# Chapter IV – RESULTS

# A. FIELD STUDIES

## A1. Presence of Social Spiders in the Field Margins: Diet Composition and Prey Spectrum Studies

The dominant crops cultivated in the study area were Paddy, Pigeon pea and Castor. Insect pests found in the cultivated crops as well as in field margins were collected using standard insect collecting equipment, they were identified and listed. Insects belonging to eight Families and four Orders were identified from collected insect specimens (Table AI.1). The spiders present in the field margins as well as cultivated crops were also identified and listed (Table AI.2). Spiders belonging to 4 families and 8 species were found along the field margins, social spider *Stegodyphus sarasinorum* Karsch was also found in Pigeon pea near the border of the cultivated crop besides spiders belonging to 9 families and 20 species. In Paddy maximum number of species i.e. 23 belonging to 8 families were found while in Castor field, spiders from 5 families and 19 species were found.

Among the insects trapped in webs of *S.sarasinorum,* the insects belonging to Orders Hemiptera, Diptera and Orthoptera were found in maximum numbers (Table AI.3). In the present study, order Hemiptera is represented by the most numerous families found in the web. The dominant family found was Aleyrodidae (whiteflies 22.54%); followed by Cicadellidae (jassids 9.86%), Membracidae (cow bugs 8.45%), Buprestidae

(Jewel beetle 7.75%), and Pentatomidae (stink bugs 4.23% and 3.52%). Among order Diptera, the dominant family was Agromyzidae (Pigeon pea pod fly 5.63%) followed by Tephritidae (4.93%) and Calliphoridae (2.11%).

However, the frequency of occurrence of insects of different orders varied in the two cropping seasons: Kharif (June to October) and Rabi (November to April). In both Kharif and Rabi season insects from order Hemiptera were the most abundant prey trapped in the webs (Figure AI.1 and Figure AI.2); however, the family composition differed. In Kharif season (Figure AI.3) family Tephritidae of Order Diptera (20.59%) was abundant followed by family Pentatomidae (17.65%) and Lygaeidae (17.65%) from order Hemiptera. In Rabi season, number of families was more numerous for all the orders as compared to those found in Kharif season (Table AI.4 and AI.5). In Rabi, (Figure AI.4), family Aleyrodidae (18.18%) of the order Hemiptera was dominant followed by Cicadellidae (7.95%) in early part of Rabi in the months of November to January; while in the later part of Rabi from January to April, families Membracidae (8.45%) and Buprestidae (7.75%) were dominant. Insects of the order Orthoptera were second most numerous; however in terms of frequency, Pigeon pea Podfly (*Melanogromyza obtusa*) belonging to Family Agromyzidae, Order Diptera, was dominant (4.55%). Moths of Family Noctuidae and Lycaenidae, Order Lepidoptera were found in Rabi but not in Kharif season, while insects of order Dictyoptera were present in low numbers in both the cropping seasons.

**Table A1.1** – List of pests found in the crops at the study site.

| Crop | Order | Family | Genus | Common name |
|---|---|---|---|---|
| Paddy | Hemiptera | Cicadellidae | *Nephotettix virescens* | Green Leaf hopper |
| | Hemiptera | Coeridae | *Leptocorisa oritarius* | Gundhi bug |
| | Diptera | Cecidomyidae | *Orseolia oryzae* | Gall midge |
| | Lepidoptera | Noctuidae | *Sesamia inferens* | Stem borer |
| | Orthoptera | Acridiidae | *Hieroglyphus banian* | Phadka grasshopper |
| Pigeonpea | Lepidoptera | Noctuidae | *Helicoverpa armigera* | Pod borer/ Heliothis |
| | Lepidoptera | Pterophoridae | *Exelastis atomosa* | Plume moth |
| | Diptera | Agromyzidae | *Melanogromyza obtusa* | Podfly |
| | Hemiptera | Coreidae | *Clavigralla gibbosa* | Pod bug |
| Castor | Lepidoptera | Noctuidae | *Achaea janata* | Castor Semilooper |
| | Lepidoptera | Noctuidae | *Spodoptera litura* | Army worm |
| | Hemiptera | Aleyrodidae | *Trialeurodes ricini* | Whitefly |
| | Hemiptera | Cicadellidae | *Amrasca biguttula bigutulla* | Jassid |
| | Orthoptera | Acridiidae | *Atractomorpha cremulata* | Grasshopper |

**Table A1.2** – List of spiders of different guilds found in the crops at the study site.

| Crop | Family | Guild structure | Scientific name |
|---|---|---|---|
| Paddy | Lycosidae | Wandering spiders | *Evippa sohani* |
| | | | *Hippasa mahabaleshwarensis* |
| | | | *Lycosa poonanensis* |
| | | | *Pardosa birmanica* |
| | | | *Pardosa mukundi* |
| | | | *Pardosa sumatrana* |
| | Clubionidae | Hunting spiders | *Cheiracanthium melanostoma* |
| | | | *Clubiona drassodes* |
| | Oxyopidae | Foliage hunters | *Oxyopes shweta* |
| | Araneidae | Web builders | *Neoscona theis* |
| | | | *Neoscona sinhagadensis* |
| | | | *Neoscona mukerjei* |
| | | | *Cytrophora cicatrosa* |
| | | | *Argiope aemula* |
| | | | *Leucage decorata* |
| | | | *Araneus bilunifera* |
| | Tetragnathidae | Web builders | *Tetragnatha mandibulata* |
| | | | *Eucta javana* |
| | Heteropodidae | Hunting spiders | *Thatanus dhakuricus* |
| | | | *Harmochirus brachiatus* |
| | | | *Phiddipus sp.* |
| | Salticidae | Wandering spiders | *Marpissa sp.* |
| | Therrididae | Web builders | *Argyrodes ambaliki* |

