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Resistance of Castor to Lepidopterous Insects with Reference to the Effect of Food Plant of *Achoea janata* Guen. on its Braconid Parasite, *Microplitis Ophiusae* R.

By

S. JAYARAJ*

Introduction: Considerable progress has been made in the recent past in the study of insect resistance in crop plants, and varieties resistant to pests have been evolved. Castor is subjected to the severe attack by many insect pests particularly the semilooper, *Achoea janata* L., and the shoot and capsule borer, *Dichocrocis punctiferalis* Guen. year after year in several parts of the country. Even though effective chemical method of control is available against many of these pests, the importance of evolution of pest-resistant varieties is increasingly felt in recent years. Castor has been studied by different authors for its resistance to many pests. Detailed investigations in screening large number of castor varieties for resistance to the jassid *Empoasca flavescens* (F) were undertaken by Jayaraj (1966-a, 1967-a). Preliminary observations were made on their resistance to the shoot and capsule borer *Dichocrosis punctiferalis* Guen. (Basu 1947, David *et al* 1964, Sulochanabai *et al* 1968), the European corn borer *Ostrinia nubilalis* (Hubn.) (Kittock and Williams 1963), the whitefly *Trialeurodes ricini* Misra (David and Radha 1964), and the red spider mite *Tetranychus telarius* (L) (Chandrasekharan

*Reader in Entomology, Agricultural College and Research Institute, Coimbatorb-3,

et al 1964). The information available on castor resistance to the caterpillar pests, particularly the foliage feeders, is very meagre and hence detailed screening of several varieties for resistance to nine leaf-eating caterpillar pests and the shoot and capsule borer was undertaken in two seasons (1962–1964) and the results are presented in this paper. Attempts have been made to understand the possible mechanism of resistance in the case of two major pests *viz.*, *A. janata* and *D. punctiferalis* and also to understand the effect of food plant of *A. janata* on the braconid parasite *Microplitis ophiusae* R.

Materials and Methods: Randomized replicated block design with twenty castor varieties was adopted. Five plants were raised in a row in each plot and from this three plants were selected at random for observation. Caterpillar counts were made with reference to nine leaves in each plant selected at the rate of three from each of the top, middle and bottom regions of the main shoot. The top-most leaf selected was the third from the teminal end leaving out the first two being too tender, the middle leaves were medium in maturity and the bottom leaves fairly advanced in maturity. Three fortnightly counts of all instars of the caterpillars were made in each of the seasons when the plants were 3, 5 and 7 weeks old.

Screening the varieties for resistance to *D. punctiferalis* was done by taking counts of the number of castor heads affected by the pest in a plant and the percentage of infected heads was worked out in both the seasons as done by previous workers (David *et al* 1964, Sulochana bai *et al* 1961).

Results: I. *Resistance of castor varieties to the foliage-feeding caterpillars:* As many as nine species of caterpillars infested the different varieties and the difference between the population levels of the various species on the varieties was highly significant. Among the species, *Achoea janata* attacked the varieties most frequently having a mean population of 17.2 per plant. This was followed by *Ergolis merione* and *Euproctis fraterna* with the mean infestations of 6.7 and 2.9 respectively. The caterpillars of *Achoea* and *Ergolis* were present on all the 20 varieties tested and as such no variety was immune to the infestation of these two species. *Euproctis fraterna* and *Porthesia scintillans* were found feeding on a number of varieties while the other five species, *viz.*, *Latoia lepida*, *Spatulicraspida castaeniceps*, *Olene mendosa*, *Spodoptera littorallis* and *Pericallia ricini* were of minor importance infesting only some varieties, the population ranging from 0.1 to 1.7 per plant. Significant results were obtained when the varieties were compared for the combined infestation of all the species of caterpillars. The varieties R. C. 1077 S. Africa, R. C. 552/1 Nagpur, Cuddapah, TMV 1 and R. C. 826 Russia had high pest populations ranging from 5.3 to 6.7 per plant. The infestation on the castor types Israel M.E., R. C. 1094 Cimmerron (U. S. A.), R. C. 1095 U. S. 74, R. C. 1096 Coonoor and R. C. 1098 Baker

(U. S. A) was comparatively very less and these varieties did not suffer from the pest attack. The interaction between the varieties and each species of insect was also highly significant (P=0.01). The infestation of *A. janata* on the various varieties varied remarkably. Among the cultivated strains of castor, TMV 2 alone was found to be susceptible and the other two TMV1 and TMV3 were not much attacked by the pest.

