CHAPTER : 10

INTER-SPECIFIC REACTIONS BETWEEN LASIODERMA SERRICORNE (F.) AND TRIBOLIUM CASTANEUM (HERBST) IN MIXED CULTURE

The red flour beetle, Tribolium castaneum (Hbst.) is a serious pest of wide variety of stored food products. The beetles thrive well in tropical to temperate climates as well as at high levels of humidity upto 90%. Maximum destructive activity is known to be displayed by T.castaneum, as compared to other insect pests of stored products (Mallikarjuna et al. 1972). As early as in 1926, Chapman demonstrated that in the case of Tribolium spp. egg cannibalism is the major factor that limits population growth, and he had suggested that this process be termed as "environmental resistance". Sonleitner (1961) reported that in T. castaneum, the egg-cannibalism is a specific behavioural trait and is not of an accidental nature. In addition to this, Park et al. (1965) and Mertz (1969) have also reported on the significant cannibalistic tendencies in T. castaneum as examplified by the adults eating eggs, larvae and pupae, and the larvae eating eggs and pupae. Further it has been noted that, in particular, beetles between 45 and 135 days of adult age, were voracious egg eaters as compared to other stages. According to them this was an important feature leading to mortality and hence to a natural population regulatory mechanism.

Rich (1956) showed conclusively that females are 19 times more voracious than the males. Polnik (1960) found that the T. confusum exhibited cannibalism against eggs, larvae and pupae of Latheticus oryzae, and finally eliminate the latter. However, according to Kabir (1970) the presence of red flour beetle was not so detrimental to the developmental stages of rice weevil.

Howe (1957) mentioned that L. serricorne appears to be vulnerable to the predators and parasites that invade ware-houses. Its only protection appears to be its ability to penetrate deeper into stored commodities. Howe in this publication has stated- "The larvae and pupae are soft and fleshy and appear to possess no physiological protection; the list of parasites and predators therefore, is long." Jacob and Mohan (1973) observed predation of some stored product pests by red flour beetle. They found that the larvae as well as adults of T. castaneum wield suprimacy over other stored product insects, including L. serricorne in their biotic environment, by predating on them.

During the course of L. serricorne culture development and population build up, a casual observation was that accidental entry of T. castaneum to the L. serricorne culture lead to the total destruction of the latter species. There is no specific report on how much benefit can be derived by using T. castaneum against L. serricorne. The current work was, therefore, undertaken

to find out in detail, the inter-specific reactions between these two pest species of beetles with respect to different developmental stages as well as adults of both.

MATERIAL AND METHODS

Adults and larvae of both L. serricorne and T. castaneum were from separate stock cultures reared on wheat flour. Rearing of L. serricorne was improved by adding 5% brewer's yeast. The interactions between the two species were tested in different ways. The experimental temperature and humidity conditions in all the cases were maintained at 29 ± 1° and 65 ± 5% r.h. The males and females of both the species were identified as described by Halstead (1963). The larval instars of L. serricorne were identified as described by Bhalodia (1974) and those of T. castaneum by following Park and Frank (1948), Park (1962), Zyromska-Rudzka (1966) and Mondal (1984).

The experimental culture medium comprising of 300 gm of wheat flour mixed with 15 gm of brewer's yeast powder as distributed in 30 glass beakers (of 100 ml capacity); each having 10 gm. The glass beakers containing yeast mixed wheat flour were divided into 6 batches of five each. All the beaker of Batch Nos. 1 - 5 invariably contained 5 pairs of 5 - 6 days old adult L. serricorne. Into each of the beakers of Batch 1 twenty larvae (mixed instars) of red

flour beetle were introduced. Five pairs of adult red flour beetle (5 - 6 days old) were introduced in every beaker of batch No.2. In batch No.3, 10 males (unmated) of red flour beetle (5 - 6 days old) were added in each replicate. In case of batch 4, in each of the beakers 10 unmated, 5 to 6 days old female beetles of T. castaneum were introduced. Batch No.5 was maintained as control of cigarette beetles alone. Five pairs of red flour beetle of the same age group were taken in each beaker of batch No.6 for control purpose. In all the batches the adults or their larval stages were introduced on the same date. The beakers were covered with gauze and rubber band and kept in the incubator. After 35 days adult emergence of both the species in all the batches were checked and recorded.

The experimental arrangements of different stages of T. castaneum and L. serricorne for observing interspecific competition between the various stages of the two species were as indicated under "Experimental protocol".

Wheat flour mixed with 5% brewer's yeast powder was filled in a total of 225 glass vials (7 X 2.5 cm), each containing 4 gm of this culture medium, as shown in the tabulated form in Experimental Protocol. The vials were covered with gauze using rubber band and were incubated at a temperature and humidity as mentioned earlier. The red flour beetle larvae introduced in the concerned vials were removed when they entered the pupal stage, so as not to

permit adults emerging in those experimental vials where the interspecific reactions with larval stages only were to be studied. The hatchability of L. serricorne eggs was determined by counting the number of hatched 1st instar larvae and then were returned into the respective vials for further development and emergence of adults. The emergence of adult cigarette beetles in all the experiments was recorded and compared. The hatchability and larval mortality of L. serricorne, when reared along-with only conspecific adults and different larval stages, were also determined simultaneously, in order to have base-line reference data. Statistical tests were carried out using analysis of varience and Duncans Multiple Range Test (Gomez and Gomez, 1967).