| | | | |
|---|---|---|---|
| Pigeonpea | Araneidae | Web builders | *Argiope anasuja*<br>*Neoscona mukerjei*<br>*Neoscona sinhagadensis*<br>*Neoscona theis*<br>*Zygeilla melanocornia* |
| | Clubionidae | Hunting spiders | *Clubiona drassodes*<br>*Cheiracanthium melanostoma* |
| | Eresidae | Web builders | *Stegodyphus sarasinorum* |
| | Linyphiidae | Web builders | *Labulla nepula* |
| | Lycosidae | Wandering spiders | *Lycosa pictula*<br>*Hippasa lycosina*<br>*Hippasa sp.* |
| | Oxyopidae | Foliage hunters | *Oxyopes shweta*<br>*Peucetia viridans* |
| | Salticidae | Wandering spiders | *Plexippus paykulli*<br>*Salticus ranjithus* |
| | Therrididae | Web builders | *Theridion manjithar* |
| | Thomisidae | Wandering spiders | *Thomisus cherapunjeus*<br>*Thomisus krishnae*<br>*Xysticus minuctus* |
| Castor | Araneidae | Web builders | *Argiope anasuja*<br>*Cytrophora cicatrosa*<br>*Neoscona bengalensis*<br>*Neoscona mukerjei*<br>*Neoscona sinhagadensis*<br>*Neoscona theis*<br>*Zygeilla melanocornia* |
| | Clubionidae | Hunting spiders | *Castineria albopicta*<br>*Castineria flavipes*<br>*Castineria zetes*<br>*Clubiona drassodes*<br>*Clubiona filicate*<br>*Clubiona ludhinanensis*<br>*Cheiracanthium melanostoma* |
| | Linyphiidae | Web builders | *Labulla nepula* |
| | Pholcidae | Web builders | *Pholcus sp.* |
| | Therrididae | Web builders | *Argyrodes gazedes*<br>*Argyrodes projelus*<br>*Theridion manjithar* |
| Field margins | Araneidae | Web builders | *Cytrophora cicatrosa*<br>*Argiope aemula* |
| | Eresidae | Web builders | *Stegodyphus sarasinorum* |
| | Lycosidae | Wandering spiders | *Hippasa mahabaleshwarensis*<br>*Lycosa poonanensis*<br>*Pardosa birmanica* |
| | Salticidae | Wandering spiders | *Phiddipus sp.*<br>*Plexippus paykulli* |

**Table A1.3** - Total list of insects found in the webs of *S. sarasinorum*

| Order | Family | Genus | Common Name | No. found (frequency) | % Occurrence |
|---|---|---|---|---|---|
| Coleoptera | Elateridae | *Agrypnus sp.* | | 2 | 1.41 |
| | Scarabeidae | | | 1 | 0.70 |
| | Chrysomelidae | | | 2 | 1.41 |
| | Coccinellidae | *Harmonia octamaculata* | | 1 | 0.70 |
| Dictyoptera | Blattidae | *Blatella asahinae* | Asian cockroach | 5 | 3.52 |
| | Mantidae | *Mantis religosa* | Praying Mantis | 3 | 2.11 |
| Diptera | Tephritidae | *Bactocera sp.* | | 7 | 4.93 |
| | Calliphoridae | | | 3 | 2.11 |
| | Agromyzidae | *Melanogromyza obtusa* | Pigeonpea podfly | 8 | 5.63 |
| Hemiptera | Pentatomidae | *Eysarcocoris mantivagus* | Stink bug | 6 | 4.23 |
| | Coreidae | *Homoecerus sp.* | | 1 | 0.70 |
| | Lygaeidae | *Lygaeus militaris* | | 6 | 4.23 |
| | Pentatomidae | *Nezara viridula* | Stink bug | 5 | 3.52 |
| | Buprestidae | *Psiloptera sp.* | Jewel Beetle | 11 | 7.75 |
| | Membracidae | *Tricentrus bicolor* | Cowbug | 12 | 8.45 |
| | Aleyrodidae | *Trialeurodes ricini* | Whitefly | 32 | 22.54 |
| | Cicadellidae | *Amrasca biguttula biguttula* | Jassids | 14 | 9.86 |
| Hymenoptera | | | | 2 | 1.41 |
| Lepidoptera | Lycaenidae | *Euchrysops cnejus* | Blue butterfly | 2 | 1.41 |
| | Noctuidae | | | 2 | 1.41 |
| Odonata | | | Dragon fly | 1 | 0.70 |
| Orthoptera | Tettigoniidae | *Euconocephalus sp.* | Grasshopper | 5 | 3.52 |
| | Acrididae | *Acridium succintum* | Grasshopper | 4 | 2.82 |
| | Gryllidae | *Gryllus compestris* | Field cricket | 6 | 4.23 |
| | Acrididae | *Poekilocercus pictus* | Painted grasshopper | 1 | 0.70 |
| | | | **Total** | 142 | 100.00 |

**Table A1.4** -The list of insect s found in the web of *S.sarasinorum* in (Kharif) monsoon cropping season

| Order | Family | No. found (frequency) | % occurrence |
|---|---|---|---|
| Orthoptera | Tettigoniidae | 2 | 5.88 |
| | Acrididae | 2 | 5.88 |
| Dictyoptera | Blattidae | 2 | 5.88 |
| Coleoptera | Chrysomelidae | 1 | 2.94 |
| | Coccinellidae | 1 | 2.94 |
| Diptera | Tephritidae | 7 | 20.59 |
| | Calliphoridae | 3 | 8.82 |
| Hemiptera | Pentatomidae | 6 | 17.65 |
| | Coreidae | 1 | 2.94 |
| | Lygaeidae | 6 | 17.65 |
| Hymenoptera | UI 1 | 2 | 5.88 |
| Odonata | UI 2 | 1 | 2.94 |
| | **Total** | 34 | 100.00 |

UI -unidentified

**Table A1.5** - The list of insects found in the web of *S.sarasinorum* in (Rabi) winter cropping season.

| Order | Family | No. found (frequency) | % occurrence |
|---|---|---|---|
| Orthoptera | Tettigoniidae | 3 | 1.70 |
| | Acrididae 1 | 2 | 1.14 |
| | Gryllidae | 6 | 3.41 |
| | Acrididae 2 | 1 | 0.57 |
| Dictyoptera | Blattidae | 3 | 1.70 |
| | Mantidae | 3 | 1.70 |
| Coleoptera | Elateridae | 2 | 1.14 |
| | Scarabeidae | 1 | 0.57 |
| | Chrysomelidae | 1 | 0.57 |
| Diptera | Agromyzidae | 8 | 4.55 |
| Hemiptera | Pentatomidae | 5 | 2.84 |
| | Buprestidae | 11 | 6.25 |
| | Membracidae | 12 | 6.82 |
| | Aleyrodidae | 32 | 18.18 |
| | Cicadellidae | 14 | 7.95 |
| Lepidoptera | Noctuidae | 2 | 1.14 |
| | Lycaenidae | 2 | 1.14 |
| | **Total** | 176 | 100.00 |