II. *Relationship of castor resistance to Achoea janata with parasitism of the caterpillar by Microplitis ophuisae (Braconidae)*: The castor semi-looper caterpillars have been reported to be parasitised by many species of parasites under natural conditions. Among them, the braconid *Microplitis ophiusae* R. is undoubtedly the most important species which keeps the pest under check. Observation on this parasite is also rather easy in view of the fact that the caterpillars carry the pupae of the parasite under the last abdominal segment. The percentage parasitism of the caterpillars varied markedly

TABLE 1. *Resistance of different castor varieties to Achoea janata L. and its relation to parasitism of the caterpillar by Microplitis ophiusae*

Variety and bloom nature of the plant	No. of A. *janata* caterpillars per plant	No. of caterpillars parasitized with *Microplitis*	Percentage parasitism
No bloom			
R.C. 1098 Baker (U.S.A.)	3.9	0.5	13.7
R.C. 1096 Coonoor	5.7	0.7	13.0
R.C. 1095 U.S. 74	11.4	2.5	22.3
R.C. 1092 Italy	11.4	2.3	20.0
Single bloom			
R.C. 1094 Cimmerron (U.S.A.)	14.4	3.2	22.6
Mauthner's Dwarf	16.2	2.6	16.4
TMV 1	7.8	1.8	23.1
TMV 3	8.1	1.8	22.0
Double bloom			
Cuddappah	29.1	8.9	30.7
R.C. 552/1 Nagpur	48.3	25.0	51.8
R.C. 1077 S. Africa	54.0	22.2	41.1
TMV 2	22.2	6.1	27.4
Dominica	20.7	6.8	32.8
Israel M.E.	13.2	4.1	31.1
CO 1	10.5	2.7	25.7
R.C. 826 Russia	9.0	2.5	25.0
Triple bloom			
R.C. 488 Egypt	12.9	2.2	17.4
E.B. 26/1 (MP)	23.7	8.9	37.5
R.C. 817 Koilpatti	11.4	1.8	15.9
C3 Pakistan	9.9	3.0	30.0

when different varieties were used as host plants by the pest indicating the indirect influence of the varieties on parasitisation. The results furnished in Table show that the parasitism ranged from 13.0% in R.C. 1096 Coonoor variety and 13.7 % in R.C. 1098 Baker variety to as high as 51.8% in R.C. 552/1 Nagpur type. Among the 20 castor varieties, seven recorded more than 30% parasitism of the caterpillars. There existed a highly significant positive correlation between the population of *Achoea janata* caterpillars on different bloomed varieties and percentage parasitism with a correlation coefficient of 0.79 (P=0.001) and a regression of Y=16.4+0.57 X (Fig. 1). Most of the varieties with double and triple blooms recorded high infestation of the pest and consequently enhanced parasitism by the braconid. "No - bloom" and "single-bloom" varieties had relatively low pest populations and parasitiation.

