Association of Some Insect Species on Coffee and Symptoms Expression with Observations on the Effect of Pesticides on Plant and Animal Populations

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Introduction

A RECOLLECTION on the history of pest incidence on coffee in the immediate past is not a whole-some one; what might happen in the future is an ordeal that tempts a scientist to investigate. To the latter end, a critical and broad analysis as well as appreciation of the entire coffee ecosystem with it splant-animal complex and interpolated cultural programmes is more basically essential than the promulgation of a few established commonsense theories. The former requisite is a part and parcel of sane scientific thought and procedure in that the more one takes into account and understands a great number of factors that singly or cumulatively make up possible or established causes, the better will he be armoured to tackle the resurgent effects.

Dealing with the basic aspects of pest problems is not often easy and deriving conclusions in a complex case does not follow in quick succession even in those endowed with clairvoyance. The purpose of this paper is mainly to throw light on the intricacies of pest and other related factors bearing upon the " new malady " of coffee and to help contribute a broad perspective in estimating their relative roles in the ecology. It is admittedly true that studies of this nature will take several years to yield detailed data. Nevertheless, the interim observations discussed below, it is hoped, will provide clues to progress onward. For clarity and continuity the discussions are split into three main heads.

i) Insects–species composition, periodicity, abundance and activity.

ii) Symptoms expression of association.

iii) Control aspects with observations on the effect of pesticides on animal (= insects etc.) and plant populations.

i) Insects–species composition, periodicity, abundance and activity

Estimating periodicity, abundance and activity of species through field collections is a basic requisite toward conducting critical observations on their relative economic importance. Studies to determine these attributes have been in progress at the Coffee Research Station, Balehonnur, since 1958. The objectives of these *'collection' studies, it should be stated,* were not actual determination of population density through critical sampling but obtaining rapid and broad estimates of species composition, their periodicity etc. and to infer, where possible, a relative index on the intensity of populations of known species in various ecological conditions.

Daily light-trap collections and representative hand–net collections in combination with hand picking, at convenient intervals, were carriep out. The former evidenced the response of populations of certain species to light in relation to their activity and abundance as influenced by meteorological factors and of which, presumably, an undetermined number

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would not have been trapped or become available for collection through the latter methods. These latter methods, on the other hand, provided indications on the diurnal activity of the species and on their possible associations with the vegetation, in general, and coffee, in particular. A list of some cf the sucking groups of insect collected is given in table I. Habits of association, where apparent, and source of collection are also indicated. Among the species, leaf-hoppers (Cicadellidae, Cixiidae, Delphacidae, Issidae, Flatidae and Tropiduchidae), frog-hoppers (Cercopidae) and tree hoppers (Membracidae) were active throughout the years, especially from August to March. At least four of the families represented, contained species apparently having phytophagous association with coffee. Species of white-flies (Aleyrodidae) were met with from July through November while plant-lice (Aphididae) were collected from April through May and August through October. Scales, ensign-coccids and mealy-bugs (Coccidae, Ortheziidae, Pseudococcidae) were present from November to June in varying intensities. Species of thrips were abundant from March to May as well as from September to December. Other pests noticed—not tabulated-included the leaf-miner. *Melanagromyza coffeae* Hering. (Agromyzidae), infesting arabica coffee primarily from October till April in various zones ; leaf-cutting weevils, *Astycus* spp., *Sympiezomias praeteritus* Mshl., *Myllocerus 11-pustulatus* Fst. (Curculionidae) during April-May ; species of semi-loopers (Geometridae) in October-November ; grass-hoppers (Acridiidae) from December to February; stink-bugs (Pentatomidae); lace-bugs (Tingidae); squash-bugs (Coreidae); leaf-bugs (Miridae) and mites (to be identified) in various periods of the collections. In the above summation it has to be noted that the species exhibited fluctuations in populations from zone to zone and from year to year.