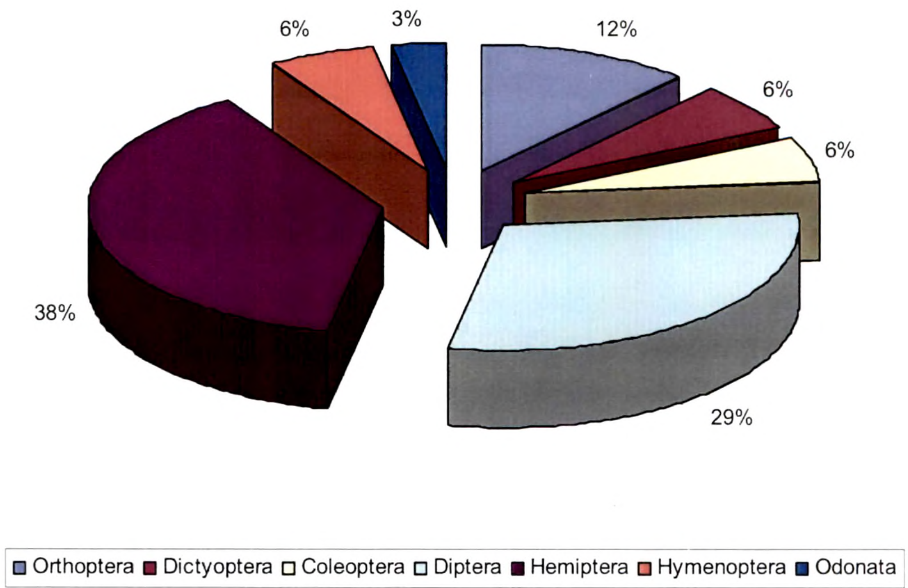



**Figure A1.1** – Order wise distribution of insects found in web of *S.sarasinorum* in (Kharif) monsoon cropping season

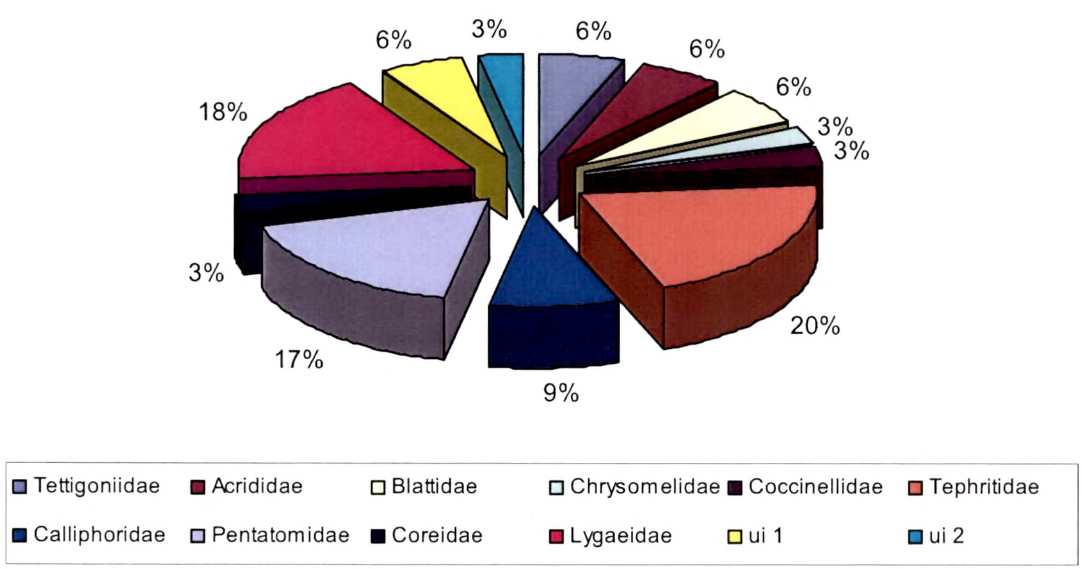



**Figure A1.3** –Family wise distribution of insects found in web of *S.sarasinorum* in (Kharif) monsoon cropping season

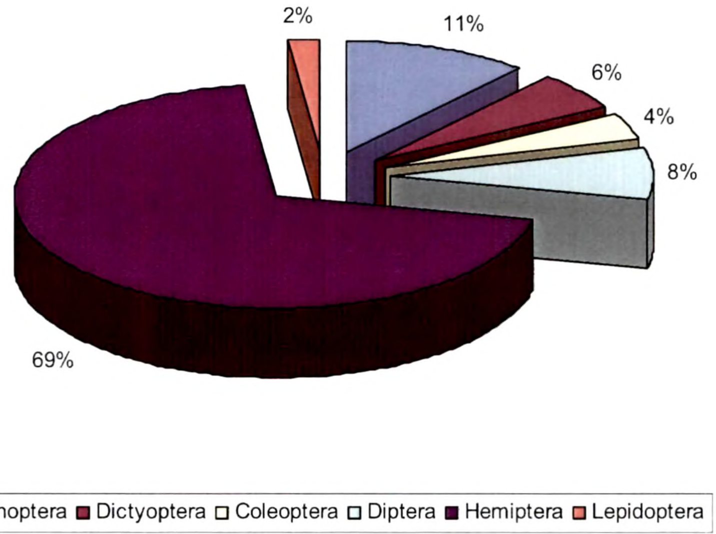



**Figure A1.2** – Order wise distribution of insects found in web of *S.sarasinorum* in (Rabi) winter cropping season

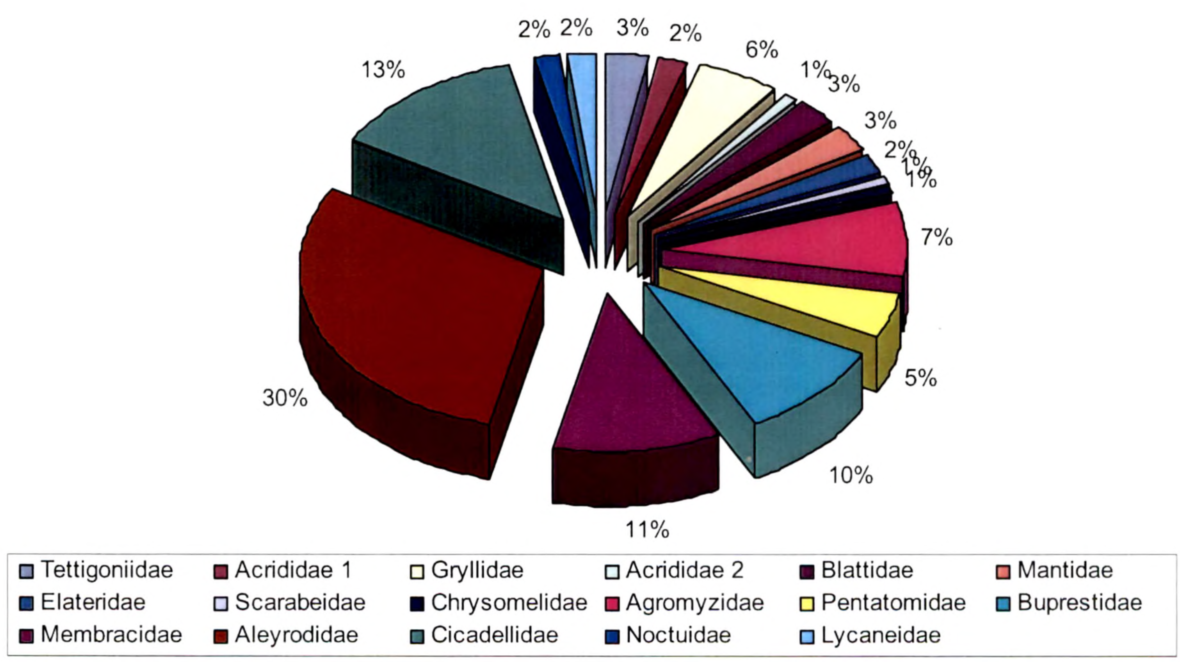



**Figure A1.4** –Family wise distribution of insects found in web of *S.sarasinorum* in (Rabi) winter cropping season

# B. LABORATORY STUDIES

## B1. Effect of Agrochemicals on Spiders: Direct Application

In Topical application studies on the *Stegodyphus sarasinorum* Karsch, Methomyl was found to have the lowest $LD_{50}$ value (Table B1.1). The $LD_{50}$ value for Azadirachtin could not be found as it was found to have no toxic effect even when tested at a dosage exceeding the recommended dose by 10 times. From the result of topical application (Figure B1.1) it can be inferred that Methomyl, a carbamate group of insecticide was found to be the most toxic, followed by Endosulfan, an organochlorine group of chemical. The least toxic among the five was Azadirachtin, which showed the least toxic affect showing less than 50% mortality even at 10 times the recommended dose. In Vial coating tests (Figure B1.2), Endosulfan was found to be having lowest $LC_{50}$ values followed by Methomyl, Azadirachtin and Glyphosate. For Imidacloprid, less than 50% mortality was observed till 10 times the recommended dose.

## **B1.1.** Effect on Web Building Potential of the spiders

The web building potential of individual spiders in response to administration of chemical pesticides through two routes were analyzed. Spiders were also treated with plain water via both the testing methods and kept in individual vials. These spiders served as reference for comparison of the webs built by spiders treated with pesticide solution. (Table B1.2). The web building activities of individual spiders were slower and erratic for / after residual toxicity / drift spray as compared to the direct toxic effects of topical application. In Methomyl treated spiders, in vial coated tests, there was no web building activity at all, however, 48 hours post treatment, some web building activity was seen (Rank 3). In the case of topical application the web building activity was entirely absent (Rank 4). In Endosulfan treatments, for vial coated tests, with the increasing dose of the chemical tested the web building potential of the spider decreased, at lowest dose (100 ppm) web building was ranked 2, and for highest dose (1000 ppm) it was ranked 4. In case of topical application, there was a delayed web building behaviour which started after 72 hours of treatment.