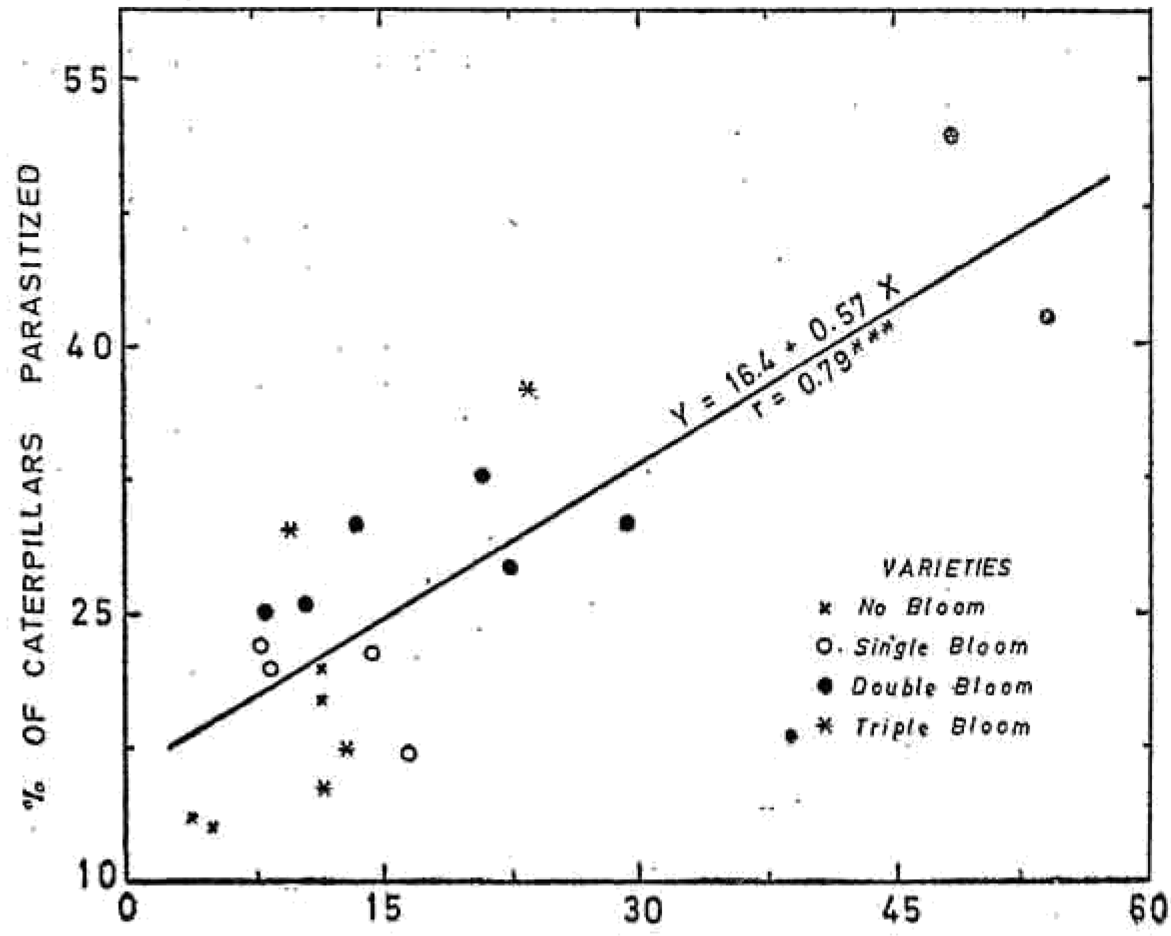

FIG. 1. Castor resistance to *Achoea janata* in relation to the percentage parasitization of the caterpillars by *Microplitis ophiusae* (Braconidae)

III. *Resistance of castor varieties to the shoot and capsule borer, Dichocrocis punctiferalis* Guen.: In assessing the varietal resistance to *D. punctiferalis*, the number of castor heads infested by the caterpillars was considered. Varieties possessing moderate to highly compact heads recorded heavy infestation of the pest ranging from 27.0 to 48.4% as against 14.2 to 21.5 in those with lax panicles. Apart from the loose nature of inflorescences, the capsules were also smooth without any spiny outgrowths in the highly resistant varieties R.C. 552/1 Nagpur and Mauthner's Dwarf.

The early maturing types like R.C. 1098 Baker, R.C. 1094 Cimmerron and R.C. 1096 Coonoor flowering in fifth and sixth weeks after sowing showed high infestation of the pest ranging from 40.0 to 48.4%. On the other hand, the late maturing types reaching flowering stage in 10th or 11th week recorded relatively low incidence. The variety TMV 1, apart from being a late type, had lax panicle and therefore behaved moderately resistant. Eventhough Mauthner's Dwarf flowered very early in the sixth week, it was highly resistant in view of the loose inflorescence and smooth capsules. The selected six early varieties showed a negative correlation between the earliness in flowering and % damage of castor heads in logarithmic scales (r = 0.46, P = 0.01). The regression equation was Y = 2.1 − 0.71 X. (Fig. 2)