In view of the array of species detected, the comparative abundance and activity of species of hoppers, aphids and thrips were briefly studied. Among the cicadellid hoppers, *Nephotettix apicalis* Mots., was found cosmopolitan. Species of frog-hoppers, and the other leaf-hoppers, Cixiidae, Delphacidae, and Flatidae, were quite abundant. Among the aphids, the activity of one species, *Toxoptera*—probably *odinae* v. d. g., was conspicuous. Of the thrips species, *Haplothrips* was more often secured than the others. Most of these species detected appeared to be phytophagous but the relative degree of damage caused on coffee has hitherto not been critically established. Species of *Franklinothrips* appeared significant in number and probably they were predacious on other species of thrips, on aphids and mites.

ii) Symtoms expression of association

Ranking by symptoms expression or severity of infestation often gives rapid assessments of the potentials of an insect species as a pest (32). Accurate on-the-spot correlations between abundance of individual species and symptoms expression on coffee were found often difficult to make in the field due to the overlapping of species incidence and due to the complexity and diversity in the environmental factors. However, where possible, efforts were deployed to identify individually the results of insect-coffee association in the laboratory and also to note the history of species incidence as related to symptoms expression in the field. These studies did not comprise all the suspected species detected in various areas which, incidentally, appeared too wide an aspect to be dealt with in a short period. Nevertheless, the data obtained on the history of insect species association in combination with those on the response of host species, in several cases, provided clues to verify the source of symptoms expression ; whether of insect origin or not.

In brief, the following phenomena were evident. Host (coffee) growth pattern influenced the number and distribution of species of hoppers, white-flies, aphids, scales, mealy-bugs and thrips. Thus, in general, the periods of fresh leaf formation coincided with the build-up in populations of these species. Fluctuations in their populations occurred at different average levels in different environments and these could be correlated to microhabitat variations as influenced by edaphic factors such as topography and soil type; and by the density, distribution of host species, nutrient levels obtained in the host medium, as well as to the intrinsic properties of the insect species. The incidence of aphids on tender foliage that were kept under observation in the laboratory, resulted in varying degrees of malformations, whereas, in the field, these were not uniformly present at a time in all cases of aphid infestations. However, abnormalities became evident in the course of time in several instances not only where the same or other insect species like hoppers, thrips, scales, white-flies and mealy-bugs intervened, but also where there were no further apparent insect associations. Also, shoot abnormalities were evident in many cases that were insecticidally protected—without apparent insect associations—as also in those not protected. Yet another interesting feature observed was the congregation of thrips species on foliage malformed due to the effect of other obvious environmental factors; there having been no apparent insect associations during the earlier stages in their growth. These observations indicated that a history of host species status, comprising its reaction to the physical factors of environment, in general, and to the incidence of pest species, in particular, was essential to discriminate the symptoms expression and, that designating the latter to factors obvious at first sight could be irrelevant. Thus, while in an area, broad explanations on shoot malformations or other symptoms expression coinciding with complex pest incidence could be juxtaposed through established records, these need not necessarily define the perimeter of the problem in general or in substance due to the inherent diversity obtained in ecological conditions; either historically or incidentally.

The above observations would suggest perceiving the problem of shoot malformations on a wide basis. In this context, the following factors should be given recognition. For optimal nutrition and multiplication, in an environment, pest species must obtain, among others, quantities of nutrients sufficient for their needs and the latter may vary with species and sexes. Quantitative requirements depend upon the proportions of available nutrients and a satisfactory balance in their proportions is necessary within and between the main classes of nutrients, especially amino acids. The effects of supplying various elements like Copper, Zinc, Phosphorus, Potassium and Iron and those of Nitrogen in improving the nutritional value of the host plant species to pest feeding by way of their concentration on various feeding loci deserve attention. Presumably, there are various reasons that could bring about such concentration of chemicals on the shoot. Hence, this should not be dispensed off solely as a resultant of pest feeding since there are established records to prove such a phenomenon taking place through applications of fertilizers, fungicides, insecticides and herbicides (5, 22, 28, 29). It is obvious that the basic aspect of the problem lies in the intricate relationship existing between the nutritional reqirements of pest species and the physiological state of the host species as influenced by climatological and cultural factors obtained in various areas (15). Thus, fulfillment of optimal nutritional requirements by the host species could contribute a great deal to the sustenance of insect species and, hence, in certain cases, to the aggravation of injury, true or otherwise (2).

iii) Control aspects with observations on the effect of pesticides on animal (=insects etc.) and plant populations.

