Chapter-VI

SUMMARY

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The Terai Agro-ecological Region of West Bengal (Location: 25°57'- 27.0° N and 88°25'-89°54' E and Altitude: 40-50 meter) is under the North Eastern Plain Agro-ecological Zone of India and is a part of the Tropical Humid Climatological Zone of the World. The insect pests of stored pulses of the Terai Region are very rich, diverse and still unexplored. Total survey area covered during the present study was 12015 sq. km. including four administrative districts, ten sub-divisions and thirty two blocks. Pulses in this region are largely stored by the farmers in indigenous store houses/devices. This region is characterized by prolong rainy season coupled with worm humid condition that favours multiplication of insect pests of stored grains including stored pulses. However, dynamics of pests on stored pulses their extent of damage, natural enemy complex and safe management is still unexplored. The thesis embodies the results of investigation on the occurrence of *Callosobruchus* spp., their biology and preference for pulse species, extent of damage caused by these pests, their parasitoids, and efficacy of the parasitoids in suppressing the population of *Callosobruchus* spp., and safe management of the insect pests using botanicals, particularly the plant oils.

A survey was conducted during the period from 1999 to 2002 in indigenous storage of farmers and markets on different species of *Callosobruchus* spp. Infesting different species of pulses *Vigna radiata* (green gram or mung), *V. mungo* (black gram), *V. aconitifolia* (moth bean), *V. catiang* (cowpea), *Lathyrus sativus* (grasspea), *Cajanus cajon* (red gram or pigeonpea), *Cicer areitinum* (Bengal gram or chickpea), *Pisum sativum* (field pea), *Lens esculentum* (lentil), *Dolicos biflorus* (horse gram) *Glycine max* (soybean) *Pisum arvense* (small pea or garden pea) and *Phaseolus vulgaris* (kidney bean). Four pest species of the genus *Callosobruchus* infesting stored pulses were recorded. Among them, *Callosobruchus chinensis* (Coleoptera:Bruchidae) was the most notorious pests of green gram, lentil, red gram, black gram, cowpea, grass pea, pea and Bengal gram, horse gram, moth bean. *C. analis* and *C. maculatus* were the next harmful insects caused damage to pulses. *C. analis* preferred mainly the black gram, green gram, grass pea and cowpea. Whereas *C. maculatus* preferred cow pea, green gram, black gram and grass pea. Another bruchid, *Callosobruchus*(=*Bruchus*) *pisorum* was specific to pea as host. Its infestation takes place in the field, and the adult beetles emerge after few months in the storage. It can not complete its biology in the storage.

Among the natural enemies of *Callosoburchus* spp. Of stored pulses, *Dinarmus vagabundus* (Timberlake) (Hymenoptera: Pteromalidae), *Uscana mukerjii* (Mani) (Hymenoptera:

Trichogrammatidae), *Cerocephala dinoderi* Gahan (Hymenoptera: Pteromalidae) and *Bracon* sp. (Hymenoptera : Braconidae) were recorded during the survey. *D. vagabundus* and *U. mukerjii* were the key parasitoids of bruchid pests whereas *C. dinoderi* and *Bracon* sp. were the minor parasitoid of *Sitophilus* sp. and *C. cephalonica* respectively.

In the area of investigation the damage caused by the bruchids, *C. chinensis* and *C. analis*, has been maximum on green gram followed by black gram, lentil, grass pea, cow pea, red gram, chick pea and pea. The bruchids could not damage soybean (*Glycine max*), Frenchbean (*Phaseolus vulgaris*) and smallpea (*Pisum arvense*).Quantitative weight loss (%) of green gram caused by *C. maculatus* recorded to be maximum followed by *C. analis* and *C. chinensis.*

The bio-ecology of *Callosobruchus chinensis* and *C. analis* has been studied in the laboratory maintaining natural temperature and relative humidity. The biological parameters such as oviposition, hatchability, adult emergence, ovipositional period, incubation period, combined larval-pupal period, total developmental period, longevity of both the sexes of adults and growth index were observed for three consecutive years from 1999 to 2002. Altogether *C. chinensis* completed 11 generations and *C. analis* completed 12 generations in a year. In case of *C. chinensis* the data on monthly incidence revealed that egg infestation occurred almost round the years but reached to the maximum level during June-July (95.6%), March-April (93.8%) and July-August (93.2%). The infestation gradually decreased to a minimum up to December and again increased up to March. The percentage of adult emergence was the maximum during March-April and minimum during the period from June-September. Developmental period of *C. chinensis* was the shortest in May when temperature was the maximum. It increased with the decreasing temperature. Hatchability of eggs was minimum during June-September (rainy season) when the relative humidity was maximum in comparison to other months. Sex ratio of *C. chinensis* was always female dominated except during the period from Aug. to September (female: male=1:1). For the growth index, March-April was the most suitable for their growth and development (G.I. = 2.19) whereas the maximum retardation of growth and development was recorded during August- September (G.I.= 0.52). All the bio-ecological parameters showed a significant negative correlation with temperature and r.h. except the fecundity. The fecundity of *C. chinensis* had a highly significant positive association to temperature and relative humidity.

The fecundity of *C. analis* was the maximum during the period from March-July although the adult emergence did not correspond to the fecundity. Adult emergence was the least during July. Hatchability also showed similar pattern of result. March to April was the most suitable for their growth and development (G I = 1.98). January to February was the least preferred months

for them. All the bio-ecological parameters had significant negative correlation and significant only the fecundity showed a highly significant positive association and highly with the temp. and relative humidity.