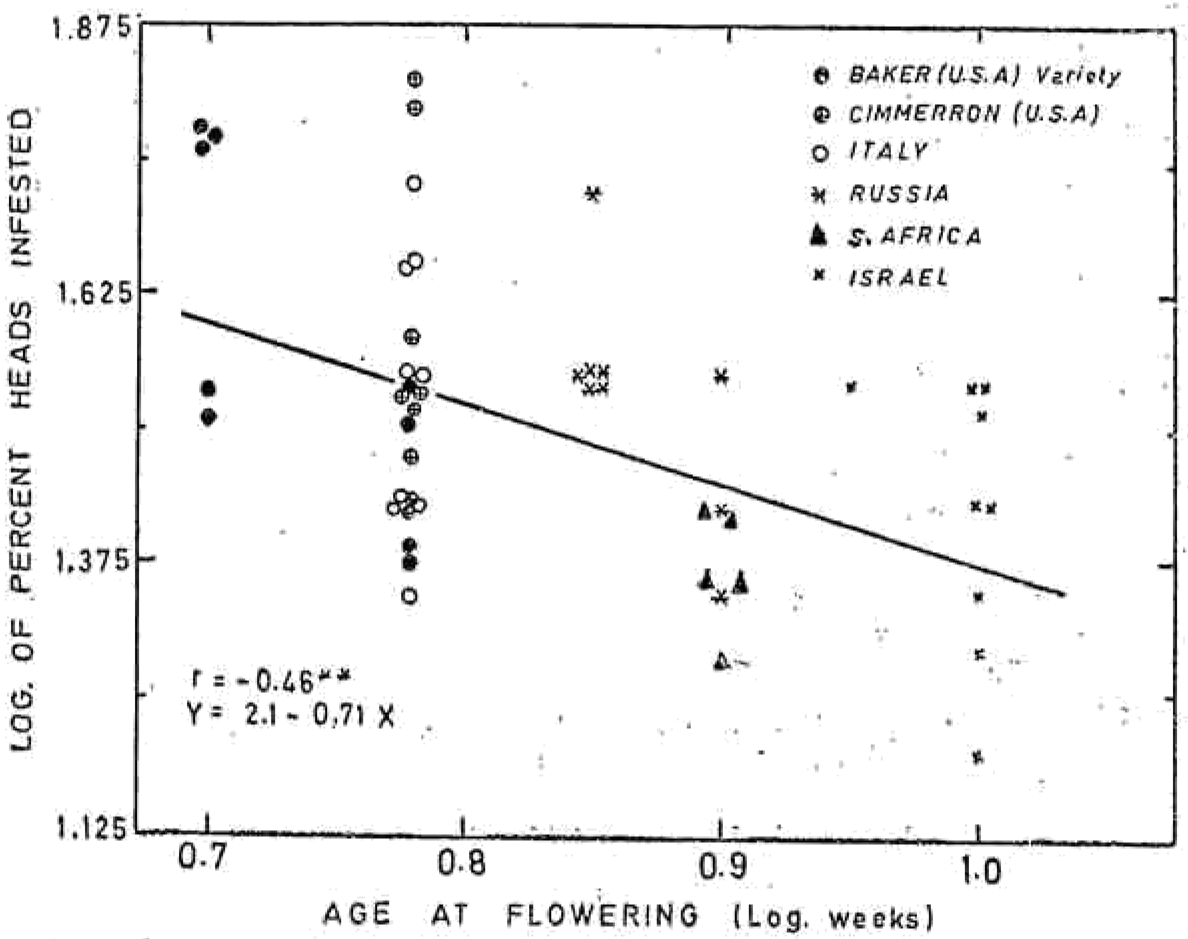

FIG. 2. Correlation between earliness in flowering of castor varieties and percent heads infested by *Dichocrocis punctiferalis*

Similarly, the infestation was related with the plant height in different varieties. It was found that in general the dwarf varieties were highly susceptible to *D. punctiferalis* as against the tall varieties. However, the only exception was the variety Mauthner's Dwarf because of its loose inflorescence and smooth capsules as indicated earlier. The negative correlation "r" value was -0.45 ($P=0.01$) with regression of $Y=2.11-0.31\,X$ for selected varieties. (Fig. 3)