Pesticides and animal populations. " For many years it has been recognized that the greatest single factor in preventing insects from overwhelming the rest of the world is the internecine warfare which they carry out among themselves " (24). While it often becomes an economic necessity to regulate the density of pest populations through pesticides, it is also worth bearing in mind that the environment is an unstable system containing species of complex interrelationships. Because pesticides affect each species differently; the latter being interdependent ; and because many pesticide residues remain for long durations in soil and in plants, indiscriminate and habitual pesticidal treatments are liable to produce disturbances in the population equilibrium. These effects manifest themselves in the resurgence or flare-up of pest populations soon after treatments (short-term) or only after a number of years, sometimes giving rise to resistant strains (long-term). Thus, in spite of the spectacular initial control, some pesticides like the chlorinated Hydrocarbons, Parathion, Sulphur, Lime Sulphur and Copper Carbonate, or even carrier materials and diluents, due to their nonselectivity, bring about sudden or gradual increase of pest species against which they are applied or of other phytophagous species which are originally present at low levels at the time of treatments. Such resurgences have been demonstrated for over 50 species comprising mites, aphids, scales, white-flies, leaf-hoppers, cut-worms, leaf-miners etc. and have often been related to the reduction of natural enemies and in several cases to the favourable influence of pesticides on the biotic potential of phytophagous species as well as to the removal of competitive species.

Several records are available to establish a negative correlation between the population density of pest species including aphids, springtails, scales, mealy-bugs, mites etc. and their natural enemies like predacious beetles, mites, thrips, parasitic wasps etc. (3, 4, 8, 9, 10, 11, 12, 13, 17, 18, 19, 21). Hence, it is important to recognize the relative importance of various species of natural enemies that pest species may have and the effect of dosages and/or formulations of pesticides on both these groups.

In the above context, a few phenomena of common experience with regard to coffee pest control in India need emphasis. One of these concerns the coffee green bug, *Coccus viridis* (Gr.). In nature, this species has several predators and a host of endoparasites,-the most abundant of the latter being the eulophids of the genus, *Coccophagus*, especially *C. bogoriensis* (Köening.) ; *Tetrastichus lecanii* (Grlt.), and the encyrtid, *Cheiloneuromyia javensis* Grlt. The white fungus, *Cephalosporium lecanii* (Zimm.), and the black fungus, *Empusa lecanii* (Zimm.), are other widely distributed parasites. The roles of the above parasite species have been remarkable in several cases of infestation. But, this aspect has not been widely recognized. There may be several reasons for it viz. (a) the diagnostic difficulty involved in detecting insect or fungus parasitized bugs, especially at the initial stages of parasitization and (b) the the unpredictability in the role of natural enemies themselves. Also, in many cases, where insecticidal (Parathion) and fungicidal sprays, either singly or in combination, have become a routine, the effective roles of predators and parasites have not been promoted partly due to the imposed absence of optimal conditions for their propagation or that the action of chemicals has masked the true course of events to an indiscriminate eye. However, an indirect analysis could pay credence to the relative roles of natural enemies in many areas, by taking into account the build-up in bug population after sprays. This, due to the selective advantage of the pest species over the natural enemies to the chemicals, often exceeds the initial level ; thus warranting further insecticidal treatments, even at higher concentrations than before, for effective control. Renewed applications, on the other hand, may also result in a still prolonged suppression in the activity of the natural (insect) enemies. While there are no data to show that the chemicals directly or indirectly stimulate natality of the bug species, it is thought that retardation in the activity of the biotic factors in an environment acts as an impetus to reinfestation in many cases. This negative correlation is also indicated in some field experiments with the less persistent insecticides where the intensity of bug population, after suffering an initial knockdown effect, in the treatments, eventually reaches a high level and persists with accelerated ant movement. Controlling ants mechanically or through the application of B. H. C. dust to the ant trials has been found to augment parasitization resulting in gradual reduction of the infestation. This would suggest the efficiency of natural (insect) enemies as a perimeter of the bug population. While the relative importance of the aforesaid natural enemies may vary from place to place or from season to season, it is possible to arrive at sound generalizations if the history of role of natural enemies is kept up and followed with reference to pest build-up and interpolated chemical control programmes. Ecological relationships of the natural enemies of other pest species are under detailed study and may provide data to explain fully the reasons behind their build-up.

