STUDIES ON THE ORIENTAL BEE (*APIS CERANA* F.) AND ITS MANAGEMENT IN PAKISTAN

By

Nasreen Muzaffar, M.Sc. (Pb.), M. Phil. (QAU)

A thesis

presented to Quaid-i-Azam University in fulfilment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in

Biological Sciences

1988

CONTENTS

CHAPTER I

INTRODUCTION

Economic importance

The oriental bee (Apis cerana F.) produces highly nutritive and immensely valuable honey for human consumption. The other important products rendered by this honeybee are wax and pollen which have innumberable commercial uses. Total honey production marketed in Pakistan was about 250-260 tonnes excluding producer's own consumption (Drescher, 1983). Three other honeybee species (Apis dorsata F., A. florea F. and A. mellifera L.) are also involved in the honeybee fauna of Pakistan, but the oriental bee colonies, being higher in number, produce a fairly large proportion of honey in the country.

The oriental bee has been in wild and semi-wild condition but has a fairly good potential for honey production. It swarmed accessively and did not develop large colony populations required for higher honey yield. The maximum honey yield was reported to be 29 kg per colony/annum in Swat (Jehangir, 1985). Thus there were good prospects for improvement of this bee for higher honey yield.

The beekeepers, except the progressive ones, are using very old honeybee management methods and are not familiar with modern beekeeping technology. Therefore, average honey yield per colony was very low in Pakistan as compared with that of Apis mellifera in advanced countries. Thus modern technology needed to be tested and further adopted for different ecological areas.

Honeybees are known to be the most important pollinating insects. A large number of crops and fruit and forest trees requires or at least benefits from bee-pollination. Among these, alfalfa, clovers (forage), apple, some varieties of citrus, musk-melon, peach, pear, plum, almond (fruit plants), sarson, safflower, some varieties of sunflower (oil-seeds), onion, radish and turnip (vegetables) are often provided honeybees to supplement pollination and to increase their yield in some advanced countries. For example, the beekeepers obtained 30 million dollars as rental fee of their colonies from farmers hiring the bees for their crops to ensure maximum seed set and quality fruit (Mussen, 1987). The populations of insect pollinators particularly those of honeybees were very low in Pakistan as compared with that in other countries (Crane, 1975). Thus it is most important to raise the bee population level for pollination of crops and fruit plants in the country.

Review of previous work

Sir Louis Dane made the first unsuccessful effort for rearing the oriental bee *Apis cerana* in Langstroth hive in the Punjab in 1882-84. Later on he made another effort to keep the bees at Lahore in 1910-11, but the colonies perished due to attack of natural enemies and severe summer heat (Haq, 1969). An apiary was established in the Murree hills in 1930 and another at Faisalabad in 1940 (Haq, loc. cit.). Beekeeping work was also started at Haripur (NWFP) in 1941 (Rabbani, 1981). Since then there had been 2 to 4 beekeeping research stations each in Punjab and NWFP. In Pakistan, studies have been made on the migratory behaviour of bees (Latif et al., 1961a), use of supplemental diets (Latif et al., 1956f, 1957d, 1961b; Qayyum and Aslam, 1960b, 1960e), preference of bees for various sugars (Latif et al., 1958j), artificial insemination (Latif and Haq, 1955a), behaviour of two queen colony (Latif et al., 1956d, 1956e), effect of two or more queens per colony on honey yield and bee strength (Latif and Haq, 1955b; Latif and Hussain, 1955a; Latif et al., 1960d), adoption of multiple-queen system to suppress swarming (Latif et al., 1960c), queen substance (Latif et al., 1957b), controlled mating of queens (Latif et al., 1958h), oviposition stimulants for queen bees (Latif and Hussain, 1955b), effect of hormonal treatment on queen's fecundity (Qayyum and Aslam, 1960c), age of queen and its oviposition (Qayyum and Aslam, 1960f), effect of surplus honey on queen's fecundity (Qayyum and Aslam, 1960a), aggressive behaviour of bees (Latif et al., 1957e), foraging range (Dhaliwal and Sharma, 1974; Cherian and Mahadevan, 1945), weight of bees (Latif et al., 1958f), biometry (Narayanan et al., 1960), effect of temperature on colony development (Qayyum and Aslam, 1960d), different packing materials and colony development (Haq et al., 1961e, 1961g), migratory beekeeping (Makhdoomi et al., 1975, 1976, 1979; Makhdoomi and Khan, 1977; Makhdoomi and Chohan, 1980), effect of repeated honey extractions on total honey yield (Haq and Chohan, 1964), comparative study of various honeys (Latif et al., 1956b; Latif et al., 1960a), pollen analysis of honey (Khan and Bhutta, 1965), relationship between moisture and specific gravity in honey (Haq et al., 1961d), effect of heat on honey granulation (Latif et al., 1958d), storage of honey (Latif et al., 1958e), standarization of beeswax (Latif et al., 1957a), wax extraction and its bleaching (Haq et al., 1961c) and scope of mud-wall hive for bee breeding (Latif et al., 1956g). Most of the information relating to the oriental bee research in Pakistan is available in the form of abstracts in Proceedings of Pakistan Science Conferences except a few detailed published papers.

Information on honey plants has been published by Rahman and Singh (1940, 1941), Rahman (1944), Latif et al.,(1958g), Kohli (1958), Thakar (1962), Haq and Aslam (1962), Haq et al.(1963), Crane (1973), Qayyum and Shahid (1975), Shahid and Qayyum (1977) and Ahmad et al. (1978). Nectar secretions by flowers (Latif et al., 1957f, 1958i), influence of fertilizers on nectar secretion of 'sarson' and 'toria' (Haq et al., 1961h) and size and shape of pollen on bee visits (Latif et al., 1957c) have also been studied. No information was available on economic importance of individual plant species for pollen and nectar production.

Among the natural enemies, the lesser wax moth Achroia grisella (F.) and the greater wax moth Galleria mellonella (L.) are the serious pests of A. cerana and other honeybees in Pakistan (Rahman, 1945b; Latif et al., 1960b; Ahmad, 1981; Ahmad and Muzaffar, 1983), India (Singh, 1975) and many other countries (Thompson, 1953). According to Morse (1978), the control measures of these pests include: (1) killing of larvae after collecting from the colonies; (2) fumigation of drawn combs with chemicals; and (3) storage of the combs below -7°C for five hours. Collection and killing of larvae is not feasible because of high cost of labour and lack of trained personnel. The fumigants are used for stored combs only and not inside the hive with live bees. Moreover, these are not easily available in most of the beekeeping areas in Pakistan. Maintenance of low temperatures for cold storage of the combs has its own limitations. Thus no effective measures are known for the control of these pests in colonies.

A Braconid parasite Apanteles galleriae Wilk. was reared from A. grisella and G. mellonella larvae infesting honeybee colonies from different localities (Ahmad and

Muzaffar, loc. cit.).This parasite is also known to attack G. mellonella in South America (Blanchard, 1936), Mauritius (Wilkinson, 1934) and North Carolina (Anon., 1959), and A. grisella and G. mellonella in Argentina (Cristobal, 1936) and France (Suire, 1933). Thus further studies were required to determine the value of A. galleriae for biological control of wax moths.

The hornets (Vespa spp.) brought about heavy losses to honeybee colonies by feeding on their adults, brood and honey reserves during the crucial floral dearth period extending from July to October. Of these hornets, Vespa orientalis L., V. auraria Sm. (V. velutina Lep. sp. auraria Sm.) (Singh, 1975; Ahmad, 1981), V. basalis Smith (Singh, loc. cit.), V. tropica (L.) (Subbiah and Mahadevan, 1958; Ahmad, loc. cit.), V. velutina pruthii Vecht. and Vespula germanica (F.) (Ahmad, loc. cit.) have been reported attacking honeybees in different areas of the country. The control measures adopted for combating hornets include killing individual hornets with fly flappers or sticks, destruction of their nests, bait trapping, mass poisoning, trapping at the hive entrance and in the apiaries, using protective screens and poultry birds (Matsuura and Skagami, 1973; De Jong, 1978). These methods of control are either expensive or have definite limitations from practical point of view.

The mites Acarapis woodi (Rennie), Tropilaelaps clareae Delfinado and Baker and Varroa jacobsoni Oudemans attack the Asian bee species A. cerana and A. dorsata (Gupta, 1967; Crane, 1968, 1978).

Some bee pathologists consider A. woodi to be a minor pest (Morse, 1978; Bailey, 1981; De Jong et al., 1982; Delfinado-Baker and Baker, 1982b) while some others are of the opinion that it can cause serious losses to honeybee colonies if combined with other diseases, bad weather or poor flowering (Borchert, 1962; Adam, 1968; Bailey, 1969; Wiese, 1980). In Pakistan it has caused tremendous losses to A. cerana colonies since its introduction in 1981. The ectoparasitic mite T. clareae was considered to cause considerable damage to honeybee colonies in Asia and some other countries (Ahmad and Muzaffar, 1984; Delfinado-Baker and Baker, 1982a; Delfinado-Baker et al. 1985; Woyke, 1985a, 1985b; Verma, 1987). The mite Varroa jacobsoni is indigenous to Asia and has been known to cause serious losses to honeybee colonies in several countries of Asia, Europe and America (De Jong et al., 1982; Nyein and Zmarlicki, 1982; Burgett et al., 1983; Nixon, 1983; Koeniger et al., 1983).

Some species of Dicrurus, Lanius, Picus and Pernis have been reported to prey upon honeybees, grasshoppers, locusts, caterpillars, black ants and other Hymenoptera in some areas in Pakistan (Ali and Ripley, 1968, 1970, 1972; Baker, 1924, 1930; Walters, 1980), and Merops have been recorded to attack honeybees at a few locations in Punjab (Ali and Ripley, 1970; Fry, 1984; Latif and Yunus, 1950). However, their degree of predation and distribution were not known in Pakistan.

A. cerana is kept mostly in wall-, log-, and pitcher hives in most of the beekeeping areas particularly some parts of Peshawar, Hazara and Swat Divisions, Murree hills and Azad Kashmir. The beekeepers, except a few progressive ones, are using traditional honeybee management practices. The modern Langstroth hives are very expensive. Therefore, the beekeepers cannot afford to purchase them. Thus an abrupt change to Langstroth hive is not easily acceptable by beekeepers.