In Glyphosate experiments, at higher doses of vial coated tests severe ataxia was observed which included constant movement and wriggling of legs, at lower doses these symptoms were not observed. In the case of topical application web building activity was delayed and started 72 hours after treatment, while in topical application there was a delayed web building activity of 96 hours. The web building was ranked 2 and at lower dose was ranked 1.

For Imidacloprid treatments, vial coated tests, resulted in immediate moulting in all the treatments. The web building rate was as that of untreated control in lowest concentration (Rank 1) and it was Rank 3 at highest concentration. In the case of topical application at lowest dose the activity was ranked 1 while at higher dose it was ranked 2. In Azadirachtin, for both the treatment methods there was no deleterious effect of the pesticides on the chemical. Hence the web building was ranked 1.

**Table B1.1**: $LC_{50}$ and $LD_{50}$ Values (in ppm) of the chemical pesticide tested on social spider *Stegodyphus sarasinorum*.

| ROUTE OF EXPOSURE | TOPICAL APPLICATION | | | VIAL COATING | | |
|---|---|---|---|---|---|---|
| | | Lower Limit | Upper Limit | | Lower Limit | Upper Limit |
| CHEMICAL | $LC_{50}$ | (95% Confidence Interval) | | $LD_{50}$ | (95% Confidence Interval) | |
| Methomyl | 812.839 | -3925.439 | 1857.660 | 331.058 | 255.365 | 425.515 |
| Endosulfan | 480.679 | 45.483 | 678.931 | 33.225 | 17.521 | 43.736 |
| Glyphosate | 9484.130 | 7345.137 | 11929.547 | 9821.453 | 8249.297 | 11060.568 |
| Imidacloprid | 5460.128 | 4630.406 | 6649.345 | - | - | - |
| Azadirachtin | - | - | - | 5602.063 | 39283.483 | 197583.580 |

**Table B1.2:** Web building rating (mean of 3 tests) for both methods of exposure to the chemical pesticides tested on social spider *Stegodyphus sarasinorum*.

| Chemical | Dose (ppm ) | Vial coating ranking | Dose (ppm ) | Topical application ranking |
|---|---|---|---|---|
| Endosulfan | 100 | 2 | 250 | 2 |
| | 500 | 3 | 1000 | 2 |
| | 1000 | 4 | 1500 | 3 |
| Azadirachtin | 1000 | 1 | 3000 | 1 |
| | 5000 | 1 | 6000 | 1 |
| | 10000 | 1 | 9000 | 1 |
| Glyphosate | 300 | 1 | 300 | 1 |
| | 6000 | 1 | 1200 | 2 |
| | 12000 | 2 | 15000 | 3 |
| Imidacloprid | 1000 | 1 | 1000 | 1 |
| | 2500 | 2 | 2500 | 1 |
| | 5000 | 3 | 7500 | 2 |
| Methomyl | 500 | 4 | 90 | 4 |
| | 1000 | 4 | 100 | 4 |
| | 5000 | 4 | 200 | 4 |
| Untreated Control | | 1 | | 1 |
| | | 1 | | 1 |
| | | 1 | | 1 |