In contrast to the sudden and transient flare-up of pest species; short-term effect; the gradual and chronic accumulation of species due to the cumulative detrimental effects of nonselective pesticides, applied for protracted periods, on the natural enemies; long-term effect; should be considered more problematical. This phenomenon is explained by the outbreaks of pest species even under less favourable environmental conditions and which apparently is the result of reduced biotic resistance contributed through the decimation of the populations of predators and parasites of low host density dependent species. Examples of this are found in the case of the California red scale, *Aonidiella aurantii* (Maskell), and its aphelinid parasite, *Aphytis chrysomphali* (Mercet), and the cottony-cushion scale, *Icerya purchasi* (Maskell), and its coccinellid predator, *Rodolia cardinalis* (Mulsant) (10).

The long-term effects have been more obvious on perennial than on annual crops where the treatments have been extensively directed against mostly monophagous or oligophagous pest species. Though to-date we do not possess many concrete instances to illustrate these phenomena with reference to coffee pests in South India, at least one case, that of the leaf-miner, *Melanagromyza coffeae*, appears to be emerging as a suitable example. The incidence of this species has been exhibiting high trends in the past few years in many coffee tracts, and especially in areas which receive regular Parathion sprays against the green bug. Whether this gradual build-up of the leaf-miner has occurred on account of the retarded activity of the eulophid parasite, *Closterocerus* sp., or other species, through Parathion sprays, remains for investigation. Nevertheless, it is advisable to recapitulate on these tendencies when prolific and continuous applications of nonselective pesticides are undertaken against any other pest species, such as thrips, whose biological relationships are not yet understood (18, 19, 20, 23).

Besides the above drawbacks encountered in the use of pesticides, there are other instances where pesticides directly or indirectly through the host plants favour the abundance and activity of phytophagous species. Direct effect of D. D. T. in enhancing the natality of the two-spotted tetranychid mite, *Tetranychus telarius* (Linn.), has been reported (16).

Soil fertility greatly influences the condition of the plants and the latter in turn the insect species feeding on them (1a, 15, 27). Application of nutrient sprays (Zinc, Copper) alone or in combination with pesticides on deficient plants is also found to increase the population of scales such as the purple scale, *Lepidoasaphes beckii* (Newman) (34).

Possible removal of competitive species from an environment and segregation of resistant strains are other aspects that deserve attention when considering the effect of pesticides on the balance of populations.

Preventing or minimizing the aforesaid unfavourable tendencies can be achieved in several cases through an alteration in the timing or in the method of application or through the use of chemicals (dosages) that are least toxic to the natural enemies and that are selective. If at a time, only limited proportion of the crop is treated, when chemical application is warranted, so that the natural enemies whose biotic potentials are known may be relatively unaffected in other areas, a favourable degree of equilibrium in the populations can be obtained. Choice of pesticide dosages that are least toxic to the natural enemies-though nonselective in general-is an important factor which an agriculturist is liable to forget when his pursuit is for the immediate control of a problem in hand. Records show that where natural enemies exert appreciable control on potential pest species ; it is more preferable to use a pesticide/ formulation/ dosage, which in spite of its apparent lower degree of toxicity on the pest or disease problem in hand than another—though bringing the problem within economic level-, leaves populations of natural enemies of the potential species least affected. This integrated approach results in a favourable equilibrium between the populations and minimizes resurgence of potential pest species in the long run (19, 31).

Selective pesticides, such as some of the systemics, which have physioloigcal selectivity on the beneficial species, have provided reliable results in pest control in many countries (25). Once the ecology of the pest species and of its natural enemies is known, selectivity has also been found attained with the normally nonselective pesticides, including systemics, through adopting modified application techniques. Such is the case reported on the control of the coffee mealy-bug, *Planococcus kenyae* (Le Pelley) (6, 26).