RESULTS AND DISCUSSION

The recorded values for emergence of L. serricorne after 35 days, when the insects were reared alone and in combination with different stages of Tribolum castaneum are given in Table 1. It could be clearly seen that not a single L. serricorne was left in the culture when 5 pairs of T. castaneum were cohabiting. This may be due to the combined cannibalistic activity of T. castaneum males, females and larvae with respect to the eggs and early larval instars of L. serricorne. This agrees with the opinion of Park et al. (1965), who have reviewed the cannibalistic

behaviour of T. castaneum and showed that this insect exhibits cannibalistic tendency not only against its own eggs, larvae and pupae but also against all the stages of another related species viz. T. confusum. Jacob and Mohan (1973) also described that T. castaneum show predatory activity over larval stages of four other insect species, including L. serricorne. When they tested this behaviour, within 24 hours, when no other food was provided, almost hundred percent removal of other larval species could be seen excepting Oryzaephilus surinamensis. Further, the same authors also noted that, the L. serricorne larvae in the age group of 0 - 15 days were foraged upon by T. castaneum even when food material was available, and that, the larvae were devoured in abundance only when they became pupae, however, a few escaped predation by pupating in cocoons made with food particles. During the course of the present investigation, it was observed that none of the L. serricorne larvae could develop through their full life cycle. Obviously, predominantly the predation was occurring at early stages and, hence, emergence of adult was out of question.

Remarkable reduction in the cigarette beetle population occurred when reared with female individuals of red flour beetle. However, when reared with male T. castaneum individuals, no influence on L. serricorne population could be observed (Table 1). This may be

explained in the following manner : that, T. castaneum females were more voracious feeders as far as the eggs and larvae of L. serricorne are concerned. This result is in agreement, to an extent, with the findings of Rich (1956), who concluded that the females of red flour beetle eat their own eggs at a rate about 19 times greater than the males.

Another possible explanation for such a differential influence of T. castaneum on the population density of L. serricorne is based on the habits of the two sexes of former species. Naylor (1959) and Ghent (1966) have demonstrated some interesting sex differences in patterns of distribution of Tribolium beetles within a habitat: Females spend more time in the flour and distribute themselves uniformly throughout the niche, whereas males were reported to restrict themselves more often to the surface and tend to aggregate. This behavioural habit may explain to a certain extent the fact that female T. castaneum normally come across the larval stages of L. serricorne, as the latter usually go deeper in the medium. Hence, female T. castaneum can predate on L. serricorne larvae more often than the male T. castaneum.

The presence of red flour beetle larval instars (mixed) also produced significant reduction ($P < 0.01$) in the cigarette beetle population (Table 1). This may be due to their predation on the developmental stages of

L. serricorne. While reviewing the literature on cannibalistic habit of T. castaneum larvae, Park et al. (1965) reported that they were predaceous over the eggs and pupae of their own. The present result indicated that the T. castaneum larvae could devour the L. serricorne eggs and larvae and thus reduced the population of the latter species. The present result is similar to those reported by Jacob and Mohan (1973), who also found that the T. castaneum larvae were predaceous to the larvae of L. serricorne.

In contrast, L. serricorne could not produce any influence on the population growth of T. castaneum (Table 2). It could be added here that the flour beetle probably has some special advantages over the cigarette beetle : that, its longevity was more and could thrive well in varied ecological conditions, its larvae and adults were more vigorous and fastmoving and that, possibly the larval cuticle and egg shells of T.castaneum are comparatively less vulnerable to attack by L.serricorne stages, thus the flour beetles dominated over the L. serricorne.

The experiments designed to find out which of the stages of T. castaneum were most destructive to which of the stages of L. serricorne, led to the data serially presented in Tables 5 to 8.

The data presented in Table 3 alongwith Table 4 are essentially the result of similar experimental design, nonetheless, they depict two important aspects viz. hatchability and subsequent survival through successive stages right up to the stage of adult emergence. Hence, they need to be dealt with appropriately.

From the recordings of Table 3 it can be seen that when 20 eggs of L. serricorne were reared with larval stages as well as adult male and female beetles, the 1st and 2nd instar larvae of T. castaneum were more destructive to the eggs of the former species than any of the other stages. Another point worthy of note was concerning the fifth larval instar, which was least destructive in this context. Further it was also seen that though the female T. castaneum beetles were highly destructive (c.f.Table 1) in an over all context, they were not so as far as the eggs of L. serricorne were concerned. This might have been so, in all probability due to the behavioural trait of the female T. castaneum prefering to remain into deeper strata of the culture medium (or the storage containers/under godown conditions); whereas the L. serricorne eggs are usually deposited in the surface layers.