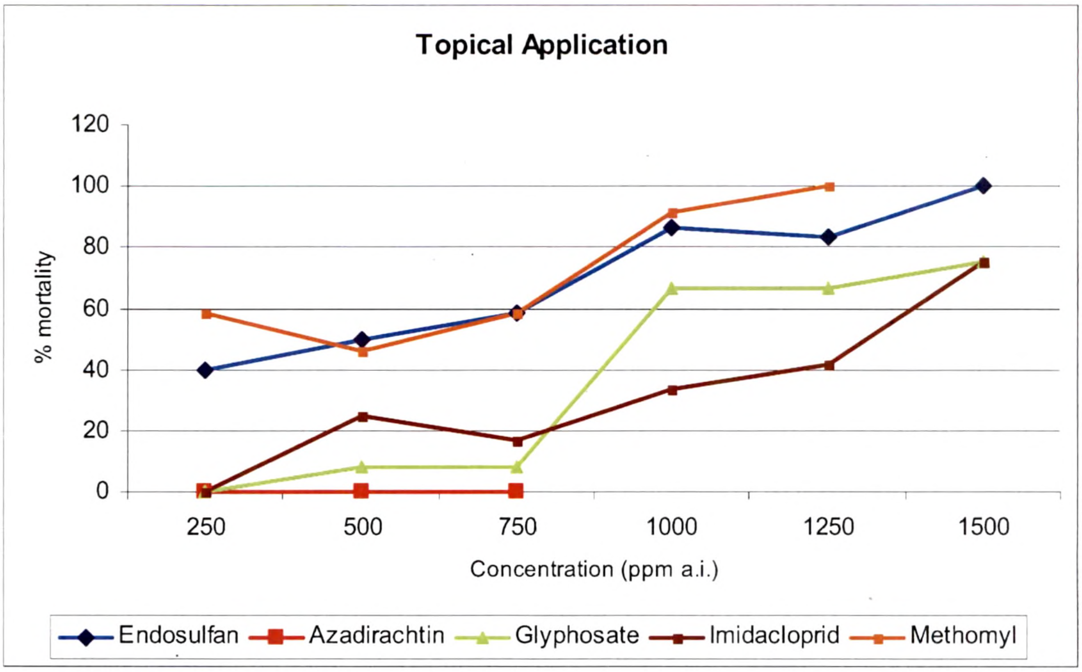



**Figure B1.1**: Impact of Topical application of five agrochemicals at various doses on the mortality of social spider *Stegodyphus sarasinorum.*

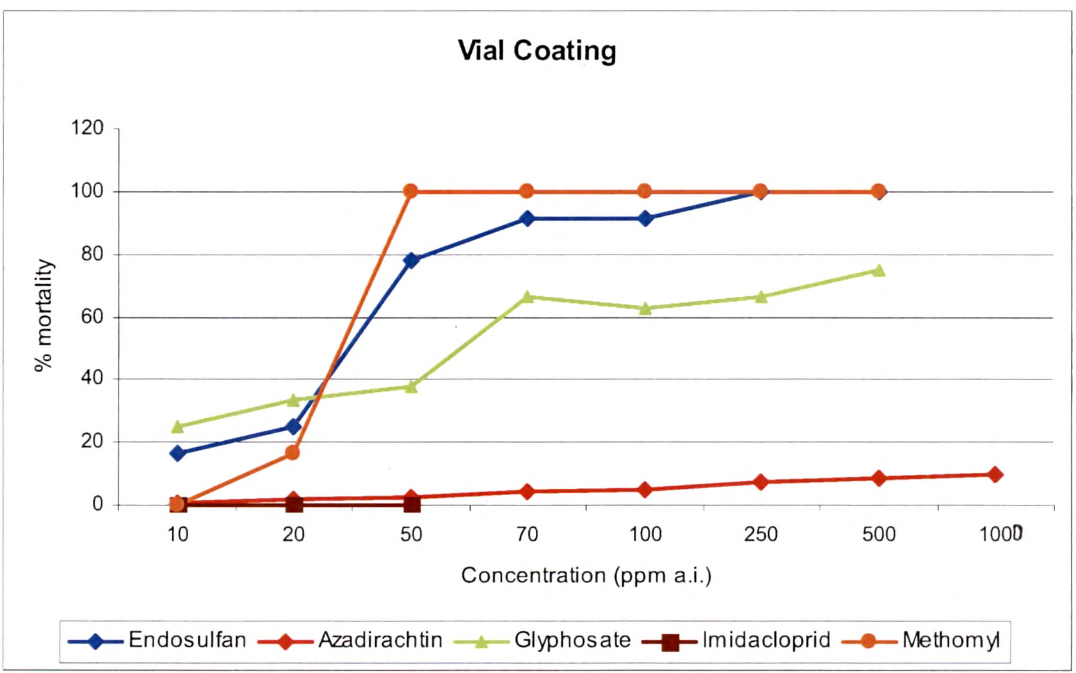



**Figure B1.2**: Impact of Vial coating of five agrochemicals at various concentrations on the mortality of social spider *Stegodyphus sarasinorum*

**B2.** Effect of Agrochemicals on Spiders: Study on Enzymes as Biomarkers of Toxicity Due to Agrochemicals on Spiders

**EVALUATION OF ACETYLCHOLINESTRASE (ACHE) by Ellman et al. Method (1961).**

AChE is responsible for neurotransmitter degradation at the cholinergic nerve synapse; and selection of a modified AChE which is less sensitive to insecticides is a common resistance mechanism observed in numerous arthropods. There was a significant increase in the levels of AChE found in all the Treated individuals as compared to Untreated Control (Table B2.1). In Untreated Control activity of AChE was found to be the lowest i.e. 0.00551μmoles/min/ml of enzyme. Highest activity was seen in Endosulfan Treated spiders at 0.0356μmoles/min/ml of enzyme for Topical Application ($P < 0.001$) and 0.0386 ($P < 0.01$)μmoles/min/ml of enzyme for Vial Coating method of exposure.

The Topical Application treatments showed higher activity (Figure B2.1) compared to Vial Coating (Figure B2.2) for all the chemicals tested. For Azadirachtin, AChE activity was found to be 0.16μmoles/min/ml of enzyme in Topical Application treatment while for Vial Coating it was found to be 0.0125μmoles/min/ml of enzyme. For Imidacloprid AChE activity was found to be 0.0247μmoles/min/ml of enzyme for Topical Application treatment while for Vial Coating it was found to be 0.165μmoles/min/ml of enzyme. For Glyphosate it was 0.0221μmoles/min/ml of enzyme for Topical Application and 0.143μmoles/min/ml of enzyme for Vial Coating. For Methomyl its activity increased to 0.024μmoles/min/ml of enzyme for Topical Application while for Vial Coating it was 0.0154μmoles/min/ml of enzyme.

**EVALUATION OF LIPID PEROXIDASE (LPO) by Benge and Aust (1978).**

LPO i.e. Lipid Peroxidase is a good indicator of oxidative damage to the tissues, especially the membrane lipids. The activity of LPO was found to be significantly low in treated spiders for all the treatments compared to Untreated Control (Figure B2.3 and B2.4). In Untreated Control 55.181nmoles of MDA/gm of tissue was formed (Table B2.2); while for Azadirachtin, in Topical Application 36.351nmoles of MDA was formed which was at par with Azadirachtin Vial Coating where 34.627nmoles of MDA was formed. This was also at par with Imidacloprid Topical Application at 37.19nmoles and for Vial Coating 34.845nmoles of MDA/gm of tissue and also at par with Glyphosate Topical Application at 33.741nmoles but lower compared to Glyphosate Vial Coating at 46.063nmoles. In Methomyl Topical Application 31nmoles and Methomyl Vial Coating 28.706nmoles MDA/gm of tissue was formed which was lowest for all the treatments closely followed by the values found for Endosulfan Topical Application at 33.002 nmoles and 32.833 nmoles for Endosulfan Vial Coating.