In an environment, where a pest outbreak occurs due to the inadequacy of one or more of the biological control agents-which, however, normally control the pest species involved-it is preferable to use a selective pesticide/ formulation/ dosage just sufficient to compensate for the change in equilibrium that has set in. This not only achieves the ecomic control required but also prevents detrimental effects on the natural enemies that are so essential to the sustained maintenance of biological equilibrium. Several years of research are essential to evolve suitable recommendations with selective compounds on foundations that are not mere surface grazing on pest control but that encompass the broad aspects in the coffee ecology. It has to be admitted that until selective pesticides are evolved to combat the multitude of pests economically, the non-selective group will have to remain and that only pesticide application is the answer to heavy outbreaks. But, the results in the long run are invariably more satisfactory when programmes are suitably planned and accommodated with due regard to the existence of biotic factors.

Pesticides and plant populations: Deposits of most organic insecticides seem to penetrate in part at least into cuticular and often into subcuticular tissues of treated plant parts (14). Certain insecticides have deleterious effect on some crops and this is termed phytotoxicity. In several cases, however, there is a manifestation of taint or off-flavour in the edible plant material. The discussions below follow an earlier presentation made on these aspects (30).

A great deal of apprehension had arisen with regard to B. H. C. toxicity, especially on young coffee. This aspect was envisaged as early as 1958 and consequently, the use of B. H. C. in the nursery was not recommended in the advisory pamphlets. Since then, attempts were being made to study, in detail, the effects of B. H. C. and other insecticides on coffee of various ages, through different methods of applications, in varying environmental conditions. Though there are yet detailed data to be collected, a brief resume on the interim observations might be appropriate to understand the problem from various practical aspects.

As reported earlier(30), basket seedlings (arabica–S. 288), three to four months old, were found highly susceptible to single soil drench of B. H. C., applied at 4, 8 and 16 pounds of the 50 wettable powder in 40 gallons of water. Obvious deterioration of the root system of seedlings was apparent within two weeks of treatments while the shoots appeared normal in the same period. The other treatments, D.D.T. 50 W.P. (rates as above) and Dieldrin 50 W.P. (½ lb., 1 lb. and 2 lbs./ 40 glns), did not evidence similar effects. The root system of seedlings in B.H.C., irrespective of the dosage, was stubby to begin with and this progressed toward complete abortion in subsequent observations. Aerial parts of some seedlings in the the three dosages of B.H.C. showed characteristic symptoms of phytotoxicity—yellowing, defoliation etc.—at the third observation i.e., approximately four weeks after treatments. In general, the higher dosages of B.H.C. brought about a greater percentage of deterioration and death of the seedlings and these were noticed approximately from the fifth week after treatments. Leaves on the surviving seedlings were small and leathery (Table II). It was, however, interesting to note that the above reactions did not so far occur in another series of experiments where one year old plants (arabica –S.795) were subjected to renewed monthly applications (1 to 6) of B.H.C., at 8 and 16 pounds in 40 gallons of water as soil drench. From these observations, it would appear that phytotoxicity need not occur as a general feature following B.H.C. applications to the substratum but, probably, the reaction of plants varies with season, age soil structure, pH, temperature and perhaps with variety. Further critical studies would help in deriving definite conclusions.

"As physiologically active substrates, plant parts may absorb and translocate topically applied insecticidal chemicals" (14). The presence of tissue necrosis in arabica coffee had lately been correlated to B.H.C. applications. This raised the question; did the problem result due to the toxic properties of the insecticide residue following swab to the plant? Whether the insecticide penetrated the bark directly or through wounds and the residue was appreciably translocated into the plant system or whether penetration/absorption and translocation took place through the roots—presuming that the dripped material during swab could accumulate in soil and reach the root system-to bring about necrosis had to be considered in this regard. While there were reports of some nonsystemic soil insecticides being absorbed and retained by corn and by certain root crops such as potatoes (33), in several cases, evidences obtained were insufficient to substantiate translocation as well as to differentiate actual absorption of the insecticides from mere pentration (14). Thus, there being subtle differences in the mode and locus of penetration and absorption, and in the degree of possible translocation, generalizations drawn from insufficient observations might not establish the source of occurrence of necrosis among coffee in natural conditions.