Role of honeybees as pollinating agents, and pollination requirements of various crops, fruit trees and vegetables have been investigated (McGregor, 1976). The bees have been found to be necessary for pollination of some fruit plants (Rahman and Singh, 1942, 1943, 1944; Latif and Qayyum, 1956; Haq et al., 1961f), 'berseem' (Latif et al., 1956c; Narayanan et al., 1961), 'toria' and 'sarson' (Mohammad, 1935; Rahman, 1940; Latif et al. 1958b, 1958c, 1960e), some varieties of citrus (Haq et al., 1978) and alfalfa (Ahmad, 1976), number of colonies required per unit area for pollination of 'toria' (Rahman, 1945a; Latif et al., 1958a) and vegetables, etc. (Haq et al.,1961a, 1961b; Latif et al., 1956a). No investigation has been carried out to determine the effect of honeybees on pollination of the new varieties of various entomophilous crops presently grown in the country.

A little is known about honeybee pollination and pest management in Brassica campestris crops. There are more than sixty species of insect pests recorded from rape and mustard (Brassica spp.) crops in Pakistan (Alam et al., 1969; Haq, 1968; Khan et al., 1978; Makhdoomi and Bajwa, 1978). Among these, the aphid Rhopalosiphum erysimi K., Brevicoryne brassicae L. and Myzus persicae (Sulz.) are known to attack the sarson Brassica campestris crop and are cosmopolitan. Of these, R. erysimi is most serious pest and is uniformly distributed almost throughout the sarson belts in Pakistan (Bodenheimer and Swirski, 1957; Ghani, 1971). Insect pests mainly aphids and diseases are known to cause 33 to 40% losses in seed yield of rape and mustard, and their seed yield can be increased from 546 kg to 822-914 kg per hectare by plant protection measures (Anon., 1975). Furthermore, pesticide spray has been a serious problem for honeybees. Rape and mustard crops are most important honeybee flora. Insect pests particularly aphids bring about significant losses in seed yield of these crops. Thus insect pest and pollinator management methods need to be further improved for protection of honeybees and other inseet pollinators.

From the foregoing review of literature it is evident that sketchy information is available on management of A. cerana in Pakistan. Soil and climate are quite suitable for beekeeping in the country. Honeybee flora is fairly abundant. Thus improvement of the oriental bee, development of better technology for honey production, control of pests and diseases, devising low cost beekeeping equipment and determination of pollination requirement of different varieties of entomophilous crops were most essential for inducing the farmers and other persons to adopt it as cottage industry or to enter successfully into the beekeeping profession. Therefore, detailed studies were made on (1) distribution and competition of A. cerana with other species, supplemental feeding, swarming, absconding, migration and other miscellaneous manipulations for development of integrated management of colonies for high honey yield; (2) honeybee flora and insect and plant sources of honeydew honey; (3) pests and diseases and their control; (4) low cost hives; (5) honeybee pollination of crops; and (6) insect pest and pollinator management of Brassica crops for protection of honeybees from pesticide losses, so as to develop beekeeping on sound scientific lines in Pakistan.

CHAPTER II

MATERIAL AND METHODS

A survey was conducted to determine the distribution of *Apis cerana* and other species of *Apis* in different areas in the country. Studies were carried out on colony development and honey production potential in private and project's apiaries in different floral belts. The foraging activity of bees was investigated in the plains, foot-hills and hills. The number of bees with pollen and possibly nectar (without pollen) entering into the colonies were counted for each 30 minutes throughout the day for determining their maximum activity time on flowers of different plant species.

The effect of space reduction on honey yield was studied by removing some frames (without bees) from the brood chamber at the beginning of honey flow period so that each colony had 1 to 3 frames lesser than that required by bees present in the hive. The super containing drawn combs was simultaneously placed over the brood chamber of the respective colony. The space available to bees in the brood chamber was insufficient. The bees were thus forced to move into the supers.

Supplemental feeds on weight basis included: (1) sugar syrup (sugar and water 1:1); (2) plain candy (sugar and honey 2:1); (3) yeast candy (sugar, honey and yeast 2:2:1) and; (4) brewer's yeast (40.5% crude protein, 50% other extract and 9.5% water).

Honey yield data were based on colonies migrated in accordance with the schedules. The colonies of different strains were placed separately during breeding season so as to keep the drones confined to their respective strains.

The honeybee queens were produced by using artificial queen cups in the selected colonies. Some two hundred colonies were examined in Haripur, Hasan Abdal, Wah and Islamabad areas and 12 best colonies were selected for queen production. The queens were produced and mated with drones of already selected stock in isolated area. The colonies headed by these queens were tested for honey yield, stinging, and swarming habits, ability to build population and resistance to cold and heat.

The pollen, nectar or honeydew sources of A. cerana were observed by the method reported by Singh (1975). Flowering periods of the plants were observed in the fields. Floral preferences of bees were studied during dearth period. The nectar and pollen collecting activities of the bees were recorded on flowers by counting their numbers within an iron grid measuring 20 X 20 cm on 400 sq cm of different plants for 5 minutes at one hour interval from 0600 to 1800 hours during July-August.

The incidence of wax moths Galleria mellonella and Achroia grisella, and the effect of releases of the parasite Apanteles galleriae were studied in the colonies of the project and private beekeepers.

The adult hornets (Vespa spp.) were captured from the apiaries with an insect net and their numbers were calculated per man hour. For natural enemies, some 46 hornet nests were removed by covering them with cloth bags at night. The adult hornets were killed by pouring 4-5 ml anaesthetic ether in each bag placed in large air tight wooden box. The dead brood and adults were examined for parasites and predators.

The mite Pyemotes ventricosus was collected from larvae of Vespa velutina pruthii. It was reared on G. mellonella and Sitotroga cerealella larvae. G. mellonella was mass produced in glass jars on powdered beeswax while S. cerealella was cultured in chimneys put over the glass dishes containing maize grains. Biological observations on the mite were taken in the laboratory (26° ± 2°C). For testing its biocontrol value, some adult hornets were captured with insect net at the apiaries. These were released in glass jars covered with muslin cloth and fed on sugar solution, honey and minced meat. Before sunset, these hornets were taken out from the glass jars placed in queen marking cages and were infected with 4-5 mites by using sable-hair brush. The infected adults were released before dusk. This operation was continued for 7 days, and some 150-180 infected adults were released at each of the three different apiary sites at Islamabad, Rawalpindi and Haripur during May. Another experiment was conducted by increasing the number of mites (7-8 individuals) per host and by releasing the infected adults (250 hornets) at Khanpur in 12 days. The effectiveness of the mite was noted by examining hornet nests after 30 and 45 days.

The efficacy of strychnine hydrochloride and zinc phosphide for the control of hornets was determined by application of the poisoned baits by the above mentioned technique used for infecting hornets with the mite. Some 30-50 adult hornets (Vespa basalis, V. orientalis and V.

velutina) were captured daily with insect net at each apiary. These were kept in glass jars and fed as stated in afore-mentioned paragraph. Before sunset, these hornets were taken out from the glass jars and placed in queen marking cages. One drop of the chemical mixed with honey (ratio 1:20) was poured with the dropper on the thorax of each hornet. These adults treated with poisoned bait were released before dusk. The operation was continued for 8 days and some 200-300 treated adults were released at each of the nine sites in Islamabad-Rawalpindi areas. Mortality of hornets by these chemicals was studied by counting the dead adults on the ground under the nests daily. The alive adults were counted by removing the nests, 3-4 days after the end of experiment, in a large gunny bag at night, putting the nest in a barrel and letting the adult hornets come out through a glass tube to a jar containing 5% formaldehide. The dead hornets (adults and brood) were estimated by breaking the nests. The results were compared with normal nests (control) at 4-8 km distance.

Annual fluctuation of the acarine mite, Acarapis woodi, infestation was studied in 12 colonies, 4 colonies each having low, medium and high infestation. The level of infestation in each colony was measured fortnightly by sampling 100 bees and counting the mites carried by them in each sample.

For detection of the acarine mite, a number of 30 worker bees were sampled from the combs of each selected colony in the apiary and from the entrance of the feral colonies. The bees were dissected and their tracheae examined under a binocular microscope. For general detection of the mite, the bees were immersed in lactic acid followed by an alcohol wash.

The alcohol in each sample vial was filtered through a filter paper dish which was then examined under the microscope for the mites washed from the bodies of bees.

Degree of infestation of bee brood by Tropilaelaps clareae and Varroa jacobsoni was determined by opening cappings of 60-100 brood cells and counting the mites. Incidence of the mites on adult worker bees was studied before and after the treatment. Some 200-400 workers were brushed out from brood combs into 75 percent alcohol put in a container or tray having a fine sieve fitted inside the container. The bees above the sieve were removed individually with the forceps. The alcohol was filtered for separation of mites that have passed through the sieve and the mites were counted for recording the degree of infestation.

To detect the numbers of mites dead and fallen on the bottom of the hive, the bottom board was covered with a butter paper and a screen (30 x 24 cm) was placed above it at least 2 cm beneath the combs. The mites were collected from the butter paper and counted for record.

For observations on life span of T. clareae, the mite adults were collected by putting a needle in front of the running mite on brood combs until the mite ascended on it. Then the mite was transferred to sheet of white paper. On the paper sheet, the mites readily mounted bees or pupae which were offered to them. The bees or pupae together with the mites were transferred into the experimental containers.The hive bees were used for these trials. Apis cerana and A. mellifera bees were taken from their hives. A. mellifera had been imported from Australia in 1978. A. cerana bees were collected from hived indigenous colonies and A. dorsata bees from a feral colony. The bees were taken from the curtain (layer of bees covering the comb) during the evening hours. A transparent PVC container was used as a test cage. The upper portion of the cage was coated with beeswax. A feeder with sugar (sugar and water 1:1) was placed on the upper side. The bottom side was made out of a wire screen (mesh 3 x 3 mm) which was placed on paper covered with a thick layer of white petroleum jelly. Mites which fell from the bees got entangled on the sticky surface of the paper and were counted easily.

For some further tests, glass vials of 20 cm^3 with a tight plastic lid were used and a single mite was kept without or together with 1 pupa. The experiments were performed inside a room (26° ± 4°C). The cages were examined on a regular basis only after an initial period of 5 to 14 hours during which 40% to 80% of T. clareae died. Then the cages were observed every two hours, and all mites previously caught on vaseline were removed and counted. A sample of dead mites from the cages was collected and carefully examined for injuries.