**EVALUATION OF GLUTATHIONE S TRANSFERASE by Habig *et al.* Method (1974).**

Glutathione Transferases are enzymes that catalyze detoxification of insecticides usually after the Phase I metabolic process (i.e. after initial Oxidation Reactions or Hydrolysis Reactions after penetration of the chemical). Enhanced activity of GST was seen for all the treatments compared to Untreated Control (Figures B2.5 and B2.6). Methomyl Topical Application and Vial Coating treatments were highly significant (Table B2.3) showing mean specific GST activity 0.435 ($P<0.001$)µmoles/min/ml of enzyme and 0.429 µmoles/min/ml of enzyme respectively. Endosulfan Topical Application was at par showing 0.418 µmoles/min/ml of enzyme. Endosulfan Vial Coating was also significantly high showing activity of 0.265 µmoles/min/ml of enzyme. Azadirachtin Vial Coating treatment also showed significant activity of 0.347 µmoles/min/ml of enzyme followed closely by Glyphosate Topical Application showing activity of 0.322 µmoles/min/ml of enzyme. Although, Azadirachtin Topical Application (0.218 µmoles/min/ml of enzyme), Glyphosate Vial Coating (0.229 µmoles/min/ml of enzyme), Imidacloprid Topical Application (0.23 µmoles/min/ml of enzyme) and Imidacloprid Vial Coating (0.248 µmoles/min/ml of enzyme) treatments were not statistically significant, however, the actual values suggest slight increase in activity of the enzyme in comparison to control.

**EVALUATION OF REDUCED GLUTATHIONE (GSH) by Beutlar *et al.* Method (1963).**

Conjugation of Reduced Glutathione (GSH) by the catalytic activity of Glutathione Transferases (GST) can dechlorinate compounds, making them less toxic and facilitating excretion by increasing water solubility. There was a significant reduction in GSH present in the treated spiders as compared to untreated control in all the treatments except for Azadirachtin Topical Application and Endosulfan Topical Application (Figure B2.7 and B2.8).

GSH activity in azadirachtin treated for both Topical Application and Vial Coating and Imidacloprid treated for Vial Coating method was comparable to the Untreated control (Table B2.4). Imidacloprid for Topical Application method showed decrease in GSH activity (235.03). Methomyl and Glyphosate treatments showed a decrease in GSH activity in *Stegodyphus sarasinorum* Karsch.

Azadirachtin treatment was at par with Untreated Control for both the modes of exposure namely (viz.) Topical Application and Vial Coating. Imidacloprid Vial Coating was at par with Untreated Control while Imidacloprid Topical Application showed significant decrease in level of GSH at 235.033µmoles/mg protein.

Endosulfan showed highly significant decrease in level of GSH in Vial Coating treatment at 171.446µmoles/mg protein while it showed significant increase in level of GSH in Topical Application treatment at 684.492µmoles/mg protein. Both Methomyl and Glyphosate showed significant decrease in level of GSH through both the methods of exposure. In Methomyl the level of GSH was 202.727μmoles/mg protein for Vial Coating treatment while it was 229.833μmoles/mg protein for Topical Application, while for Glyphosate Vial Coating it was 304.427μmoles/mg protein and 257.819μmoles/mg protein for Topical Application treatment.

**Table B2.1**: Mean activity of AChE found in *S.sarasinorum* for different insecticide treatments. (One way ANOVA, Bonferronii multiple comparison test)

| AChE | | | | | |
|---|---|---|---|---|---|
| **Topical Application** | | | | | |
| **Treatment** | **Mean** | **SD** | **SE** | **p val** | **sig** |
| Azadirachtin | 0.016 | 0.00228 | 0.000807 | < 0.001 | sig |
| Imidacloprid | 0.0247 | 0.00395 | 0.00176 | < 0.001 | sig |
| Endosulfan | 0.0356 | 0.00322 | 0.00114 | < 0.001 | sig |
| Glyphosate | 0.0221 | 0.00727 | 0.00257 | < 0.005 | sig |
| Methomyl | 0.024 | 0.00416 | 0.00147 | < 0.001 | sig |
| Untreated Control | 0.00551 | 0.00156 | 0.0011 | - | - |
| **Vial Coating** | | | | | |
| Azadirachtin | 0.0125 | 0.00301 | 0.00123 | < 0.005 | sig |
| Imidacloprid | 0.165 | 0.00167 | 0.00059 | < 0.005 | sig |
| Endosulfan | 0.0386 | 0.00978 | 0.00489 | < 0.005 | sig |
| Glyphosate | 0.143 | 0.00289 | 0.00102 | < 0.005 | sig |
| Methomyl | 0.0154 | 0.00289 | 0.00102 | < 0.005 | sig |
| Untreated Control | 0.00551 | 0.00156 | 0.0011 | - | - |

**Table B2.2**: Mean level of LPO found in *S.sarasinorum* for different insecticide treatments. (One way ANOVA, Bonferronii multiple comparison test)

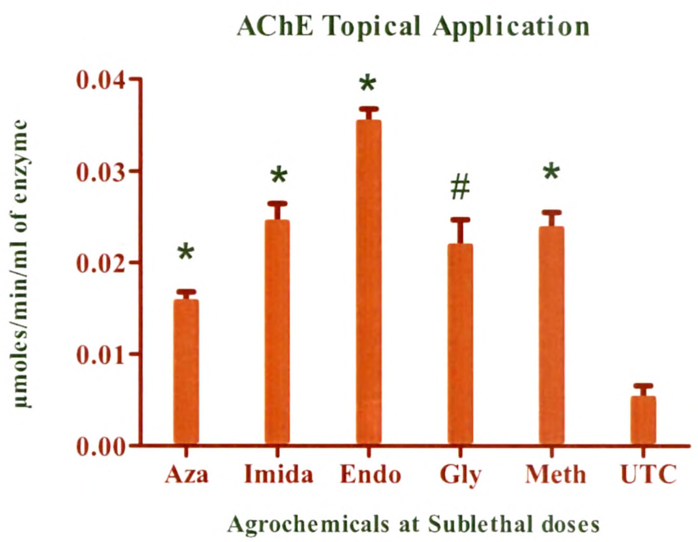
| LPO | | | | | |
|---|---|---|---|---|---|
| **Topical Application** | | | | | |
| **Treatment** | **Mean** | **SD** | **SE** | **p val** | **sig** |
| Azadirachtin | 36.351 | 0.549 | 0.275 | < 0.005 | sig |
| Imidacloprid | 37.19 | 1.485 | 1.05 | < 0.005 | sig |
| Endosulfan | 33.002 | 6.622 | 4.682 | < 0.005 | sig |
| Glyphosate | 33.741 | 1.566 | 0.783 | < 0.001 | sig |
| Methomyl | 31 | 2.025 | 1.013 | < 0.001 | sig |
| Untreated Control | 55.181 | 2.219 | 1.11 | - | - |
| **Vial Coating** | | | | | |
| Azadirachtin | 34.627 | 0.583 | 0.413 | < 0.001 | sig |
| Imidacloprid | 34.845 | 0.0492 | 0.0348 | < 0.001 | sig |
| Endosulfan | 32.833 | 5.407 | 2.703 | < 0.005 | sig |
| Glyphosate | 46.063 | 5.253 | 2.626 | < 0.005 | sig |
| Methomyl | 28.706 | 0.359 | 0.254 | < 0.001 | sig |
| Untreated Control | 55.181 | 2.219 | 1.11 | - | - |