That pith disorganization and discolouration would result due to B.H.C. as reported earlier (1), in this context could only be taken as to represent the normal behaviour of 'cut-twigs' of many plants in the presence of poisonous chemicals or chemicals in high concentrations. It would be of interest to note that such disorganization and discolouration also took place with Dieldrin (0.1 a.c.) and D.D.T. (1.0 a.c.); to some extent, with Parathion (0.01 a.c.) and normal nutrient solution within five to ten days of exposure of twigs to the chemicals.

To verify the extent of necrosis in the existing natural conditions, preliminary studies on plant material having different B. H. C. swab histories and devoid of such history were undertaken. The plants, selected at random, were examined for necrosis within branches, main stem and roots, with exceptions where the concerned party disagreed to their uprooting. Tissue discolouration, other than that generally occurring in white steam borer infestation, in any of the parts examined was designated to represent as one case. It was seen (Table III) that there was no consistent correlation between tissue necrosis and swab history. Also, it did not appear, so far, that in the existing conditions, necrosis was primarily a resultant of Bordeaux mixture sprays and of B. H. C. swabs since neither in old arabica and in arabica station selections, nor in robusta, did the history of treatments bear relationship with necrosis. These field observations were further substantiated by the absence of necrosis in potted one and a half year old plants (arabica–S.288) that received B. H. C. (8 and 16 lbs.) and Lindane (0.65 and 1.30 lbs.)–in 40 gallons of water-swabs from one to six montly sequences. Though, at the time of this report, no obvious signs of phytotoxicity appear on the shoot systems of plants in any of the treatments, mild swellings on many of the lateral root tips were apparent, mostly in plants in B.H.C. high concentration; applied five and six times; after an interval of five and four months respectively from the last treatment. Further observations are in progress.

In this connection, it would be worth considering whether necrosis arose due to pathological factors probably having insect association or due to physiological disturbances in the plant system. The former possibility was recently reported with reference to tea (7).

The fact that B. H. C. sprays affected the flavour of coffee had been reported (32a) and this appeared to be a resultant of the characteristic of deposits of several organic insecticides possessing properties of penetration into the cuticular and subcuticular regions of leaves and fruits. It should, however, be noted that climatic and soil conditions as well as cultural methods would determine the expression of the phenomenon. That bricky flavour also resulted through B.H.C. swabs–pre plus post-monsoon–, as practised in South India, was pointed out earlier (30). Data are yet to arrive to aid in understanding the rate of build-up of B.H.C. residue in different environmental conditions. Until the relative degrees of penetration and possible translocation, if any, of the insecticide through topical applications, or of absorption and translocation through the roots, were defined, the source of the problem would appear difficult to judge. Preliminary data (Table IV) obtained, nevertheless, showed that discontinuing either of the swabs minimzed the taint problem and this, in turn, suggested that a minimum time-lag was essential following swabs for the metabolic degradation of the chemical constituents below a particular level contributing to taint.

Summary

Insect and mite species detected among coffee are reported. The nature of association of some of these and the symptoms expression on coffee are briefly dealt with.

Observations have shown that while in some cases shoot malformations can be correlated to apparent insect species incidence, the source of the problem need not basically be of such origin in all. It is indicated that a history of host (coffee) species status, comprising its physiology and reaction to the physical and biotic factors of the environment, is essential to discriminate and analyse the source and progress of manifestations.

Because enviroment is an unstable system containing species of complex interrelationships, indiscriminate use of pesticides can be harmful giving rise to sudden or gradual resurgence of pest species despite the spectacular initial control effected on a pest species through such

applications. The build-up of the coffee green bug, *Coccus viridis* (Gr.), has, in several cases, been found to be a resultant of the detrimental effect of chemicals on the natural enemies. The increasing degree of incidence of the leaf-miner, *Melanagromyza coffeae* (Hering), appears to represent the long-term effect of pesticidal applications.

When chemical control is warranted, to achieve economic control of a pest species-which is the main aim of most programmes-it is important that an integrated schedule is followed where, pesticides are only selectively used in order to compensate for the change in the population equilibrium that has set in due to the influence of various ecological factors.

