Shukla & Shri Krishna Tiwari*

Department of Zoology, D.D.U. Gorakhpur University, Gorakhpur – 273 009, U.P. India

Abstract

The larvicidal and pupicidal effects of pyrethrum extract were studied on the third-instar larvae of *Corcyra cephalonica*. Pyrethrum extract at an estimated concentration of 0.0010 % (active ingredient, v/v) was sufficient to cause 100% larval mortality, indicating absolute toxicity to the pest.

Keywords: biopesticide; toxicity

Introduction

Insect damage causes losses ranging from 5-30% of the world's total agricultural production, and stored-food grain damage from infestation is especially severe because the insects concerned have adaptations (morphological, physiological and behavioral) that suit them to the actions of humans, who transport them throughout the world and offer a protected habitat within stored foodstuff. Of these, the rice-moth, *Corcyra cephalonica* (Staint.) is a notorious pest of stored cereals and cereal commodities in India as well as in other tropical and subtropical regions of the world. Its larval stages cause appreciable loss to rice, sorghum, currants, gram, milled products, cocoa beans, peanuts, cottonseed, linseed, raisins, chocolates, army biscuits and nutmeg (Atwal 1976; Piltz 1977; Allotey 1991). Sufficient knowledge exists on the nutritional and reproductive physiology of this lepidopterous pest (Krishna & Narain 1976; Bhatt & Krishna 1982, 1984a, 1986; Srivastava & Krishna 1976, 1978; Mishra & Krishna 1980). There have been several studies on the effects of insecticidal agents such as organochlorines, organophosphates, and a few synthetic pyrethroid and botanical insecticides on its development and larval biochemistry (Tiwari & Bhatt 1994a, b, 1999a,b, 2000; Tiwari & Tripathi 2001, 2006; Pathak & Tiwari 2010a, b; Shukla & Tiwari 2011).

The use of organophosphorus and organochlorine insecticides poses problems such as poisoning in man and other animals (Pichaet & Philogene 1993), pest resistance to pesticides (Chand & Birthal 1977), and the risk of contamination causing injury to non-target organisms and pollution to our own environment, thus disturbing the ecosystem. Hence there is an urgent need to develop safe alternatives to conventional insecticides for the protection of grain and grain products against insect infestations. Higher plants are a rich source of novel natural substances that can be used to develop environmentally safe methods for insect control (Jbilou *et al*. 2006). Plant materials with insecticidal properties have been used traditionally for generations throughout the world (Belmain *et al*. 2001). Botanical rather than synthetic insecticides may be safer for the environment, are generally less expensive, and are more easily processed and used by farmers and small industries (Belmain *et al*. 2001). They are often only active against a limited number of species, and are often biodegradable or non-toxic. Thus they are potentially suitable for use in integrated pest management, and could lead to the developmental of new classes of safer insect control agents (Kim *et al*. 2003).

Plants and plant products are useful and desirable tools in pest management programmes because they are effective and often complement the actions of natural enemies (Schmutterer 1990; Ascher 1993). In a number of investigations, chemical compounds that are

* Author for correspondence: tel +919450264779 email : *sktzddu@rediffmail.com*

potential pesticides have been isolated and identified from leaves and seeds of various plant species, such as the potential pesticidal activities of neem, pyrethrum and tephrosia products (Akhtar & Isman 2004; Greenberg *et al.* 2005; Mbaiguinam *et al*. 2006; Iloba & Ekrakene 2006). Extracts of plants, or their active components, have also been used in a practical sense in the control of noxious insects. Extracts from plants such as eucalyptus (*Eucalyptus* spp.), chrysanthemum (*Chrysanthemum cinerariifolium*) and neem *(A. indica*), have been developed to give many more efficient insecticides, synthesized and commercialized more than a decade ago (Voss & Roman 2005). Azadirachtin extracts from the Indian neem tree (Jilani & Saxena 1990) and pyrethrum from *Chrysanthemum cinerariifolium* have received the most attention.