Some indigenous material such as clay, wheat straw, glauconite ('multani mitti'), newspapers, wheat flour, dry agave leaves, rice husk and rice husk ash were used to construct hives. The material on weight basis included (1) clay and chopped wheat straw (CCWS) in the ratio of 8:1; (2) glauconite, newspapers and fine wheat flour (GNPWF) in the ratio of 5:1:1; (3) glauconite, newspapers, fine wheat flour and dry agave leaves (GNPWFAL) in the ratio of 16:4:2:1; (4) cement, sand and newspapers (CSNP) in the ratio of 2:5:2; (5) clay and rice husk (CRH) in the ratio of 15:1; and (6) clay and rice husk ash (CRHA) in the ratio of 25:1. These constituents were mixed with sufficient quantity of water and prepared to form fudge. It was difficult to mix newspapers. Therefore, these were torn into pieces, heated in water (100°C) and mixed well. This material was used to construct brood chambers, shallow supers and outer covers having dimensions of Langstroth hives. The colonies of the oriental bee A. cerana (5 frame bees) were kept in hives of all these types using Langstroth frames in December, 1986. These hives, except those of cement, were covered with plastic sheets to protect them from rain. The Langstroth hive was used as control. The colonies were shifted to short distances depending upon the availability of flora. The honey yield of the colonies having equal strength was studied for evaluation of these hives.

Six types of frames were made and tried in A. cerana colonies in clay hives. These included: (1) a wooden piece tied with a triangular comb foundation sheet supported with 1 mm thick wire (WPTCFS); (2) standard full depth frames with 1 mm thick wire covered with wax (SFDWW); (3) super frames with 1 mm thick wire covered with wax (SFWW); (4) standard full depth frames with plastic or cloth sheets (having holes each of ½ cm diameter at 2 cm distance with 70 g wax and passed through comb foundation machine (SFDFPSW); (5) standard full depth Langstroth frames with normal comb foundation sheets (SFDFNCFS); and (6) cavities in walls without frames (CWWOF). The colonies provided with the frames at No. 1, 4 and 5 were supplied each with two litres sugar syrup (sugar and water 1:1 by weight) and at No. 2 and 3 were fed 3½ and 3 litre sugar syrup, respectively, at the time of placing the package bees in these hives.

Effect of honeybee pollination on fruit/seed setting was studied by providing 2 to 5 colonies per ha. These studies were conducted in the field: (1) by covering flowers/ plants without bees in mosquito net (2) covering flowers/ plants with honeybees in mosquito net, and (3) by leaving the flowers open for visits of honeybees and other insect pollinators. Observations were taken on fruit setting and yield of selfed and honeybee pollinated plants. The treatments were randomized to remove the row and column effects.

To determine the effect of insect pollinators on seed yield, 30 rape (Brassica campestris var. sarson) plants of almost uniform size were selected at the commencement of flowering at Mandra (Rawalpindi) in second week of December, 1985. These plants were isolated by covering them with muslin cloth cages. Then 8 honeybee colonies, 4 each of both A. cerana and A. mellifera, were placed in a rape crop area of about 4 ha. At the end of flowering, in the second week of February, 30 unisolated, normally developed palnts of almost uniform size which had been visited by bees were selected from the same field. The number of pods were counted on both open pollinated and isolated plants. On the basis of pod number, the plants of both groups were arrayed in descending order of the number of fruits. The range in each group was divided into ten sub-divisions. Single plants having almost equal numbers of pods were selected from each corresponding sub-division of both groups. Ten plants from each group were selected in such a way that the total number of pods were almost equal on all plants in the group. Two plants of almost equal number of fruits were selected from each set so as to prepare an array of plants in descending order of fruiting capacity.

Pirimicarb (50% D.P.), Permethrin (25% E.C.) and Monocrotophos (20% E.C.), which have different duration of residual effect, were tried to work out their suitable doses in Mandra area where the crop is grown in more than 1000 ha. Finally Pirimicarb 250 g a.i. , Permethrin 50 g a.i. and 100 g a.i. and Monocrotophos 500 g a.i. were sprayed with knapsack sprayer by using 220 litres water per hectare. Each dose was tried in an area of 0.4-0.5 hectare.

As aphid infestation develops from foci and thereafter spreads throughout the field, only infested patches were sprayed with knapsack sprayer. The plot size was one ha but 2-3 ha area around each plot was sprayed with the same dose. Spraying of the infested patches required about 1/5 to 1/4 pesticide dose (50 g Pirimicarb, 12.5 g and 20 g Permethrin and 100 g Monocrotophos a.i. per ha) in 45-54 litres of water in third week of December (first spraying), 1/4 to 1/3 pesticide dose (83.0 g Pirimicarb, 16.5 and 25 g Permethrin and 125 g Monocrotophos a.i. per ha) in 54-72 litres of water in the first week fo January (second spraying), and 1/3 to 2/5 pesticide dose (100 g Pirimicarb, 20 and 33 g Permethrin and 166 g Monocrotophos a.i. per ha) in 72-90 litres of water in third week of January (third spraying). These three sprayings of infested patches of crop in one ha were accomplished with the pesticide dose to be used for spraying of the whole one ha field of the crop.

Mortality of aphids was studied by counting their number per 30 plants before treatment and 4 days after spraying. Incidence of the parasites, Diaeretiella rapae and Aphidius matricariae, of aphids was investigated in samples each of 800 aphids collected before treatment and 4 and 8 days after spraying. The effect of insecticides on predators Coccinella septempunctata, Scymnus nubilus, Chrysoperla carnea and Orius sp. which commonly occurred in the crop was determined by collecting from the nearby fields and adding a large number of these in equal numbers in each plot and by counting their numbers associated with almost uniform groups of host individuals in each sample ranging from 3,000 to 4,000 aphids. The effect of insecticides on the pollinating fauna was observed daily by counting the number of dead insect pollinators in an area of one m^2 at 20 places in the centre of sprayed plots for 7 days.

CHAPTER III

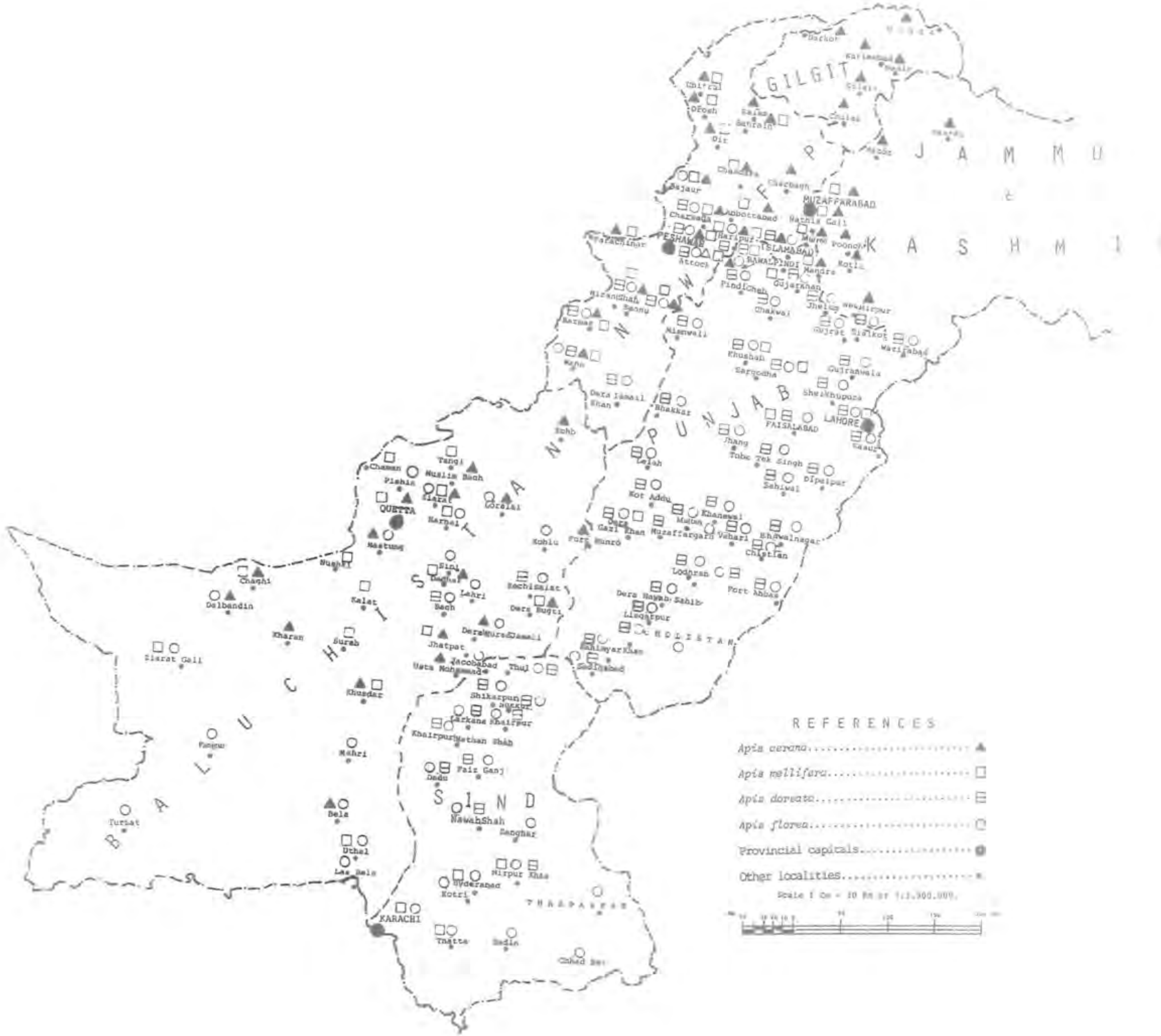
MANAGEMENT OF COLONIES

1. DISTRIBUTION OF APIS CERANA F. AND ITS COMPETITION WITH OTHER APIS SPP.*

Apis cerana F., *A. dorsata* F., *A. florea* F. and *A. mellifera* L. occur in Pakistan, but little information was available on their distribution in different ecological areas in the country. Gassparian (1977) has reported that *A. cerana* was brought by some farmers into Iran from Baluchistan(Pakistan) centuries ago. He further stated that some natural migration of this bee did occur gradually in the past and has been proven by fossil records. Presently, there are about 30,000-35,000 colonies of *A. cerana*, 55,000-65,000 of *A. dorsata*, about 13,000 of *A. mellifera* and thousands of *A. florea* in Pakistan. These four honeybee species overlap in distribution and seem to compete with each other in some areas in the country.