Phytotoxic effects of B.H.C. on coffee appear to be related to season, age of plants, soil structure, pH, temperature and perhaps to variety. Tissue necrosis can occur in cut twigs kept in direct contact with several chemicals. The presence of necrosis in coffee, under natural conditions, does not so far appear to be strictly related to application of plant protection chemicals.

Data suggest that brickly flavour in contributed through B.H C. swabs but it is also seen that discontinuing either of the swabs for certain periods minimizes this problem.

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TABLE I

List of insects collected from Coffee Plantations

Order/Family	Identity	Host and nature of association	Locality
Hem. Homoptera			
Cicadellidae	**Nephotettix apicalis** (Mots.)	On arabica and robusta coffee–trap and net-apparently feeding on shoot	C. R. Station and Coorg
Cicadellidae	**Gypona** sp.	On arabica coffee—net—association unknown	C. R. Station
Cicadellidae	"**Tettigonia**" **ferruginea** (Fab.)	Among arabica coffee—trap—association unknown	C. R. Station
Cicadellidae	**Bothrogonia** sp.	On arabica coffee—net—association unknown	C. R. Station
Cercopidae	not determined	On arabica coffee–trap and net—apparently feeding on shoot	C. R. Station, Saklespur & Coorg
Membracidae	not determined	On arabica coffee—net and hand—association unknown	C. R. Station, Saklespur & Çoorg
Cixiidae	not derermined	On arabica and robusta coffee—net—apparently feeding on shoot	C. R. Station and various zones
Delphacidae	not determined	Among coffee—trap and net—association unknown	C. R. Station and various zones
Issidae	not determined	On arabica coffee—net—association unknown	C. R. Station
Flatidae	not determined	On arabica and robusta coffee—trap, net and hand—apparently feeding on shoot	C. R. Station and Coorg
Tropiduchidae	not determined	Cn arabica coffee—net—association unknown	C. R. Station
Aleyrodidae	**Aleyrolobus** sp. ?	On arabica coffee—net—apparently feeding on shoot	C. R. Station, Coorg and Saklespur
Aphididae	**Toxoptera** spp.	On arabica and robusta coffee—net and hand—feeding on shoot	C. R. Station and various zones
Coccidae	**Coccus** spp.	On arabica and robusta—feeding on shoot	C. R. Station and various zones
Ortheziidae	**Orthezia insignis** (Br.)	On arabica coffee and **Coleus** sp.—feeding on shoot	C. R. Station, Saklespur & Coorg
Pseudococcidae	**Planococcus** sp. ?	On arabica coffee—feeding on shoot	C. R. Station

List of insects collected from Coffee plantations *(Continued)*

Order/Family	Identity	Host and nature of association	Locality
Thysanoptera			
Aeolothripidae	**Franklinothrips** (sp. underscribed)	Among coffee—trap—association unknown	C. R. Station
Thripidae	**Heliothrips haemorrhoidalsis** (Bouche)	On arabica and robusta coffee—net—apparently feeding on shoot	C. R. Station
Thripidae	**Thrips** sp.	On arabico and robusta coffee—net—apparently feeding on shoot	C. R. Station
Thripidae	**Thrips florum**(Schmutz Gr.)	On arabica and robusta coffee, Shoot & blossom-net-apparently feeding	C. R. Station
Thripidae	**Scirtothrips** sp.	On arabica and robusta coffee, Shoot & blsossom-net-apparently feeding	C. R. Station
Phloeothripidae	**Haplothrips** sp.	On arabica and robusta coffee, Shoot & blsossom-net-apparently feeding	C. R. Station
Phloeothripidae	?	Among coffee—net—association unknown	C. R. Station
Phloeothripidae	?	Predacious on eggs and larvae of **Xyleborus morstatti** (Hgdn·)	C. R. Station
Ecacanthothripidae	**Ecacanthothrips** sp.	On arabica and robusta coffee—net—association unknown	C. R. Station

TABLE II

Effects of soil applications of B.H.C., D D.T. and Dieldrin on *C. arabica* (S-288) basket seedlings