Pyrethrum is obtained from flowers of *Chrysanthemum cinerariifolium* harvested shortly after blooming, and either dried or powdered, or the oils within the flowers extracted with solvents. Pyrethrum extract is important in the control of household pests, in barns, stored products, and for direct application to man and livestock. Pyrethrum is generally considered to be the safest insecticide, and hence it has been selected as one of the safer substitutes to control rice-moths. Hence the objective of the present work was, for the first time, to design and conduct and investigatation into the effect of pyrethrum extract against its immature stages.

Materials & Methods

A standard culture of *C.cephalonica* was maintained in the laboratory on normal dietary medium composed of coarsely ground jowar (*Sorghum vulgare*) mixed with 5% (w/w) yeast powder inside glass containers (150 mm diameter, 200 mm height) at 26 ± 1 ^{0}C and 93 ± 5% relative humidity. Pyrethrum extract 23.3% (active ingredient) was purchased from Sigma-Aldrich, Steinheim, Germany (Lot. SZE7135X). For the preparation of different dose levels of pyrethrum extract in dietary media, a stock solution of known concentration was prepared in organic solvent (ethanol) and then adjusted via serial dilutions to achieve the required concentrations. Measured volumes of this stock solution were thoroughly mixed with particular quantities of dietary medium to get the desired dose levels of pyrethrum extract. This treated food was then air-dried at room temperature to eliminate completely the excess of organic solvents. For control purposes, the normal food was thoroughly mixed with a required volume of organic solvents similar to that of the treated food, and then air-dried in the same way.

To evaluate the toxic effects, freshly hatched larvae of *C. cephalonica* were allowed to feed on a normal dietary medium (kept inside 250 ml beakers) for exactly 15 days. On the 16th day, 25 third-instar larvae were transferred to a similar rearing chamber containing 50 gms of dietary medium mixed with a known dose of pyrethrum extract. Experiments were conducted on six different concentrations of pyrethrum extract (0.0001, 0.0002, 0.0004, 0.0006, 0.0008 and 0.0010%). 25 larvae were also kept on a normal dietary medium as a control. On the completion of the developmental cycle, the percentages of adult emergence and pupal death were recorded and mortality calculated. Experiments were replicated five times and the values expressed as the mean ± S.D. Linear regressions were calculated between concentrations of pyrethrum and response variables (percentage larval, pupal and adult mortality). The amount of insecticide consumed by larvae was calculated as µg/larva at each dose level of pyrethrum extract.

Using Polo Plus Probit and Logit Analysis, Version: 2.0 (LeOra Software), based on Probit analysis (Finney 1959), the following parameters were calculated: LD_{50} values (µg/larva) with 95% confidence limits, the slope of the relationships between each response variable and pyrethrum concentration, the value of *g* (used to calculate the confidence limits, which should be less than 0.5) and the heterogeneity (the value of chi-squared goodness of fit divided by the degrees of freedom, a check on the assumptions of the analysis, which should equal 1.0).

Results

There was a highly significant linear regression between mortality of the L3-L5 larva and pyrethrum concentration, with a slope of 2.180 ± 0.143. The estimated LD_{50} value was 0.00036 μg/larva, with 95% confidence limits of 0.00031 and 0.00039. The model was a reasonably good fit with heterogeneity of 1.54, and the confidence limits are well estimated because *g* was only 0.028.

Larval mortality increased greatly with increasing dose of pyrethrum in the diet (Table 1). At 0.0001%, larval mortality was only 18%, while 100% mortality was recorded at 0.0010%. As dose increased, there was a significant reduction in pupation and an insignificant enhancement in pupal death occur. 82% of larvae pupated at the 0.0001% dose, decreasing to only 25% at 0.0008%. Pupal mortality increased rapidly to 100% at the 0.0008% dose. A significant reduction in adult emergence with pyrethrum dose was the consequence of these effects (Table 1).