A survey for *Apis* spp. was made in various parts of the country. The distribution of these species is presented in Fig.1. *A. cerana* is mainly found in the hills and foot-hills. Some beekeepers migrate the colonies of this bee to different areas in the plains. *A. dorsata* wild colonies occur almost throughout the plains, foot-hills and small hills (>1200 m height). *A. florea* covers almost all the distribution areas of *A. dorsata* including coastal, sub-coastal and semi-desert areas, plains, foot-hills and valleys in the small hills.

*Paper accepted, letter attached, appendix I.


GILGIT
JAMMU
&
KASHMIR
N. W. F. P.
PUNJAB
BALUCHISTAN
SIND
CHOLISTAN
MUZAFFARABAD
PESHAWAR
ISLAMABAD
RAWALPINDI
FAISALABAD
LAHORE
QUETTA
KARACHI
Chitral
Bajaur
Charsada
Abbottabad
Attock
Kotli
Gujarkhan
Chakwal
Mianwali
Jhelum
Gujrat
Sialkot
Khushab
Sargodha
Gujranwala
Sheikhupura
Bannu
Dera Ismail Khan
Bhakkar
Jhang
Kasur
Leiah
Toba Tek Singh
Sahiwal
Dipalpur
Kot Addu
Khanewal
Multan
Muzaffargarh
Vehari
Bahawalnagar
Chishtian
Lodhran
Fort Abbas
Liaqatpur
Fort Munro
Kohlu
Chaman
Pishin
Ziarat
Harnai
Loralai
Mastung
Nushki
Chaghi
Dalbandin
Kalat
Kharan
Surab
Khuzdar
Ziarat Gali
Sibi
Lehri
Dera Bugti
Jhatpat
Jacobabad
Shikarpur
Larkana
Khairpur
Dadu
Nawabshah
Sanghar
Hyderabad
Kotri
Mirpur Khas
Thatta
Badin
Turbat
Bela
Uthal
Las Bela
Panjgur
REFERENCES
Apis cerana
Apis mellifera
Apis dorsata
Apis florea
Provincial capitals
Other localities

The recently introduced A. mellifera is found throughout the distribution area of all the three local species.

Studies conducted on the relative abundance of honeybees showed that A. cerana, A. mellifera, A. dorsata and A. florea foraged on clovers in the ratio of 53:103:1:40 at Haripur, 9:200:7:12 at Islamabad, 15:8:0:0 at Murree and 0:0: 35:28 at Sargodha in April 1987 (based on counts in an area of 1 m^2 per 4 hours). This indicates dominance of various species in different areas.

The four honeybee species were present in the foot-hill areas of Rawalpindi and Islamabad during September-May. Thereafter, almost all the wild colonies of A. cerana migrated to the hills (Murree, Abbottabad) resulting in a remarkable decrease in its population due to shortage of flora in the second half of the year. A. dorsata migrated to the plains of Punjab, Sind and some parts of Baluchistan and NWFP depending upon the availability of flora. A. florea colonies remained in the plains,coastal and sub-coastal areas and foot-hills throughout the year, while A. cerana and A. mellifera in modern hives faced dearth period in the plains and foot-hills and were shifted to the hills where wild bee flora provided nectar and pollen to bees during late summer and in autumn.

A great variation occurred in the ecological conditions in different areas in Pakistan. The agricultural system provides good bee forage depending upon the climatic factors.The temperature, rainfall and vegetaion are shown in Figs.2-5 (Kureshy, 1978). These bees were found to visit hundreds of plant species which provide them nectar and pollen and that bee flora was different at various locations owing to variation in ecological