Treatments		Part	Observations: 2 wk. after treat.	4 wk. after treat.	6 wk. after treat.	8 wk. after treat.
			PLANTS 1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10	1 2 3 4 5 6 7 8 9 10
B.H.C. 50 W.P.	4 lb.	S	Normal	— N N P N N N N N N	— F F — D D F P F F	— F F — — D F P F F
		R	St	— Ab	— —Ab	— — — >Ab
B H.C. 50 W.P.	8 lb.	S	Normal	— N N N N N N N P N	— P F P P P P D — D	— P F P P P P D — —
		R	St	— Ab	— Ab	— >Ab — —
B.H.C. 50 W.P.	16 lb.	S	Normal	— N N N N N N N N P	— D P P P P P D P —	— D P P P P P — P —
		R	St	— Ab	— >Ab —	— — >Ab —
D.D.T. 50 W.P.	4 lb.	S	Normal	— N N N N N N N N N	— F N N N N N N N —	— — N N N N N N N —
		R	N	— N	— N —	— — N —
D.D.T. 50 W.P.	8 lb.	S	Normal	— N N N N N N N N N	— — N N N N N N F N	— — N N N N N N — N
		R	N	— N	— — N	— — N —
D.D.T. 50 W.P.	16 lb.	S	Normal	— N N N N N N N N N	— N N — N N N N N N	— N N — N N N N N —
		R	N	— N	— — N	— — N —
Dieldrin 50 W.P.	½ lb.	S	Normal	— N N N N N N N N N	— N — N N N N N N N	— N — N N N N N — N
		R	N	— N	— — N	— — N —
Dieldrin 50 W.P.	1 lb.	S	Normal	— N N N N N N N N N	— N N N N N N — N N	— N N N N N N — — N
		R	N	— N	— — N	— N — —
Dieldrin 50 W.P.	2 lb.	S	Normal	— N N N N N N N N N	— N N N N N — N N N	— N — N N N — N N N
		R	N	— N	— N —	— — — N
Control		S	Normal	— N N N N N N N N N	— N N N — N N N N N	— N N N — N N — N N
		R	N	— N	— — N	— N — —

D—Dead, P—Poor, F—Fair, N—Normal, S—Shoot, R—Root, St—Stubby, Ab—Aborted, > Worse than

At each observation, one plant was removed, per treatment, to observe the root system.

TABLE III

Necrosis in relation to history of treatments

Plant material	Age	Zone	Categories (10 plants each) I	II	III
			Number of plants with necrosis		
S. 795	2–3 Yr.	N. Wynaad	8 Rst	not represented	2
S. 795	4–5 Yr.	S. Wynaad	1	not represented	2
Old Coffee	40 Yr.	Nelliampattis	1	not represented	not represented
Old Coffee	50 Yr.	Biligiris	not represented	10	not represented
Old Coffee	30 Yr.	Anamalais	not represented	not represented	10
Kents, S. 795 and S. 288	12 Yr. 8 Yr.	S. Coorg	1 St	not represented	not represented
Kents	30 Yr.	S. Coorg	not represented	1 Rst	not represented
Kents	75 Yr.	S. Coorg	not represented	not represented	2 Stb
S. 795	5 Yr.	Koppa	nil	not represented	not represented
Arabica Sel ?	8 Yr.	Koppa	not represented	1 b	not represented
S. 795	4 Yr.	Koppa	not represented	not represented	2 Stb

Category I — Swabs with B. H. C. in vouge since their recommendation
Category II — Swabs with B. H. C. undertaken for sometime but discontinued
Category III — Swabs not practised
Rst—In root and stem; St—In stem; Stb—In stem; and branch; b—In branch

TABLE IV

Effect of various sequences of B. H. C. swabs on cup quality

Block	Swab sequence	Cup quality 1960	1961
A—	No swab in either seasons—beginn:ng from April 1959 swab.	Very sour	Very poor
B—	No swab in october—beginning from April 1959 swab.	Sour	Very poor
C—	No swab in April—beginning from October 1959 swab.	Bricky (represent 2 swabs,	Sour (represent one swab)
D—	Two swabs—April-May and September-October.	Not tested	Bricky