dose	amount eaten (μg/larva)	larval death	pupation	pupal death	adult emergence	Acute toxicity
control	0	0	100	0	100	
0.0001	0.20	18 ± 2	82 ± 2	0	82 ± 2	poor
0.0002	0.40	30 ± 2	70 ± 2	1.4 ± 1.8	69 ± 3	moderate
0.0004	0.77	43 ± 2	57 ± 2	5.3 ± 2.2	54 ± 4	moderate
0.0006	1.12	60 ± 3	40 ± 3	15.0 ± 3.6	34 ± 2	severe
0.0008	0.96	75 ± 2	25 ± 2	100	-	extreme
0.0010	0.40	100	-	-	-	extreme
slope		+91537	-88210	-102733	-104050	
p		<0.001	<0.001	n.s.	<0.001	

Table 1: Toxicity of pyrethrum extract against immature stages of the rice moth, *Corcyra cephalonica*. Doses are expressed as the percentage of pyrethrum extract in a dose added to standard dietary mixture (see Methods). Values are expressed as the mean (± SD) of five replicates. Known weights of diet were given to each set of 25 larvae. The amounts eaten were calculated by weighing the remaining food after completion of the life cycle. 'slope' is the slope of the regression between dose and each response variable, and 'p' is the significance of this regression. For 'Acute toxicity', see Discussion.

Discussion

Plant can provide potential alternatives to currently used insect control agents because they constitute a rich source of bioactive chemicals (Wink 1993) that can be developed into products suitable for integrated pest management. Many are selective to pests, have no or few harmful effects on non-target organisms and the environment, act in a variety of ways on the pest complex and can be applied to crops in the same way as other agricultural chemicals (Hedin *et al.* 1997).

The toxicity of pyrethrum extract increased with concentration for each development stage of the pest. On the basis of these data, the relative effectiveness of different concentrations can be categorized (Fitzpatric & Dowell 1981). The dose of 0.0010% was extremely toxic with 100% larval mortality. At 0.0008%, larval mortality (75) and pupation

(25) resulted in no adult emergences: this dose can therefore also be considered to be extremely toxic. The dose of 0.0006% resulted in only 34% emergence, and can be regarded as severely toxic. Doses of 0.0004% and 0.0002% can be considered as moderate, while 0.0001% caused only 18% mortality, indicating rather poor toxicity.

Pyrethrum powder is known to be very effective against the Larger grain borer (*Prostephanus truncatus* Horn.) and the Maize weevil (*Sitophilus zeamays* Motsch) (Mulunga *et al*. 2010). Flower and leaf extracts of various *Chrysanthemum* species are effective against *Tribolium confusum* (Haouas *et al*. 2008). Pyrethrum extracts stabilized with cotton and neem seed oils exhibit a marked increase in efficacy against Maize weevils (Wanyika *et al*. 2009). The chemistry, toxicology, extraction, refining and environmental fate of pyrethrum extracts have been reviewed by Casida & Quistad (1995). Products from pyrethrum have low mammalian toxicity, and are easily degraded making them relatively safe to the environment and consumers.

Pyrethrins are the main insecticidal constituent of pyrethrum extract, and insecticidal activity is known from six esters formed by the combination of the acids chrysanthemic and pyrethric and the alcohols piretrolone, cinerolone and jasmolone. These compounds act both on the central nervous system and in the peripheral nervous system, causing repetitive discharges followed by convulsions.

From the present investigation, it may be concluded that 0.0010% dose of pyrethrum extract can be used for the effective control of *C. cephalonica*.

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الملخص العربي

تأثير مستخلصات البايريثريم على مراحل نمو فراشة الأرز، كورسيرا سيفالونيكا (رتبة حرشفية الأجنحة: فصيلة بيراليدا)

سنيهالتا شوكلا وشري كريشنا تيواري
قسم علم الحيوان، دين دايال أوبدهياي، جامعة جوراخبور، جوراخبور 009 273 ، الهند

تناولت الدراسة التعرف على تأثير مستخلصات البايريثريم على يرقات وعذارى يرقات الطور الثالث من فراشة الأرز. كانت تركيزات البايريثروم 0.001%، والتى كانت كافية لإحداث نسبة وفيات تصل إلى 100% بين اليرقات، لتوضح مدى التأثير السام على تلك الفراشة.