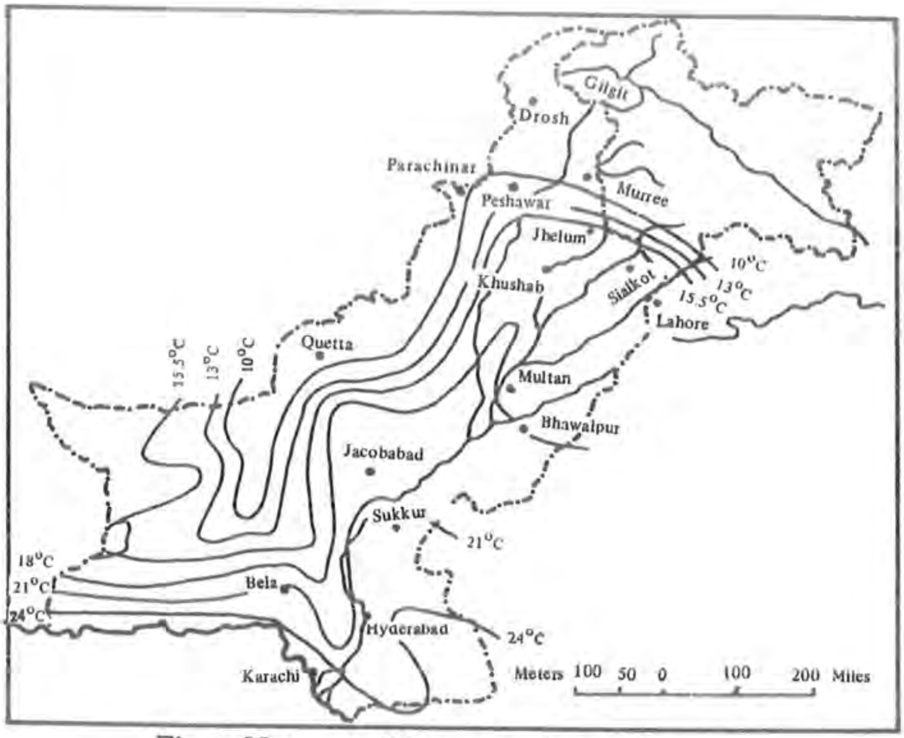


Fig. 2 . Mean monthly temperature in January

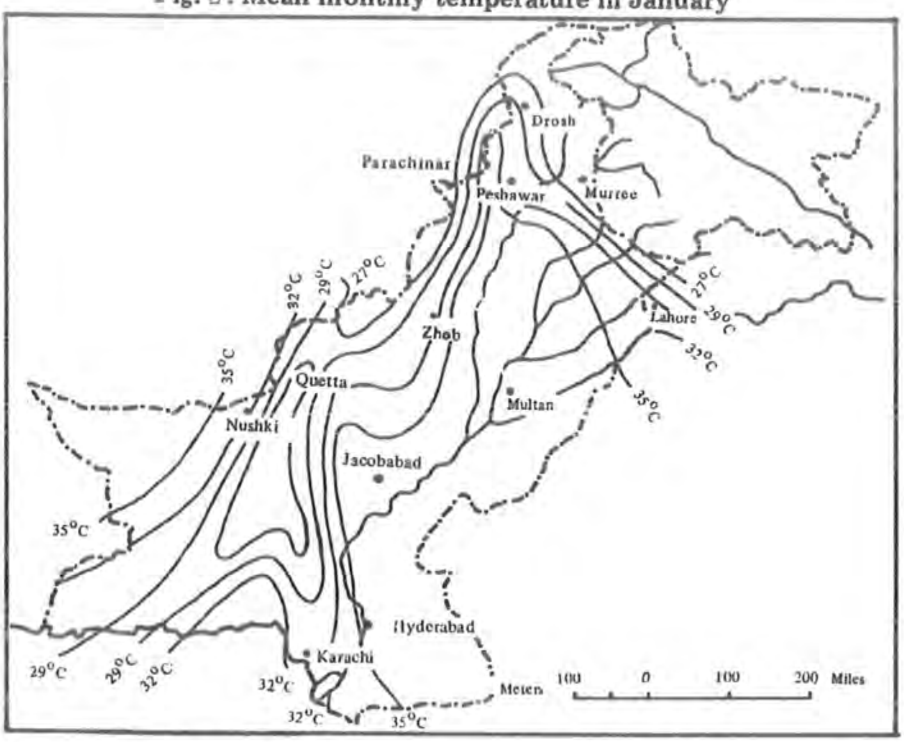


Fig. 3 . Mean monthly temperature in July

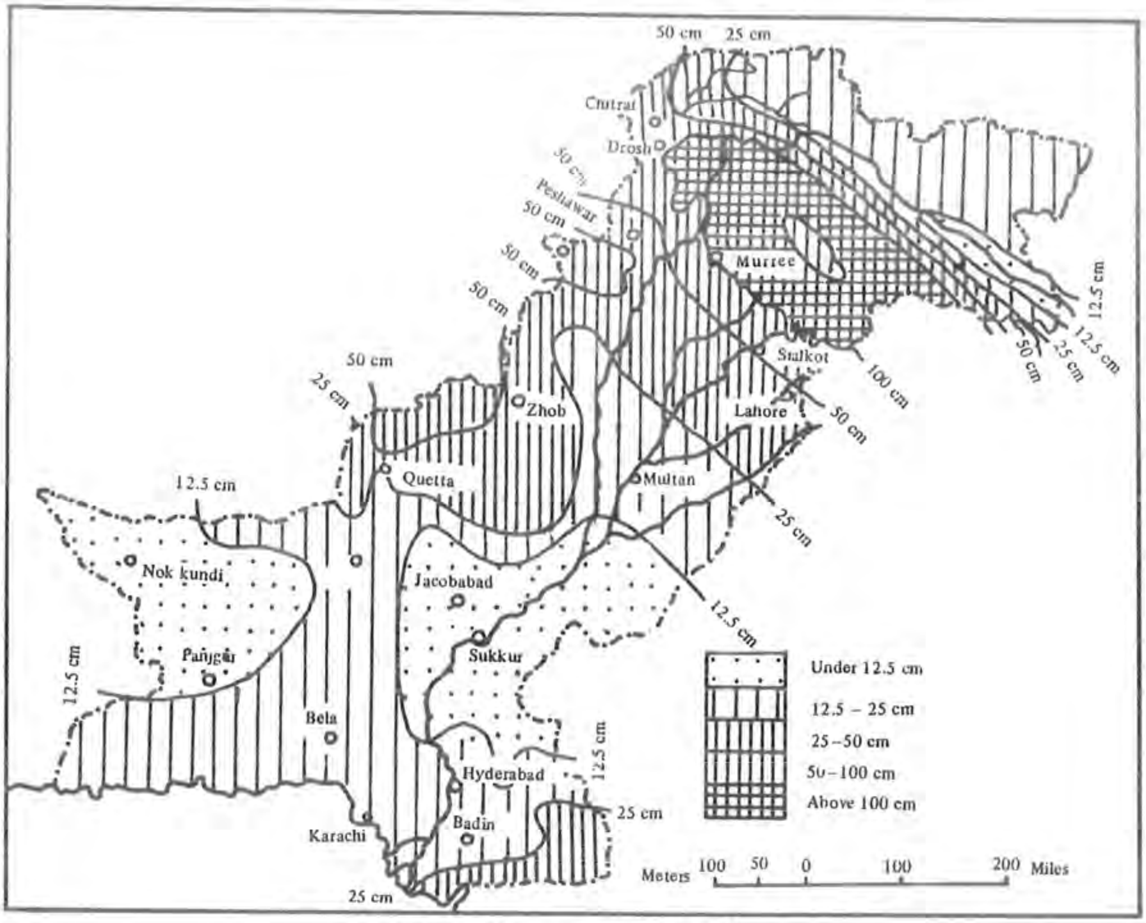


Fig. 4. Mean annual rainfall

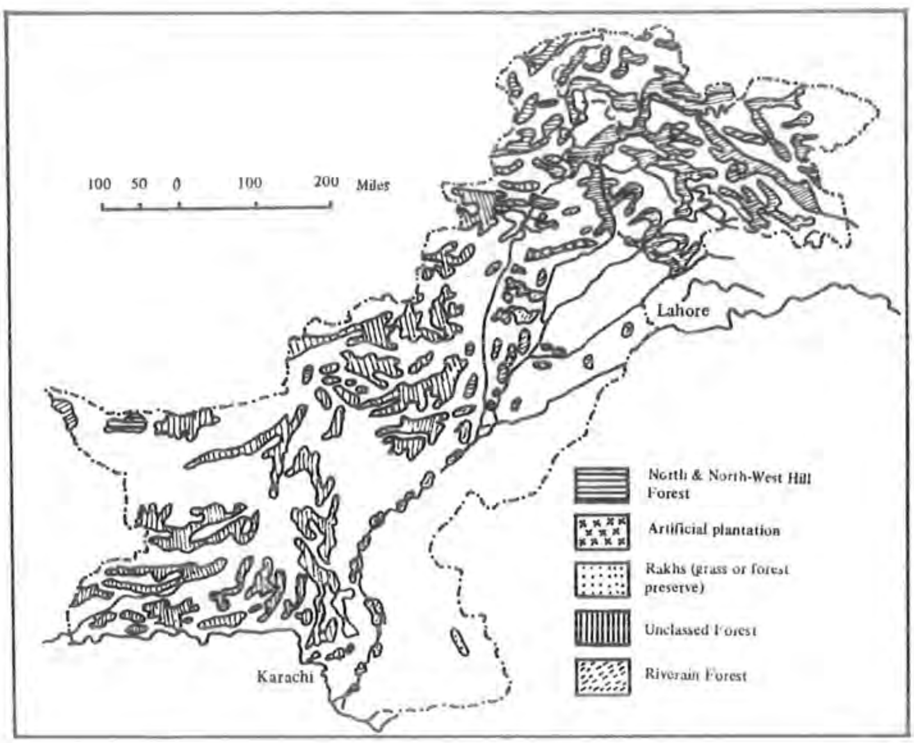


Fig. 5. Natural vegetation

conditions.

According to Koeniger and Vorwohl (1979), some specific characteristics which enable A. cerana and the three other Apis spp. to coexist in the same area include competition for food, nesting sites and mating. The competition for food is avoided or reduced by species-specific adaptations to different groups of flowers and that the disadvantage of a short flight range of the small bee (A. florea) is compensated by a more aggressive behaviour of its foragers towards other Apis spp. Present studies on foraging behaviour of the bees showed that A. dorsata preferred large flowers of those plants which produced larger quantities of nectar and pollen. This bee stayed in areas where nectar and pollen were abundant. Flora visited by A. cerana and A. mellifera were almost the same. These bees existed with little lesser quantity of nectar and pollen as compared with that of A. dorsata. A. florea required the least amount of food. It was capable of getting nectar and pollen from very small flowers, and has been found to occur in habitats with small nectar and pollen sources where other honeybee species could not exist.

As far as competition in mating, Butler et al. (1967) have found that the main component of the sex attractant in all honeybees is 9-oxo-2 decenoic acid. Production of drones starts early in A. cerana in February and in A. mellifera in March-April in the foot-hill areas. The drones of A. cerana are attracted by queens of A. mellifera and vice versa casuing losses due to non-fertilization of queens of these honeybees. A. cerana, A. florea and A. dorsata are known to avoid this competition by using separate species-specific times of day for their mating flights (Koeniger and Wyjajagunasekara, 1976). But present studies showed that presence of A. cerana and A. mellifera creates serious mating problem for each other at some locations in the country, and A. cerana populations were adversely affected in areas where A. mellifera drones were abundant.

As regards nesting behaviour, wild A. cerana bees nest in tree trunks, rocks and cavities in walls of houses. A. mellifera and A. cerana are kept in modern hives in the apiaries. A. dorsata nests on branches or trunks of trees or on rocks. A. florea builds combs around a thin twig or bush. These species do not seem to compete with each other for nesting sites.

The population densities of Apis spp. differ in different areas depending upon the availability of flora. The competition for mating and availability of nectar and pollen appears to be important factor for occurrence and abundance of these species in different parts of the country.

2. WINTER MIGRATION*

According to Latif et al. (1961 a), A. cerana colonies migrated from higher (2000 m) to lower (600 m) altitudes from September to November and in reverse direction from March to June. During the present studies migration of this species was observed from the Murree hills to Islamabad and Rawalpindi during October-December. Some multiple-queen colonies were seen in which the queens were individually held in clusters of workers, seemingly protected by their own attendants. Thus it indicated that bees of several small colonies had gathered to form a larger colony for their protection from winter hazards.

*Paper accepted, letter attached, appendix II.

FIG. 6. THE WORKERS OF MULTIPLE-QUEEN COLONY FORMING CLUSTER AROUND THE QUEENS

A colony of 9-10 frame bee strength settled in a building at Islamabad in the last week of November. It had 14 queens each encircled by at least 30-90 bees having appearance of small ball. The colony was collected and placed in Langstroth hive. Some of the queens got separated temporarily from the main colony and dropped on the ground. The multiple-queen colony was fed 50 percent sugar solution. Daily observations showed that there appeared no chance of free movement of the queens in the colony. The queens clustered with workers sometimes fell on the bottom board and were again carried to the frames.

After a few days, five queens were isolated individually in package boxes. Each queen was provided with one frame bees from the main colony. The attendant bees in these single-queen colonies did not let their queens move freely even after four days. These workers were sprayed with 50 percent sugar solution to get their attention diverted from the queen. This produced positive effect on the bees which separated themselves from each other. Thus all the queens were freed and apparently started normal functions. Two of the five colonies were rendered queenless by bees of the main colony within 24 hours after spraying sugar solution. The remaining nine-queen colony was kept under observation. Three queens died in the clusters each after second, fourth and seventh day, respectively, possibly owing to suffocation or lack of proper nutrition. Thereafter six surviving queens were isloated in separate queen cages for 5 hours. These were re-introduced in their parent hive one by one at 5 minutes intervals. After half an hour, one queen was found performing normal functions; another was dead, and the rest four were lightly encircled by the bees. On spraying sugar syrup twice at an interval of three hours, another queen was freed. But it was killed within 2 hours after last spray. The colony was then divided and each of the three queens were given one frame bees in small boxes packed with wheat straw. The queens started functioning normally. Some 48 hours later, the bees of the three boxes absconded, leaving the queens (having clipped wings) in their respective boxes. They got united with another colony of 2-3 frame bee population. It seemed that colony population dwindled due to low temperatures and dearth of flora in winter. The decrease in bee population possibly induced this type of behaviour leading to formation of multiple-queen colony. It appears that some weak colonies possibly united and overwintered in this manner.

Observations were made in an apiary comprising 23 hives having 9 colonies with 4 frame bee population, 8 with 3 frame bees and 6 with 2 to 2.5 frame bees placed in sarson crop at Islamabad in early November. Some single or multiple-queen swarms settled near the apiary on a tree and sometimes entered in empty hives and also inside those having bees in them. At one time bees of 2 hives and at other time bees of 5 hives having smaller bee strength (2-4 frame bees) left their brood and food reserves and united with the winter swarm to form a large colony. The wings of queens of wild colonies in all the hives in the apiary were clipped to check absconding. However, the incoming colonies induced the bees of most of the hives to leave their clipped queens,and united in the main swarm. Such colonies were dislodged and put back in the hive providing one queen each in a queen cage. The bees, because of mixing, had lost identity of their own queen. Many winged queens located in the swarms were also clipped and supplied to queenless colonies. However, 17 queens died in or near their hives owing to their desertion by bees, many of which had flown away with the wild swarm. This sort of bee behaviour was observed during November. Consequently the surviving 6 colonies had only 1 to 2 frame bees. Thus the colonies suffered appreciably not only because of mortality of a number of queens but also owing to union of the bees of the hives with the swarms. This behaviour of bees is apparently helpful for maintaining better colony strength for over wintering of weak wild colonies and survival of vigorous queens.

3. ANNIHILATION OF WILD COLONIES

The wild colonies of *A. cerana* had variable populations in Marghalla area. Some of these reduced their strength and perished during summer or autumn. Although shortage of nectar and pollen seemed to be the reason for the death of the colonies, but it was found that some abnormally smaller queens failed to lay sufficient number of eggs and could not maintain their colonies. Therefore, such queens were studied from cell-stage to the death of the colony.

In Marghalla area, swarming occurred during January-February. It was found that there was marked difference in the size of queen cells in some colonies. The colonies having larger population of bees had comparatively larger queen cells while those having very small populations had mostly smaller queen cells. It seemed that the size of the queen cell is dependent, to some extent, on bee strength of a colony and availability of nectar and pollen.

To study the effects of bee strength on the size of queen cells and queens, two colonies each having about 5,000-6,000 bees and the other two each with 30,000-35,000 bees were selected for queen production in March 1987. The colony having 5000-6000 bees occurred in an area having little flora. The brood had been almost depleted in them and there were little food reserves in their combs. The other two fairly populous colonies had sufficient flora in their vicinities, and they had large quantity of nectar and pollen in their combs. Ambient temperature was in the range of 13° -28°C during the day. The length of capped queen cells varied considerably in these colonies. However, they were mostly subnormal in small colonies and none were longer than 14 mm. Some 15 such cells were found in two colonies having 5000-6000 bees. The colonies that had 30,000-35,000 bees produced 13 queen cells of comparatively larger size and some queens emerged from these were much better-built than those produced from small colonies. It appeared that smaller queens produced from subnormal queen cells were due to lack of nurse bees in small colonies (thickness of thorax 3.8-4.0 mm in small queens as compared with 4.2-4.5 mm in normal queens).

