DIFFERENT LEVELS OF GLUTATHIONE *S*-TRANSFERASE ACTIVITIES IN BENEFICIAL AND PEST INSECTS

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With 1 table

ABSTRACT. Glutathione *S*-transferase activities measured in a series of beneficial insects belonging to different orders (Neuroptera, Hymenoptera, and Coleoptera) are higher than in a series of pest insects (Lepidoptera and Coleoptera). This enzyme is responsible for the detoxication of insecticides and other exogenous compounds. Therefore these findings correspond to the higher susceptibility to insecticides like endosulfan[3], of noxious insects in comparison to beneficial ones. This fact opens a way of selective pest control without harming beneficial species.

INTRODUCTION

According to the human requirements, insects are divided into noxious and beneficial species. Noxious species should be controlled but beneficial species, *i.e.*, those feeding on noxious ones, help to control pest insects and therefore are or should be protected.

In chemical control of pest insects, the problem of species selectivity arises. That means that the insecticide in question should act only on the pest insects to be controlled, and not at all on other species. Some insecticides do in fact indifferently attack any insect while some of them, *e.g.* the systemic ones, attack only those insects which feed on the plant material containing these chemicals. Because of these first generation insecticides with their insufficient or lacking specificities, also modern ones which are more specific are incriminated by public opinion to be undesirable for the combat of pest insects. An argument heard very often is that insectivorous insects are more susceptible to insecticides than phytophagous ones but no proof for that statement has ever been given.

In this contribution, we want to show that there are certain biochemical differences between noxious and beneficial insects which are a good basis for a more prudent and more specific control of noxious insects with little or no harm to beneficial insects.

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In vertebrates (including man), there is a whole battery of enzymes which metabolize and detoxify foreign compounds, *i.e.*, compounds which are not normal body constituents. The activities of these different enzymes differ to a great degree, both interspecifically and intraspecifically. There are activity differences related to age, sex, hormonal state, and previous contact with foreign compounds.

In comparison to vertebrates, relatively little is known about species differences in pattern and activity of this kind of enzymes in arthropods (DAUTERMAN & HODGSON 1978; BEYHL & KERN 1993). During our biochemical study of several insect species of different groups, we have found out that there are striking species differences in the activity of these enzymes. So their activity levels differ at different life stages of insects and differ in insecticide-susceptible and -tolerant strains (BEYHL & KERN 1993).

There are several types of enzymes which metabolize foreign compounds: mixed-function oxidases, glucuronyl- and glucosyltransferases, hydrolases, and glutathione *S*-transferase. In our study, we concentrated on glutathione S-transferase (GST) which is one of the most important detoxifying enzymes in insects.

METHODS

We examined the following species: a.) Coleoptera: *Lebia concinna* (beneficial), *Callida scutellaris* (beneficial), *Coccinella septempunctata* (beneficial), *Eriopis connexa* (beneficial), *Anthonomus grandis* (noxious), *Epilachna varivestis* (noxious), *Diabrotica undecimpunctata* (noxious), *Leptinotarsa decemlineata* (noxious), *Hypothenemus hampei* (noxious), b.) Neuroptera: *Chrysopa carnea* (beneficial), c.) Hymenoptera (all beneficial): *Polistes erythrocephalus*, *Cephalonomia stephanoderis, Prorops nasuta, Bracon mellitor*, d.) Lepidoptera (all noxious): *Heliothis virescens*, *Heliothis armigera*, *Manduca sexta*, *Lymantria dispar*, *Anticarsia gemmatalis*. In this study we also included *Lycosa pseudoannulata* (Araneae), as another predatory arthropod.

From the animals to be studied, we prepared crude homogenates by homogenization in ice-cold, isotonic KCl solution as already described (BEYHL & LINDNER 1976). These homogenates were centrifuged at low spin for removal of chitinous components and used for the determination of enzymic activity. GST was measured spectrophotometrically, with *2,4-dinitrofluorobenzene* as the substrate (HABIG *& al.* 1974).

RESULTS AND DISCUSSION

The results are shown in table 1. Activities of GST are generally lower in insects than in mammalian livers. There are differences in enzymic activities of GST between the

different species. The most striking finding is that the activities of this enzyme are higher in those insect species which are classified as beneficial than in those which are regarded as noxious. This unexpected effect is of eminent practical value because it is the clue for a better way of differentiating between noxious and beneficial insects in pest control. But from a scientific point of view, it remains to be explained.

Many insects which feed on plant material ingest toxic plant compounds such as alcaloids and terpenoids. Plants are believed to defend themselves against their hosts by these compounds (WILLIAMS *& al.* 1989; SMITH 1989). In this so-called "chemical warfare", deterrents, phytoalexins, antibiotics, venoms, allergens, etc. should be mentioned which are all used for interspecific defense (SCHLEE 1992; WEATHERSTONE & PERCY 1972; WHITMAN *& al.* 1990).