The values given in Table 3 essentially represent the rate of hatchability under the conditions employed here. The rate of hatchability apparently was fairly good when reared alongwith the last three instars and the

adult beetles of both sexes of T. castaneum. Taking this observation into consideration it was thought desirable to follow up the developmental stages right upto adult emergence subsequent to the hatching of eggs as under Table 3, which is represented in Table 4. The values recorded therein speak of the rate of emergence which was lowest with 1st and 2nd instar and the female T.castaneum cohabitation, whereas it was significantly low with respect to the 3rd instar, the 4th instar were comparatively less harmful, and the rate of emergence was fairly satisfactory with respect to 5th and 6th instars. From this it could be surmized that the very early larval stages and the female beetles were maximally voracious to the eggs and the early larvae of L. serricorne.

It is clearly seen that significant ($P < 0.01$) destruction occurred when the 1st instar larvae of L. serricorne were reared with almost any of the stages of the T. castaneum (Table 5). From the values presented in Table 5, it can be concluded that maximum destruction of the 1st instar larvae of L. serricorne occurred when cultured alongwith 3rd and 4th instar and that of female beetles of T. castaneum. The 2nd and 5th instar larvae of the latter were almost equally destructive but not the same extent. Cohabitation of 1st instars of both the species and with the males of the latter was comparatively less destructive. The chances of survival and development

were comparatively better when the 1st instar of both the species probably due to the fact that those of T.castaneum could not get sufficient edge over the other. In case of T. castaneum males, as was remarked earlier, their habit of remaining on surface layers of the culture medium might have led to comparatively better survival of the 1st instar larvae of L. serricorne. One more fact was noticing related to the 6th instar larvae of T. castaneum. Their cohabitation with 1st instar larvae of L. serricorne permitted maximum survival of the latter possibly because the former were more engaged in pupation rather than feeding activity.

Values obtained for development and adult emergence from 2nd instar L. serricrone are given in Table 6. It was noted here that, in general, the 3rd, 4th, 5th and 6th instar larvae and females of T. castaneum reduced the population of the L. serricorne significantly. Among these the 4th instar larvae exhibited maximum foraging activity.

From table 7 and 8 it can be seen that when 3rd and 4th instar larvae of L. serricorne were reared alongwith T. castaneum stages, no marked differences were found between the treatments and their respective controls. Jacob and Mohan (1973) reported that full grown L.serricorne larvae were not devoured by the T. castaneum and stated that this might be due to thick growth of setae on the body surface. Actually each instar larvae of cigarette beetle are known to prepare cases before moulting and the cases

prepared by the late instar larvae were probably afforded better protection.

The results of the present experiment with *L. serricorne* eggs, 1st and 2nd instars clearly shown that these early stages are the heavy sufferers of predatory activity of *T. castaneum* stages as compared to the later stages of *L. serricorne.* This can be explained on the basis of the facts that the early instars are small, less mobile, fleshy, and not so much sclerotized nor the larval hair are not so thick and long. In addition, the intersegmental membrane of larvae are relatively soft and thus these instars were more vulnerable to attack by *T. castaneum* adults as well as larvae. *L. serricorne* larvae might also be vulnerable immediately after a molt. On the other hand *T. castaneum* adults as well as larvae are active feeders, fast movers and, therefore, efficient cannibals.

It can be mentioned here that the only protection possessed by the *L. serricorne* larvae is its ability to penetrate and live deeper inside the beans and stacks (Howe, 1957). The *T. castaneum* larvae are also bottom feeders and always settle at the bottom of the culture jars and thus the *L. serricorne* larvae were subjected to easy attack by the predator. With increase in age, *L. serricorne* became less vulnerable to the *T. castaneum* attack. The predation also depends on the duration of the

active stage of the predator species and for this reason the 5th and 6th instar, due to shorter spans of the stadia; were less effective as compared to other instars.

The L. serricorne adults as well as larvae had not produced any influence on either the hatchability or the rate of mortality of conspecific eggs and larvae, the data on this aspects are omitted for the sake of reducing avoidable details.

Apart from furnishing information on the inter-specific competition between the two species considered here; the present observations raise a question as to the possibility of employing T. castaneum for biological control of L. serricorne species. Though the idea is attractive, the T. castaneum itself is known to be a serious pest of stored commodities in its own right. Hence, further understanding of the whole situation only may show some way out. In this respect the present findings do indicate certain possibilities in this directions. On the basis of the findings reported here it would be suggested that unmated females or suitably sterilized beetles of this species could profitably be employed to control L. serricorne infestation with no possibility of increase in the predator population. The latter could then be easily managed. This suggestion may find more favour in controlling L. serricorne in godowns where tobacco or spices are stored since these items do not constitute normal food of T. castaneum.