Two swarms headed by queens produced from the small colonies were studied for their brood rearing abilities. Although they laid a small number of eggs yet the colonies flourished satisfactorily from April to mid-June. Thereafter, the colonies were broodless; the bee strength dwindled; and the colonies became queenless in the first and fourth weeks of July. The number of bees at that time ranged from 4000 to 5000 per colony. This indicates that the queens produced from such subnormal cells laid a lesser number of eggs and could not increase the bee strength of the colony. The dilapidation of subnormal queens possibly resulted in fairly high reduction in the number of colonies in Marghalla area during July-September.

4. FORAGING ACTIVITY

Foraging activity of *A. cerana* bees was noted on some crops and fruit and forest trees. Counts of honeybees visiting the flowers per one square meter area were made throughout the day (sunrise to sunset). The names of plant species, blooming period, maximum bee activity time and number of foragers visiting plants per hour (h) in one square meter area at various localities during different months are given in Table 1.

Table 1

Maximum bee activity time on different flora

Name of flora	Blooming period	Max. activity period (h)	Av. No.of foragers/h	
			Active period	Rest of the day
Eriobotrya japonica	Nov.-Jan.	10.00-13.00	41	23
Brassica campestris	Jan.-Mar.	9.00-11.30	43	27
Acacia modesta	Apr.-May	9.00-11.30	35	20
Trifolium alexandrianum	May -Jun.	7.30-13.30	68	50
Zea mays	Jul.-Aug.	8.00-13.30	29	11
Plectranthus rugosus	Sep.-Oct.	10.00-11.30	30	12
Callistemon citrinus	Mar.-Apr.	6.00-12.30	39	14
Pyrus communis	Feb.-Mar.	7.00-11.00	38	12
Prunus persica	Feb.-Mar.	9.00-12.30	51	23
Prunus bokhariensis	Feb.-Mar.	8.30-11.30	70	26

It appears that bee activity was considerably high on different crops/plants during first half of the day possibly owing to availability of pollen and nectar. The density of bees varied at different locations depending upon the relative abundance of nectar and pollen.

The behaviour of honeybees for pollen collection was studied in sarson fields at Mandra. Counts of pollen collecting bees were taken from second week of February (sarson in full bloom) to first week of March 1987 (sarson flora exhausted) at weekly intervals. It was found that among the pollen collecting bees, 84-89% carried pollen load of sarson plants and 11-16% pollen of some weed plants in February; and 81-87% sarson pollen and 13-19% weed pollen in March. 'Maina' Medicago polymorpha and 'senji'(Melilotus indica) were fairly common in sarson fields and these plants were in full bloom at that time. But later on when there were no sarson flowers, the bee activity again increased and some 79-89% honeybees were bringing pollen from 'maina' and 'senji'. This indicates that honeybees tend to forage on flowers of a single species and continue to collect pollen from the same plant species they initially forage on so long as the food was available. This conforms to the observations reported by Clements and Long (1923) on Apis mellifera.

5. ALTERATION OF FRAMES AND ITS IMPACT ON HONEY YIELD

Honeybee management includes various practices which contribute to the development of colonies and production of higher honey yield. The general arrangement of bee frames in the hive is also an important practice in honeybee management. The bees are known to do maximum work on the frames in the middle of the bee hive. Keeping in view this behaviour of the bees an experiment was conducted in which the positions of the frames in the colony were changed after different intervals in the evening during the honey flow period (Table 2).

Table 2

Different positions of frames in the hive

Position	Frame number									
I	1	2	3	4	5	6	7	8	9	10
II	2	3	4	5	1	10	6	7	8	9
III	3	4	5	1	2	9	10	6	7	8
IV	4	5	1	2	3	8	9	10	6	7
V	5	1	2	3	4	7	8	9	10	6

The treatments (changes in position of the frames) included: (T1) the position of the frames changed and data recorded after every four days; (T2) the position of the frames changed and data recorded after every eight days; (C1) control i.e. no change in the position of the frames and data recorded after every four days, and (C2) control i.e. no change in the position of the frames and data recorded after every eight days. The experiment was replicated four times. Data were recoreded for the amount of pollen and honey in the frames before every changed position. The effects of changes in the frame position on pollen and honey collection are presented in Table 3 and the rates of increase in the amount of pollen and honey are shown graphically in Figures 7 and 8.

Table 3

Average number of pollen and honey frames per colony before each changed frame position in different treatments

Treatment	Number of frames at different position				
	I	II	III	IV	V
Pollen					
T1	0.7	0.78	0.81	0.88	1.24
T2	0.33	0.49	0.53	0.85	0.86
C1	0.83	0.96	1.02	1.05	1.03
C2	0.77	0.84	0.83	0.92	1.41
Honey					
T1	2.29	2.48	2.55	2.62	2.78
T2	2.62	3.56	3.85	4.66	5.41
C1	3.00	3.34	3.76	3.90	4.20
C2	1.95	2.25	2.58	2.98	3.36

A change in frame position after every 4 days (T1) increased pollen collection by 77.5 percent over its initial position as compared with 159 percent in frames changed after 8 days (T2). The increase in C1 and C2 was 30.9 percent and 83.8 percent, respectively. The rate of increase was highest in T2 as compared with other treatments (Fig.7) indicating that the colony performance was adversely affected by opening it after every four days or by some other factors.

The effect of changes in frame position on honey collection (Fig.8) indicated 21.3 percent increase in T1 and 106.5 percent in T2. The rate of increase in C1 and C2 was 39.8 and 72 percent respectively. It can be concluded from these data that in the bee hive a change in frame position after every eight days

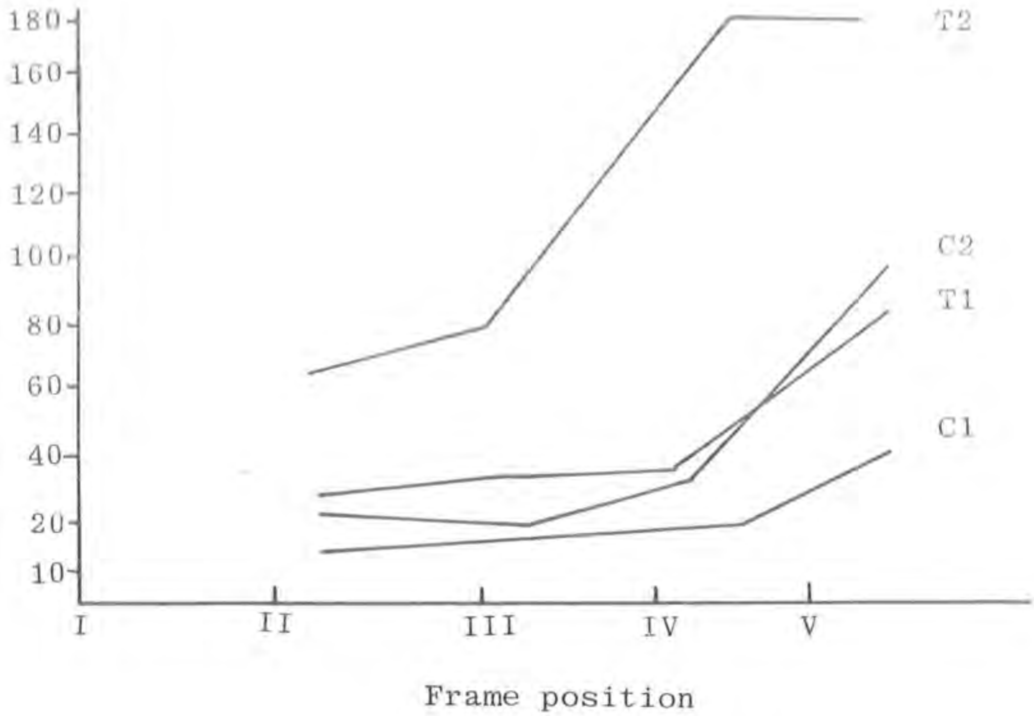


Fig. 7. Percentage increase in pollen in different treatments

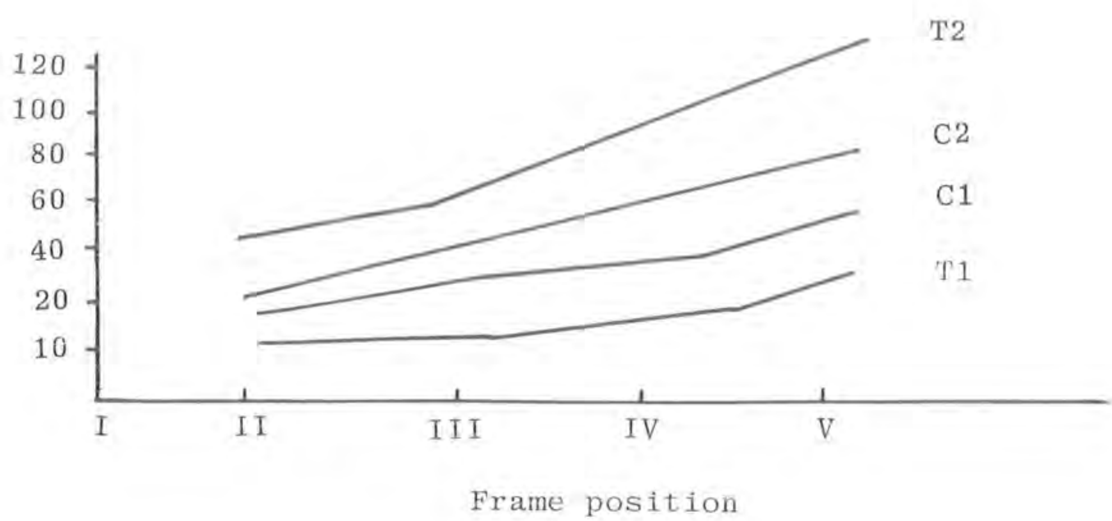


Fig. 8. Percentage increase in honey in different treatments

is better treatment as it shows maximum rate of increase both in pollen and honey. A change in frame position after every four days decreased pollen and honey possibly due to disturbance to the hive or some other factors.