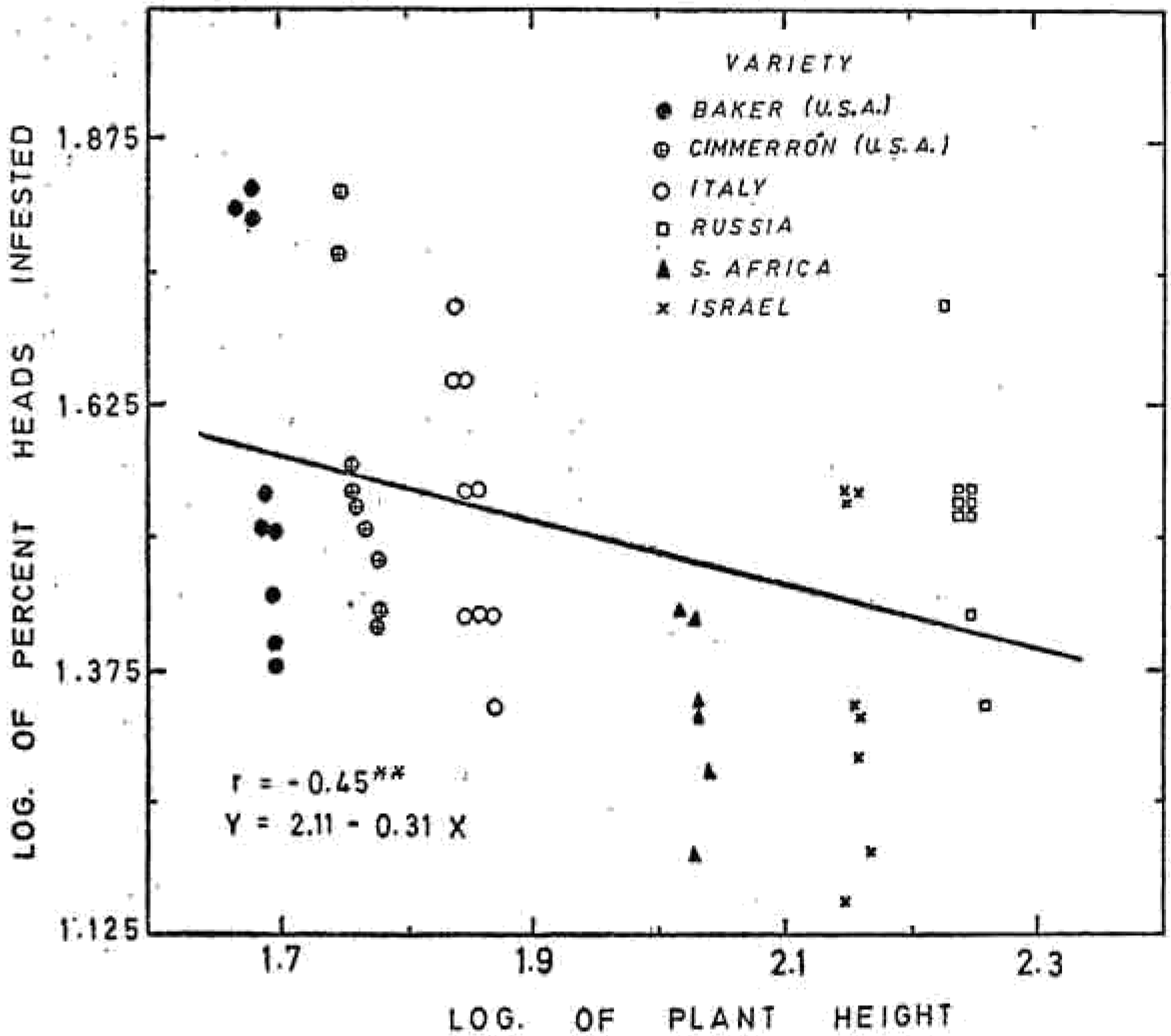

FIG. 3. Correlation between plant height of castor varieties and percent heads infested by *Dichocrocis punctiferalis*