During evolution, phytophagous insects acquired enzymes to inactivate and detoxify these plant toxins (BEYHL & KERN 1993) or even acquired the capability to accumulate these toxins within their body in a way which is not deleterious to themselves, in order to deter their predators (PASTEELS *& al.* 1992; SPENCER 1988).

Such an accumulation of toxic compounds occurs in the Monarch, *Danaus plexippus* whose caterpillars feed on *Asclepias* plants and enrich cardenolid glucosides originating from these plants, to such an extent that not only the imago is protected by them but also eggs and young hatching caterpillars (REICHSTEIN *& al.* 1968). Another Lepidopteran which contains plant poisons for its protection is *Heliconius* (SPENCER 1988). This enrichment of plant toxins in phytophagous insects seems to be a very widespread phenomenon. Also the European Lepidopteran, *Deilephila euphorbiae*, is reported to contain toxic compounds of its host plant, *Euphorbia cyparissias* (SMALIAN 1915), but this has not been proven hitherto by modern chemical methods.

A series of caterpillars synthesize allergenic compounds in order to deter their predators (KATZENELLENBOGEN 1955). e.g. those of *Thaumatopoea pinivora Wilkinsoni (= Th. Wilkinsoni)* which infest the mediterranean *Pinus halepensis* and the Canarian *P.canariensis* (CHEVERTON 1986), *Th. processionea* (procession caterpillar) (SCHMEIL 1908; NOVAK *& al.* 1987), *Euproctis chrysorrhea* (brown tail moth) (ESCHERICH 1913), *E.similis* (mulberry tussock moth) (DE-LONG 1981), *Orgyia pseudotsugata* (douglas fir tussock moth) (PRESS *& al.* 1977), and *Lymantria dispar* (gypsy moth) (ESCHERICH 1913; ETKIND *& al.* 1982; FARNHAM & BEAUCHER 1982; SHAMA *& al.* 1982) which, on mass infestations are dangerous to man by causing dermatitis and even conjunctivitis. Not only forest and orchard workers are endangered but also laboratory personal which has to handle the caterpillars. Gypsy moth mass infestations just occurred in 1993 and 1994, in parts of Central Europe.

So also insectivorous predators which stand in a higher level of the trophic pyramid than their phytophagous prey insects, are often confronted with toxic compounds enriched in their prey and therefore have even higher activities of these enzymes than their preys in order to survive the toxicity of these constituents of their diet.

So under this aspect of chemical warfare within the trophic pyramid, it is by no means surprising to learn that entomophagous insects have higher levels of GST and can metabolize and detoxify foreign compound more easy than phytophagous insects.

In the spider, *Lycosa pseudoannulata*, however, the enzymic activity of glutathione *S*-transferase is relatively low as compared to that in the beneficial insects mentioned above. It is just somewhat higher than in *Anthonomus grandis* which has the highest GST activity which we found in noxious insects, in our study. This shows that spiders do not fit into the scheme we established for insects. Seen from a taxonomical point of view, they are no near relatives to insects and myriapods but belong to a group of arthropods which is related to them only very distantly.

If one uses insecticides in dosages just high enough to inactivate or to kill pest insects (especially in their younger stadia where the activities of detoxifying enzymes are lower than in later ones) (BEYHL & KERN 1993) these dosages will be low enough not to harm beneficial insects because harmful insects are more susceptible to insecticides such as endosulfan (Thiodan^R EC35) than are beneficial ones (KERN *& al.* 1993).

TABLE 1 - Enzymic activities of glutathione *S*-transferase (U/g: body fresh weight) in several beneficial and noxious arthropods (*i*: imago, *l*: larva).

Polistes erythrocephalus (*i*)	64.9 U/g
Chrysopa carnea (*i*)	35.5 U/g
Bracon mellitor (*i*)	34.8 U/g
Prorops nasuta (*i*)	23.4 U/g
Lebia concinna (*i*)	21.8 U/g
Callida scutellaris (*i*)	21.5 U/g
Cephalonomia stephanoderis (*i*)	21.2 U/g
Eriopis connexa (*i*)	17.8 U/g
Coccinella septempunctata (*i*)	14.5 U/g
Lycosa pseudoannulata(*i*)	7.45 U/g
Anthonomus grandis (*i*)	5.9 U/g
Diabrotica undecimpunctata (*i*)	5.4 U/g
Heliothis virescens (*l*)	4.4 U/g
Heliothis armigera (*l*)	4.1 U/g
Hypothenemus hampei (*i*)	3.3 U/g
Leptinotarsa decemlineata (*i*)	3.3 U/g
Manduca sexta (*l*)	2.3 U/g
Lymantria dispar (*l*)	1.8 U/g
Epilachnia varivestis (*i*)	1.7 U/g
Anticarsia gemmatalis (*l*)	1.7 U/g

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