6. INTEGRATED MANAGEMENT OF COLONIES

The beekeepers in Pakistan are still not using modern management methods. Many colonies are left to their own devices until they obviously require serious attention. Some colonies may be well; some colonies may be weak; and the others may swarm. It may be impossible to bring weak colonies up to the required standard during the nectar flow season. As a result, honey production is much lower than the potential; labour input is relatively high; and the number of colonies may even be reduced. It was considered worthwhile to employ combined management practices including pest control, feeding as required, regular queen replacement, swarm control, minimum labour input for maximum honey production and colony increase either for replacement or long term programme. Therefore, a trial was started to develop an integrated colony management method.

Experiment was conducted on three colonies each with a single brood box containing 10 frame bees in Langstroth hive. Each colony was given a second brood box on February 3, and fed 6 litres of concentrated sugar syrup (2 parts sucrose and 1 part water) on February 20. These colonies were queen-right and healthy.

On February 25, each colony was prepared for division. In addition, one very populous colony was producing queen cells from the selected stock. All the bees including the queen were shaken into the bottom brood box onto 4 combs of brood, with 3 combs of honey next to them and 3 empty combs. The upper brood box was placed above a queen excluder over the lower brood box; it contained 4 combs of brood, an adjacent comb of honey and 5 empty combs.

This manipulation gave a good opportunity for quick and careful examination of 4 combs of brood in each colony for wax moth attack, when they had been shaken free of bees. There was no evidence of disease in any colony. However, a few moth larvae were found in two colonies and were killed.

Bees from the lower brood box began to move through the queen excluder straight away, and covered the brood in the upper box. The next day the two brood boxes of each colony were interchanged, the queen excluder was removed, and replaced by a temporary second floor board made by nailing a wooden rim to a piece of hardboard cut to the outer dimensions of a brood box. A gap was left in one side of the rim to provide a small entrance. Each colony was thus artificially swarmed; it had a queenless nucleus in the bottom brood box. The small entrance for the upper colony was positioned above the main hive entrance.

On February 27, a ripe queen cell was introduced into each queenless bottom box from a supply of cells in a cell-producing colony, which was then divided in the same way as the other 3 colonies. An additional nucleus was made from the cell-producing colony and was housed in a 4 frame nucleus hive, placed on a separate stand, and given a ripe queen cell.

On March 15, a deep honey super was placed on each upper queen-right colony, above a queen excluder; and each was fed 6 litres of concentrated syrup on March 16 onwards.

The colonies in the bottom boxes were examined on April 2, and all were found to have laying queens. The queen in the nucleus hive was also laying. The nucleus formed on February 27 was transferred into hive with a single brood box. The colonies that had been divided on February 25 were then manipulated to make them large, and with approximately equal populations. Each upper colony was united to a bottom colony; the smaller colonies were united to the normal ones, and additional combs of brood and bees were taken from some large colonies and added to small ones. Each colony was then headed by a current year queen. In addition, one nucleus colony was made. It was headed by one of the original upper-colony queens.

As a result of this colony manipulation, each of the hives contained 10 combs of brood and 2 deep boxes of bees, with the queen confined to the lower brood box under a queen excluder. The deep honey supers added on March 15 were placed on the second boxes. Each had ample stores of honey and pollen. There was also a colony in a single brood box, headed by a young queen, and a nucleus with one of the original upper-colony queens, later on replaced by a supersedure queen.

The colonies were examined again on June 15 for assessment. None of the colonies had swarmed. All including the nucleus were queen-right and apparently healthy. Three kg sugar syrup was given to each colony on July 25, 3 kg on November 2 and 3 kg on November 30, 1987.

Some 11.3 kg surplus honey per hive was produced from these colonies during April and 9.6 kg in October. Sugar costs Rs.9/- per kg and market rate of honey is Rs.50-55 per kg for whole sale and Rs.80-100 per kg for retail. Thus the use of sugar for feeding to bees to develop the colonies for honey flow is very useful.

7. SUPPLEMENTAL FEEDING BEFORE NECTAR FLOW

The honeybee colonies suffered winter losses and had very low populations in early spring. Some colonies went through rapid development and attained maximum population of foragers in early spring. These colonies produced fairly high honey yield from Acacia modesta and other spring flora. Some colonies remained weak and produced little or no honey. Keeping in view this situation, the weak A. cerana colonies were fed sugar syrup, plain candy and yeast candy at the rate of six kg per colony during mid-winter and early spring (January 1- March 20). These supplemental feeds induced the queens to lay eggs and built-up their populations. The effects of supplemental feeds on colony strength and honey production are given in Table 4.

Table 4

Effect of supplemental feeds on bee strength and honey yield

Feeds	Bee frames			Honey super frames	Honey
	Jan.1	Mar.25	Apr. 29	Apr. 29	(kg)
Sugar syrup	5	8.0	12	12	9.0
Plain candy	5	10.0	14	18	18.0
Yeast candy	5	9.0	13	16	11.0
Control	5	3.5	7	7	5.7

The data (Table 4) indicate that the colonies fed on supplemental diet built up comparatively strong population and produced fairly large quantity of honey as compared with that in control. On the whole plain candy gave better honey yield.

8. SUPPLEMENTAL FEEDING AFTER NECTAR FLOW

Three supplemental diets were tried during June-August and their effect on honeybee colonies was determined. These diets were prepared by mixing on weight basis: (1) one part of soybean flour(after extracting oil) and pollen (ratio 3:1) and two parts of cane sugar and water (ratio 3:1); (2) one part brewer's yeast and pollen (ratio 3:1) and two parts of cane sugar and water (ratio 3:1); and (3) brewer's yeast, cane sugar and water (ratio 3:3:2.5). It was found that the population of the bees fed upon these diets (4 kg per colony) was, respectively, 3,2.5, 1.5 times more than that in control colonies indicating a fairly large build up of bees with these diets. Thus the beekeepers can use these diets to improve the strength of their colonies during the floral dearth period.

The honeybees were under stress from mid-June to July because of high temperature and shortage of bee flora. The bees brought a small amount of nectar and pollen. Sugar was provided to supplement the food requiremets of honeybees. The bees laid a few eggs and the colony population started declining rapidly. Keeping in view this situation, a concentrated multivitamin soluble powder was fed to bees (4 frame colony with 1-1.5 frame brood, n=3) at the rate of one teaspoon per 12 litres of sugar syrup (sugar and water 2:1). It contained vitamin A 4540,000 units, vitamin D 908,000 units, vitamin B2 4,540 mg, vitamin B6 1662 mg, vitamin B12 6,810 mg, niacinamide 22,700 mg, cal. pantothenate 6,810 mg, folic acid

454 mg, vitamin E1 816 units and vitamin K3 908 mg in 456 g material (cost Rs. 13). Those vitamins (3 teaspoonful) along with sugar syrup were fed three times to 8 colonies in about four weeks. Brood area was measured in treated (fed on sugar and vitamins) and control colonies (fed on only sugar syrup) six weeks after first feeding. It was found that brood area was about 2-3.5 frames more in colonies fed on vitamins mixed with sugar syrup and 1-1.5 frame in colonies provided sugar syrup only. Thus it seems that vitamins in sugar syrup enhanced the brood rearing capacity of the bees.

9. SPACE REDUCTION IN BROOD CHAMBER

Studies were conducted to determine the effect of reducing bee space in brood chamber on honey yield during honey flow period. A. cerana colonies foraged on clovers (Trifolium spp.) in May-June. The space was reduced in the brood chamber on May 2. On reduction of space the bees started storing honey in the super frames. Observations were taken at the end of honey flow period on June 10, 1988 and are presented in Table 5.

TABLE 5

Effect of reducing bee space in brood chamber on honey yield

Colony No.	Brood chamber		No. of sealed honey super frames		Honey (kg)
	No. of bee frames	No. of frames removed	Ist super chamber	2nd super chamber	
1. Less space	6	1	8	-	6.3
2. "	7	1	10	3	9.7
3. "	7	3	10	2	9.1
4. "	7	3	10	1	8.3
5. "	7	2	10	2	9.2
6. Control	6	-	3	-	2.3
7. "	7	-	5	-	3.8
8. "	7	-	4	-	3.0
9. "	7	-	6	-	4.6
10. "	7	-	5	-	3.7

The data indicate that there was an appreciable increase in the honey yield in colonies with less space (6.3-9.7 kg) as compared with that in control having sufficient space in brood chamber (2.3-4.6 kg). Thus reduction in the number of frames in the brood chamber had a marked effect on the honey yield per colony.

10. BROOD AND QUEEN PRODUCTION IN LATE SUMMER

Maize pollen was fairly abundant and nectar was not available at Rawalpindi in June. The brood rearing declined and some of the colonies suddenly became queenless. Taber (1977) has stated that bees will rear more brood regardless of weather and time of the year if sufficient pollen and sugar is continuously provided. Thus each of the twelve queen-right colonies were fed 10 kg sucrose (sugar and water 1 : 1) and 3 kg musk-melon (Cucurbita moschata) extract during May 24 - August 31.

This helped maintain the bee strength in the colonies and induced the queens to produce drone brood. First six days of profused sucrose feeding resulted in the formation of supersedure queen cells in these colonies. The young daughter queens were allowed to remain in the parent hives (one per colony) while the old mated queens were transferred to 3 frame nucs maintained separately. In 12 test colonies, four colonies each reared 2 supersedure queen cells, four colonies each 3 supersedure cells, two colonies each had one, while two supersedure cells were cut off by bees in two colonies. These cells produced 22 queens. Of these, 13 queens (59%) mated successfully and each laid 515-1494 (average 720) eggs per day in the second week after commencement of oviposition (based on one day's observation for each queen). In control, one colony absconded, three were queenless after one week, seven reared a small amount of brood while one was completely broodless and succumbed to the attack of wax moths. It was observed that the supplemental feeding prolonged brood production and queen rearing for a considerable period. This practice provided young mated queens for the queenless colonies and improved the colony strength by producing 10,000-15,000 bees during the period.

11. QUEEN REARING IN AUTUMN

Swarming of bees occurred in Swat during September-October when blooming of Plectranthus rugosus plants was in full swing. The local beekeepers reported that only a few queens could successfully be reared during this period and that the queens produced in some areas of Swat showed better brood production than that in others. Weather conditions varied in the main beekeeping areas such as Bahrain and Hasan Abdal in September. It is possible that weather affects fertilisation of queens resulting in variable success at different localities in Swat. To confirm the effects of weather on fertilisation of queens, sixteen queens were produced each at Hasan Abdal and Bahrain in September. Of the queens reared at Hasan Abdal,3 died while the others,on average, produced about half frame brood on sarson in December.Six queens produced at Bahrain did not lay eggs and 7 disappeared from the colonies within 32 days after emergence.The remaining 3 queens had sub normal performance and reared a small brood.The other colonies having queens reared in spring (March-April) produced on average 5 to 6 frame brood in December. This indicates that temperature and rainfall have possibly more adverse effects on fertilisation of queens at Bahrain than at Hasan Abdal and that shifting of colonies to warm areas immediately after emergence of queens would possibly enhance the prospects of successful rearing of queens in September.