**Table B2.3**: Mean activity of GST found in *S.sarasinorum* for different insecticide treatments. (One way ANOVA, Bonferronii multiple comparison test)

| GST | | | | | |
|---|---|---|---|---|---|
| **Topical Application** | | | | | |
| **Treatment** | **Mean** | **SD** | **SE** | **p val** | **sig** |
| Azadirachtin | 0.218 | 0.0245 | 0.0122 | 0.486 | ns |
| Imidacloprid | 0.23 | 0.0899 | 0.0318 | 0.442 | ns |
| Endosulfan | 0.418 | 0.0721 | 0.0255 | < 0.001 | sig |
| Glyphosate | 0.322 | 0.0373 | 0.0132 | < 0.001 | sig |
| Methomyl | 0.435 | 0.117 | 0.0413 | < 0.001 | sig |
| Untreated Control | 0.19 | 0.285 | 0.0101 | - | - |
| **Vial Coating** | | | | | |
| Azadirachtin | 0.347 | 0.0698 | 0.0247 | < 0.001 | sig |
| Imidacloprid | 0.248 | 0.128 | 0.0453 | 0.195 | ns |
| Endosulfan | 0.265 | 0.0327 | 0.0116 | < 0.001 | sig |
| Glyphosate | 0.229 | 0.0436 | 0.0154 | 0.056 | ns |
| Methomyl | 0.429 | 0.0572 | 0.0202 | < 0.001 | sig |
| Untreated Control | 0.19 | 0.285 | 0.0101 | - | - |

**Table B2.4**: Mean activity of GSH found in *S.sarasinorum* for different insecticide treatments. (One way ANOVA, Bonferronii multiple comparison test)

| GSH | | | | | |
|---|---|---|---|---|---|
| **Topical Application** | | | | | |
| **Treatment** | **Mean** | **SD** | **SE** | **p val** | **sig** |
| Azadirachtin | 529.327 | 290.523 | 118.605 | 0.475 | ns |
| Imidacloprid | 235.033 | 34.454 | 17.227 | < 0.005 | sig |
| Endosulfan | 684.492 | 172.248 | 70.32 | < 0.005 | sig |
| Glyphosate | 257.819 | 9.622 | 4.811 | < 0.005 | sig |
| Methomyl | 229.833 | 17.964 | 8.982 | < 0.001 | sig |
| Untreated Control | 445.857 | 122.166 | 43.192 | - | - |
| **Vial Coating** | | | | | |
| Azadirachtin | 403.968 | 80.375 | 32.813 | 0.481 | ns |
| Imidacloprid | 395.923 | 107.158 | 53.579 | 0.505 | ns |
| Endosulfan | 171.446 | 120.268 | 60.134 | < 0.005 | sig |
| Glyphosate | 304.427 | 7.27 | 3.635 | < 0.005 | sig |
| Methomyl | 202.727 | 7.707 | 3.853 | < 0.001 | sig |
| Untreated Control | 445.857 | 122.166 | 43.192 | - | - |




z

**Figure B2.1** - Acetylcholine esterase activity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via topical application. " #' represents P<0.005; " *' P< 0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

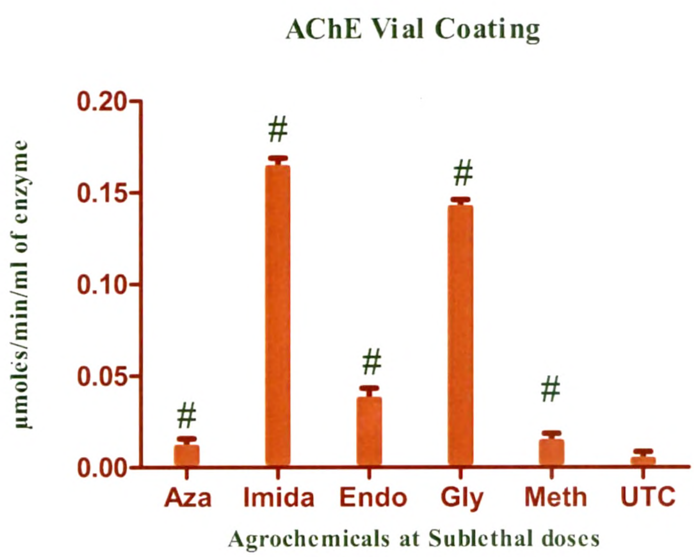



**Figure B2.2** - Acetylcholine esterase activity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via Vial Coating. " #' represents P<0.005; " *' P< 0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

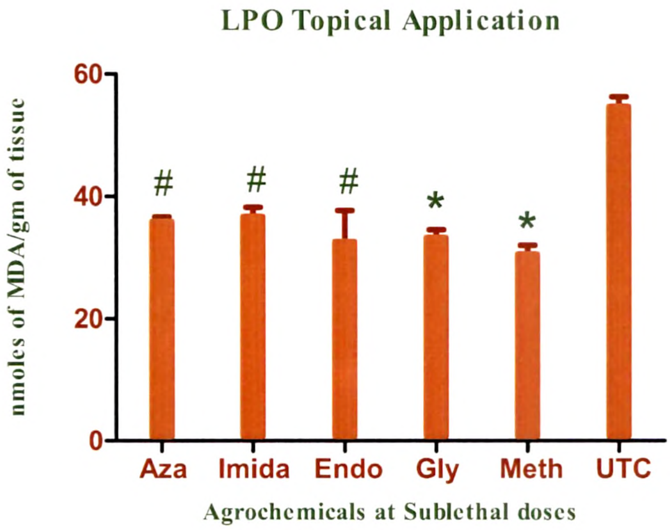



**Figure B2.3** –Lipid Peroxidase ac tivity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via topical application. " # " represents P<0.005; " *" P<0.0 01, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