Discussion: *I. Mechanisms of resistance to Achoea janata:* Evidence is being presented for the first time regarding the differential behaviour of castor varieties in relation to the infestation of *A. janata* and other foliage-feeding insects. Out of the nine species of leaf-eating caterpillars, only *A. janata, Ergolis merione, Euporctis fraterna* and *Porthesia scintillans* were found to infest a large number of castor varieties, and even among them *A. janata* alone may be considered to cause extensive damage to the crop. R. C. 1098 Baker and R. C. 1096 Coonoor varieties were highly resistant. The caterpillars were also remarkably very small on these varieties indicating the possible antibiosis mechanism of resistance. Interestingly these varieties were also proved earlier to be highly resistant to another foliage-feeding insect *Empoasca flavescens*. (Jayaraj 1966a, 1967a). The jassids when bred on these varieties were markedly small in size leading to reduction in fecundity due to the antibiosis nature of the host plants (Jayaraj 1967 b). The same may be attributed for the small sized caterpillars of *A. janata* now observed on them.

There has been a general agreement among workers dealing with castor that the intensity of 'bloom' is related to the varietal susceptibility to pests. In general 'no bloom' and 'single bloom' varieties were found to be resistant to *A. janata* (Table) when compared to the 'double' and 'triple bloom' types. The preference of *A. janata* for castor varieties in this respect is on the same lines as that of the red spider mite (Chandrasekaran *et al.* 1964), the whitefly, (David and Radha 1964), and the leafhopper (Jayaraj 1968). A similar instance has also been reported by Thompson (1963), who found that non-waxy plants of *Brassica* were not colonized by cabbage aphid, *Brevicoryne brassicae* L., whereas the normal waxy plants had large colonies. The possibility of waxes being involved in the reflection of light in connection with plant resistance has been mentioned by Painter (1951). The 'no bloom' varieties, in the absence of any waxy coating, may be able to reflect light better than other varieties with bloom, incidentally also repelling the insects. The production of waxy bloom in the castor varieties has been explained by Jayaraj (1966 b) based on the organic acid contents. The higher concentrations of organic acids in the preferred host varieties may intensify the synthesis of fatty acids, ultimately leading to the production of waxes which are esters of long-chain fatty acids (Meyer and Anderson 1959).

The earliness is not associated with resistance to *A. janata* since some of the late flowering varieties like TMV 1, TMV 3 and CO. 1 are also resistant harbouring low infestation of the pest. Similarly, other plant characters like height, number of nodes, internode length, petiole length, branching *etc.* did not show uniform relationship with resistance to the semilooper. Kennedy and Stroyan (1959) also viewed that resistance commonly depends more on physiological than on morphological characters of the plant.

2. *Effect of food plant of Achoea janata on its braconid parasite, Microplitis ophiusae:* It was observed that the percentage parasitism of semiloopers by the braconid parasite varied significantly when the pest utilised different varieties as host plant (Table). For some time it has been recognized that the host plant may confer on the host insect a kind of immunity to parasitization (Doutt 1959). As high as 51.8% of the caterpillars were parasitized when fed on the susceptible R. C. 552/1 Nagpur castor variety as against only 13.3% on the resistant R. C. 1096 Coonoor variety. Little information is available concerning the parasite's reaction to different plant

varieties used by the host. The literature available now mostly pertains to the different species of the plants utilized by the pest. Simmonds (1944) has shown conclusively that the lemon, in camparison with the orange, as a host for the California red scale, *Aonidiella aurantii* (Mask.), has a marked inhibiting effect on the development of the parasite *Comperiella bifasciata* How. Similarly, De Bach, *et al* (1949) reported that under comparable conditions the red scale on oranges is under better natural control than on lemons by the golden chalcid *Aphytis chrysomphali* Timb. The earlier discovery by Flanders (1942) that the hymenopteran parasite *Habrolepis rouxi* Comp. reproduced normally on the red scale on *Citrus* spp. but not on sago palm, *Cycas revoluta* Thumb. was of much importance in the successful biological control of the pest. Resently Smith (1957) has also shown that while the parasite *H. rouxi* suffers very little mortality (3.1%) of its immature stages when attacking the red scale on grape fruit, 100% mortality occurs when the scale was cultured on sago palm.