Relative susceptibility of *C. chinensis* and *C. analis* to the 14 pulse species have been studied. Ovipositional performance was dependant on the seed texture, seed weight, thickness of seed coat, seed moisture and phenol contents of seeds. The fecundity and adult emergence of the bruchids showed a highly significant positive correlation with phenol contents. Higher phenol contents of *Glycine max* (soybean), *Pisum arvense* (small pea) and *Phaseolus vulgaris* (kidney bean) resulted in complete inhibition of adult emergence of the bruchids. The phenol content > 0.87 mg/g of seeds drastically retarded the growth and development of bruchid pests.

Dinarmus vagabundus (Timberlake) was recorded for the first time from North-astern India as an important, gregarious larval-pupal ectoparasitoid of bruchid pests. The earlier description, it was revised through systematic detail and description of its morphological features especially morphometrical diagnosis, structure of mouthparts, genital apparatus and sexual dimorphism. Furthermore, the morphological study of a very minute, rare solitary potent egg parasitoid (*U. mukerjii* Mani) has been also revised. It is also a first time record from the North-eastern India as egg-parasitoid. These two are naturally occurring key parasitoids of bruchid pests.

The potentiatiality of using *D. vagabundus* and *U. mukerjii* as biological control agents have been explored in laboratory studies. Their biology has been studied during summer and winter seasons. Fecundity and percentage of parasitization were always higher in summer. It has also been observed that the parasitization percentage showed significant variation on different species of stored legume seeds infested by *C.chinensis*. It was maximum on cow pea (27.01) during summer followed by green gram, red gram and chick pea. The parasitization potentiality of *D. vagabundus* did not correspond to the high rate of reproduction but the capacity to penetrate the stored seeds and kill/paralyze the larva/pupa of *C.chinensis* by their modified strong ovipositor has distinguished this parasitoid from other hymenoptera parasitoids. Its larval-pupal diapauses (quiescent period) for 2-3 months during winter season has also been recorded. This diapause properly opens the scope of utilization of *D. vagabundus* as a bio-control agent for the management of stored pulses later on from the excessive damage by *C.chinensis*.

Uscana mukerjii was also found as naturally occurring solitary endo-parasitoid of *C.chinensis* eggs. It preferred to oviposit 0 to 48 hr. old bruchid eggs deposited on the surface of stored pulse seeds. Biology and potentiatiality of parasitization of *U. mukerjii* have been studied during winter, autumn, summer and rainy seasons in the laboratory. Total developmental period was longest during winter (15 days) and the shortest recorded during rainy seasons. The beneficial

role of this parasitoid in regulating pest population and its use as bio-control agent is recognizable; Parasitization percentage has been maximum during summer (49.6) which was followed by rainy (48.9), autumn (39.5) and winter (35.2). Its growth and development varied significantly in different seasons and were influenced by temperature and relative humidity.

The philosophy and practices of I P M will continue to change and will remain dynamic simply because of its diverse nature and range of faunal appearance on the stored pulses. The effectiveness of easily available plant oils were used to test on adult *C. chinensis*. Present investigation also included to evaluate the efficacy of different plant oils and to find out more effective means of stored pulse managements that leaves no toxic residue, hazardous to health and environment. The indigenous plant oils are comparatively safer to man due to their biodegradable nature. Use of plant oils on botanicals is assumed to be an important approach to pest management. Insecticidal effect of different edible oils such as of rice bran *(Oryza sativa)*, sesame (*Sesamum indicum*), mustard (*Brassica juncea*), soybean (*Glycine max*), coconut (*Cocos nucifera*), niger (*Guizotia abyssinica*), safflower (*Carthamus tinctiorius*), palm (*Elaeis guineensis*), sunflower (*Helianthus annuus*) and non-edible oils such as of neem (*Azadirachta indica*), citronella (*Cymbopogon winterianus*), castor (*Ricinus communis*), clove (*Eugenia* sp.) and chaulmoogra (*Hydonocarpus kurzii*) were evaluated on the adult *C. chinensis*. It was evident that the non-edible oils were more effective to cause death of adult beetles. Among them, chaulmoogra oil was the most effective to cause death of adult at 24 hours of exposer. Other oils namely soybean, clove, safflower, citronella, neem and castor were also found promising to kill the adults.

Through the effective utilization of the finding under present investigation, the legume seeds can be stored at least up to a period of for four months using botanical oils as protectants against the bruchid to save food, seed, feed and sale. An adverse effect on oviposition of *C. chinensis* was observed which ultimately increased storage ability of seed. Gradual decline in egg laying was recorded with the rise of concentration (0.05 – 0.03% v/w) of all the oils. Among the different edible and non-edible oils, the persistency of toxicity was the longest (120 days) from chaulmoogra oil, followed by clove oil. Suppression of egg laying and adult emergence has been assessed on 30. 60, 90 and 120 days after treated with the oils. Interactions of different oils, their concentrations and days after applications were significantly different from the control (untreated seeds). The developmental period of *C. chinensis* was prolonged in the seeds treated with soybean, clove and chaulmoogra oils. All these plant oils are locally available and cheap, hence easily accessible to the poor farmers and also advantageous to stored pulses for commercial traders. Easy availability, higher biodegradable nature and non-hazardous properties as well as low cost of most of the oils as compared to synthetic pesticides once again focus attention to the use of the potentially promising plant oils as an alternative to the management of insect pests(*C.chinensis*) of stored pulses.