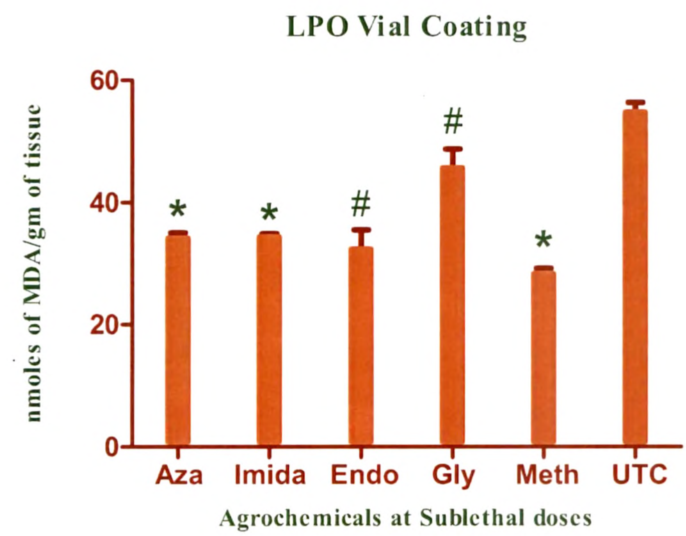



**Figure B2.4** –Lipid Peroxidase ac tivity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via Vial Coating. " #' represents P<0.005; " *" P<0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

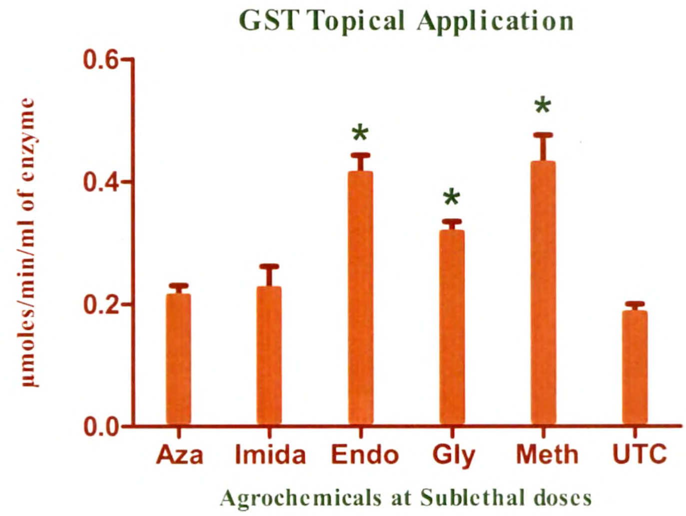



**Figure B2.5** – Glutathione S Transferase activity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via topical application. " #' represents P<0.005; " *' P<0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

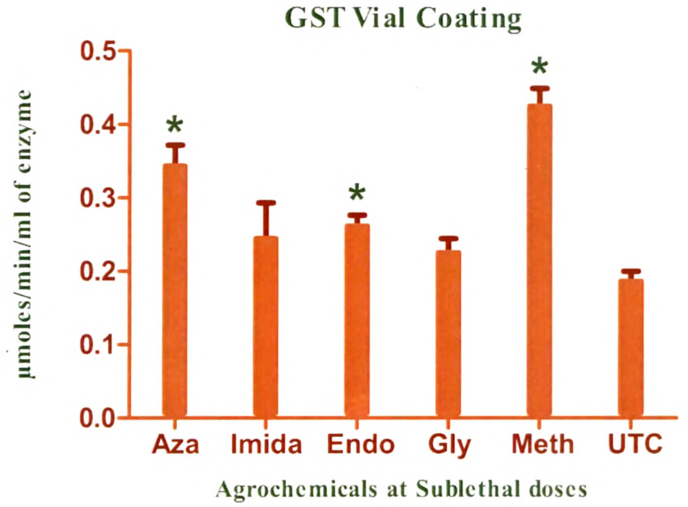



**Figure B2.6** – Glutathione S Transferase activity (Mean ± SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via Vial Coating. " #' represents P<0.005; " * " P<0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

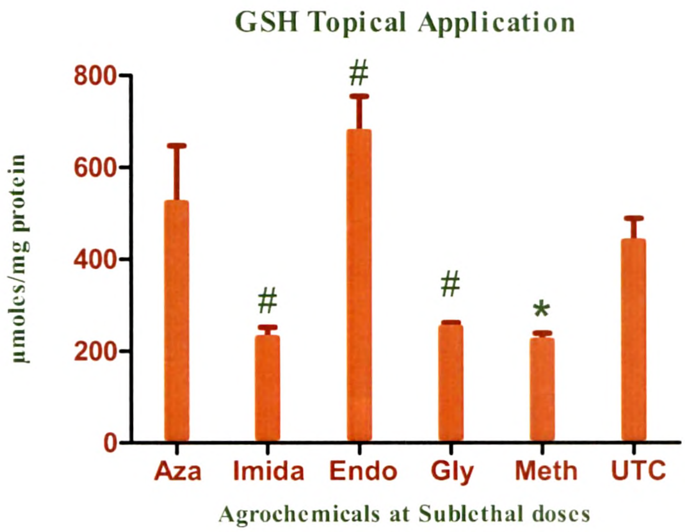



**Figure B2.7** –Reduced Glutathione activity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via topical application. " # " represents P<0.005; " *" P<0.0 01, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

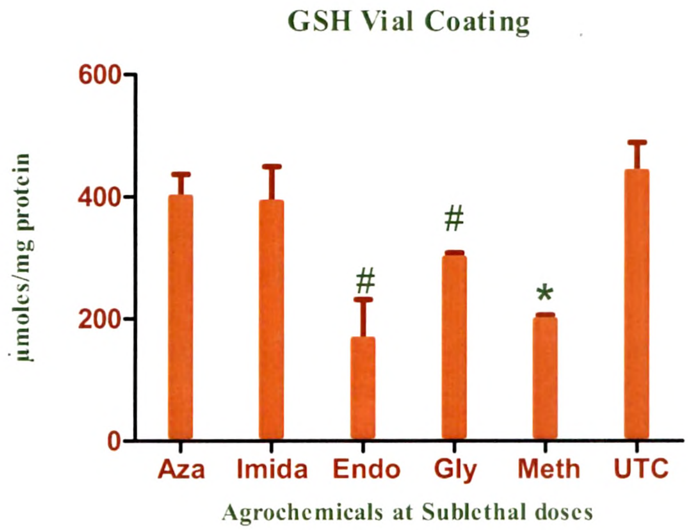



**Figure B2.8** –Reduced Glutathione activity (Mean ±SE) in *Stegodyphus sarasinorum* exposed to five agrochemicals at sublethal dose via Vial Coating. " #" represents P<0.005; " *" P<0.001, [One Way ANOVA, Bonferronii multiple comparison]; Aza-Azadirachtin, Imida-Imidacloprid, Endo-Endosulfan, Gly-Glyphosate, Meth-Methomyl, UTC-Untreated Control

**Prey found trapped in the webs of *S. sarasinorum* – Small sized insects**

Several insects of Order Diptera

*Melanogromyza obtusa*


Coccinellid beetle

Chrysomelid beetle

**Prey found trapped in the webs of *S. sarasinorum* – Large sized insects**

*Gryllus compestris*

*Acridium succintum*

*Euconocephalus sp.*


*Nezara viridula*

Membracid bug

Buprestid beetle

*Lygaeus militaris*

Scarabid beetle

*Euchrysops cnejus*

Noctuid Moth