Evidence is also available to show the influence of plant host on insect predators by way of the insect host. Mortality of the pentatomid predators, *Podisus maculiventris* (Say) and *Perillus bioculatus* (F) was also greatest when the host larvae of Colorado potato beetle, *Leptinotarsa decemlineata* (Say) fed on *Solanum carolinense* than on other species (Landis 1937). Hodek (1956) reported 100% mortality of both larvae and adults of *Coccinella septempunctata* L. when fed on *Aphis sambuci* L. on elder. He attributed this to the presence of a glycoside sambunigrin found in the plant host which is transferred to the body of the aphid and in turn eaten by the predator where it is split by enzymes to cyanic acid and other compounds. Analogous to this predator, Chelliah (unpubl) observed high mortality of early instans of *Chilomenes sexamculata* fed on *Aphis craccivora* K. on *Gliricidai* plants, while normal development and reproduction were observed on the aphids fed on *Doliahos lab-lab* plants.

Eventhough heavy mortality of the parasite *Microplitiso phiusae* was not observed on *A. janata* fed on any of the castor varieties as reported in other cases of parasites and predators discussed above the present data conclusively show the adverse effect of certain varieties on the percentage parasitization. As mentioned earlier, the semilooper caterpillars on resistant 'no bloom' and 'single bloom' varieties were much smaller in size owing to the nutritional inferiority of the host plants. This would ultimately influence the prolificacy, size and sex ratio of the insect parasite as has been reported by Flanders (1936) in many species of parasites. These effects have been recognized as due to the profound effect of host plant on the physiology of insect pests which may ultimately affect the establishment of their parasites and predators.

The information now available also indicates that the relationship between resistant varieties of castor and the parasites of *A. janata* affected by the plant resistance may take another trend. Reduction in the population level of *A. janata* might lead to the difficult host-finding in the parasites resulting in an adverse effect on biological control of the pest by parasites. Integrated approach of insect control utilising these two methods would not therefore be possible under these circumstances.

3. *Resistance of castor to Dichocrocis punctiferalis:* Castor varieties possessing lax type of panicles with smooth capsules were highly resistant to the shoot and capsule borer when compared to the varieties having compact heads with closely-set capsules. This is in agreement with the observations of David *et al* (1964) and Sulochanabai *et al* (1968). Resistance has also been correlated with earliness in flowering and plant height statistically. It has been found that the early types flowering in 5th and 6th weeks after sowing were in general highly susceptible. McFarlane and Rieman (1943) have observed that bean varieties that matured early were generally the most susceptible and those that matured late tended to be resistant to *Empoasca fubae* (Harr). However, in many other cases earliness was associated with resistance to pests as in castor leafhopper, (Baldrati 1948, Jayaraj 1968). Biochemical bases involving the nutritional physiology of the caterpillars should be studied in detail to understand the mechanisms of resistance in this regard.

Summary: Studies were made to screen different cultivated varieties of castor for their degree of resistance or susceptibility to ten species of lepidopteran insects in order to suggest suitable parent varieties which could be used in breeding pest-resistant strains. Field experimentation indicated that among the species studied, *Achoea janata*, *Dichocrocis punctiferalis*, *Ergolis merione*, *Euproctis fraterna* and *Porthesia scintillans* were found to infest a large number of varieties while *Spatulicraspeda castaneiceps*, *Olene mendosa*, *Spodoptera littoralis* and *Pericallia ricini* were of only minor importance.

The semilooper, *A. janata*, and the shoot and capsule borer, *D punctiferalis*, caused extensive damage to the crop. While the varieties R. C. 1098 Baker (U. S. A.) and R. C. 1096 Coonoor were highly resistant to *A. janata*, they were found to be susceptible to *D. punctiferalis*. The varieties Mauthner's Dwarf and R. C. 552/1 Nagpur were highly resistant to *D. punctiferalis* in view of their lax panicles and smooth capsules. Resistance was also correlated with late flowering habit and taller plant height and on the other hand resistance to *A. janata* was associated with, No, or, single, bloom character.

Semilooper caterpillars infesting resistant plants were much smaller in size and were not preferred by the braconid parasite *Microplitis ophiusae*. This showed that the host plant may confer on the host insect a kind of immunity to parasitization. The possible mechanism in this regard has been discussed.

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