12. SWARMING VERSUS DIVIDING BEE COLONIES

In Pakistan, the strength of apiaries is usually increased by natural swarming which causes serious difficulties for the beekeepers in managing the colonies during this period. Therefore, studies were made to determine the comparative efficiency of new colonies produced by natural swarming and by dividing into two halves. For these studies, the natural swarms were captured and placed in the same apiary.The divided colonies with the old queens were also kept in the same apiary and the other halves (without queens) having a ripe queen cell were taken to a distance of more than two km from the parent hive. Each colony (swarmed and divided ones) contained three frame bees (three replicates). In both cases, the bee colonies settled and started their work within 24 hours.The performance of bees in all the colonies was almost the same. Anyhow, the swarming time was usually uncertain; recapturing of swarm was difficult; and sometimes two or more swarms issued at a time intermixed and killed the queens. Therefore, dividing the colonies was better than producing swarms by themselves.

13. SWARM PREVENTION

Studies were conducted on prevention of swarming in three colonies with 7-10 frame bees in apiaries of private beekeepers in January-April 1987. These colonies had one-year old queens and were requeened with the young queens. Thereafter these were examined at 4-5 days intervals for removal of queen cells. Some 3-4 brood or super frames more than the requirement of the bees were provided to each colony. The colonies were almost completely prevented from swarming and became strong (12-15 frame bees) resulting in high yield of honey (12 to 16 kg) as compared with control colonies those produced 3 to 5 swarms yielding little or no honey during February-June.

14. EFFECT OF COMB FORMATION ON HONEY YIELD AND SWARMING

There has been a controversy among the beekeepers about the merits and demerits of wax renewal in the brood or super chambers on the onset of major honey flows. Several scientists put forward their suggestions in favour of the building of new combs in *Apis mellifera*. Zecha (1964) claimed that the best beekeeping results are achieved when the bees are allowed to draw out as many comb foundations as possible and that this helped fight many other diseases besides nosema. Villumstad (1970 and 1980) and Jaksland (1971) recommended the removal of all frames before wintering, and to substitute with comb foundation frames. Hansson (1980) claimed that for hygienic purposes, combs should be used for only two years and then melted, and that every colony should draw out at least 15 comb foundations yearly. Jordan (1960) indicated that the use of same combs for several years in the brood nest is deterimental as the bees will become successively smaller. Paschke (1950) claimed that new comb building partly inhibits swarming. Wulfrath and Speck (1957) and Zecha (loc. cit.) supported this opinion. However, Szabo (1975) stated that honey yield is reduced significantly if large number of comb foundations are drawn out before or during the honey flow. No information was available on renewal of combs in A. cerana. Therefore the influence of comb construction on swarming and honey yield was determined in A. cerana colonies having one year old queens. Twenty four healthy colonies with 5 to 9 bee frames foraging on sarson (Brassica campestris) were selected for the experiment. The experimental bees were divided into two groups each of twelve colonies. Group No. 1 received 10 super frames with drawn combs while group No. 2 was provided supers each with five drawn combs and five comb foundation frames. First supers were given on February 3, 1986 and additional supers added into the colonies according to their needs. The two sets of colonies received similar management during the course of experiment. The honey crop of both the sets was measured for each hive individually by weighing the supers before and after extraction. When the nectar flow decreased, supers with comb foundations were not added. In the group 2, the number of combs drawn per colony were on average 1.3 on sarson (B. campestris) during February-March, 0.5 on acacia (Acacia modesta) in April, and 1.0 on berseem (Trifolium alexandrianum) in May-June. Honey yield (kg) on these three major honey crops is given in Table 6.

Table 6

Average honey yield in colonies in group 1 (old combs) and in group 2 (comb foundations and old combs)

Months	Crops	Honey yield (kg) per colony	
		Group I	Group 2
February	*B. campestris*	3.5	2.0
March	-do-	4.0	2.5
April	*A. modesta*	4.2	3.0
May	*T. alexandrianum*	5.5	3.0
June	-do-	6.0	2.7
	Total	23.2	13.2

The data indicate that the honey yield in group 1 was significantly higher than in group 2. Average number of comb foundations drawn in group 2 was 2.8 per colony resulting in reduction of 10 kg honey because of comb construction during the honey flow.

During the course of this experiment, swarming tendency based on the production of queen cells was noted by making a regular check of the colonies at the interval of 5 days and the swarm cells were destroyed and royal jelly collected. The results based on the production of queen cells in 12 colonies of each group are presented in Table 7.

Table 7

Queen cell formation in colonies in group I (old combs) and group 2 (old combs and comb foundations)

No. of queen cells produced in different colonies													
Group 1							Group 2						
Colony Nos.	Feb.	Mar.	Apr.	May.	Jun.	Total No. of cells	Colony Nos.	Feb.	Mar.	Apr.	May.	Jun.	Total No. of cells
2	2	2	–	–	–	4	1	4	3	4	–	–	11
3	7	4	4	4	–	19	6	3	2	–	–	–	5
4	2	3	3	–	–	8	8	5	3	2	–	–	10
5	1	3	–	–	–	4	11	2	1	–	–	–	3
7	6	5	7	3	–	21	12	5	5	3	3	–	16
9	11	8	3	–	–	22	14	2	4	2	–	–	8
10	3	2	–	–	–	5	15	7	5	6	6	3	27
13	5	11	3	–	–	19	16	7	7	5	3	4	26
17	5	8	6	8	2	29	18	9	1	6	7	–	23
20	2	1	–	–	–	3	19	2	3	2	–	–	7
21	6	7	11	4	–	28	22	6	4	4	–	–	14
23	8	7	7	4	–	26	24	–	2	–	–	–	2
Total	58	61	44	23	2	188	–	52	40	34	19	7	152

The data indicate that the numbers of queen cells were a little higher (188 cells) in colonies provided with drawn combs as compared with the colonies supplied with comb foundations and drawn combs (152 cells) and that number of queen cells produced were highest in February-March. Swarming tendency was considerably reduced in April and May, and was negligible in June. Colony Nos. 2, 5, 10 and 20 in group 1 and colony 6, 11 and 24 in group 2 had a lesser propensity for swarming.

15. FACTORS AFFECTING ABSCONDING BEHAVIOUR

Colonies of *A. cerana* frequently absconded. Therefore, studies were made to determine various factors, viz. presence of reserve food and brood in the colony, high temperature and availability of water which possibly affected absconding behaviour of this species. The colonies were placed at different locations in Rawalpindi (one colony at each place) during third week of June(mean min. 24°C and max. 39°C). Berseem flora had exhausted and other than these experimental colonies from this area were shifted to Swat. The details of the colony condition and absconding are given in Table 8.

Table 8
Factors affecting absconding behaviour of the bees

S.No.	Colony condition	Absconding
1.	Colony with some brood, no reserve honey, no feeding on sugar syrup, no water channel in the vicinity.	Absconded within a week
2.	Colony with some brood, no reserve honey, feeding on	No absconding

1	2	3
	sugar syrup (2 kg only), water channel in the vicinity.	No absconding
3.	Colony without brood and reserve food, no feeding on sugar syrup, no water channel in the vicinity.	Absconded within a week
4.	Colony without brood and reserve food, feeding on sugar syrup (2 kg only), no water channel in the vicinity.	Absconded within 3 weeks
5.	Colony heavily attacked by wax moths.	Absconded
6.	Colony with brood, reserve food and water channel in the vicinity.	No absconding

These observations show that the colonies absconded possibly due to high temperature, non-availability of water, shortage of bee flora and heavy attack of wax moths.

16. CLUSTERING OF BEES

Clustering of *A. cerana* bees commonly occurred on front wall of the hive in the foot-hills and plains during summer. The culsters were so large that it became very difficult for the beekeepers to get the clustering bees into the hives for shifting the colonies during night. Thus, some of the bees were left at the apiary site when the colonies were shifted to other areas. Furthermore, the clustering bees were attacked by rats, frogs, lizards and other natural enemies, which adversely affected the colony strength. In addition, clustered bees became very ferocious when disturbed for preparing the colonies for shifting. Such bees also stored lesser honey as compared with non-culstered ones.

According to Shaparew (1980) clustering is caused by insufficient air supply to dry the nectar and not by high temperature within the hive. He further stated that the bees commonly clustered in strong and highly propolised colonies particularly when only nectar was available to bees and the temperature (more than 21°C) and humidity were fairly high and that clustering can be prevented by constructing honey drying ventilators devised by him. These ventilators are too expensive and our beekeepers cannot afford to construct them. Therefore, studies were made to eliminate clustering in *A. cerana* bees.

As insufficient air has been reported to be the main factor responsible for clustering of bees, it was considered that alteration in the hive such as widening of entrance holes, addition of super or brood chambers and reduction in the number of frames in hive bodies might be effective in eliminating the clusters. Accordingly one or two supers were added on the brood chamber. It slightly reduced the number of bees in clusters but there was no marked effect on the overall clustering.

The entrance holes of the colonies having clusters were widened by removing the rods. It did not release pressure and was almost ineffective to eliminate clusters. Thereafter, empty super chamber were added below the brood chamber of each colony. It was observed that bees moved into the hive, and started normal functions, eliminating the cluster within 2-3 hours. Thus addition of a super chamber possibly increased the air supply and released the stress condition in the hive.

Honey yield was studied in non-clustering and clustering colonies of almost equal strength (3 replicates). It was found that non-clustered colonies produced 8-13 (average 11) kg honey while the colonies having clusters yielded 5-9 (average 7) kg honey during April-June 30,1986 indicating a fairly high increase in the yield of normally functioning colonies.

17. COMB FORMATION ON DIFFERENT KINDS OF SHEETS OF APIS CERANA WAX

Comb foundation sheets are costly and are not easily available to beekeepers particularly in the remote areas of Murree, Swat, Dir and Hazara. Therefore, plane, lined (with common pin) and comb foundation sheets were tested to compare their usefulness in building the comb. The sheets were fitted on hive frames, and one of these sheets was placed in the colony (three replicates). Three colonies were kept without additional sheets as control. All the bee colonies were almost of equal strength (three frame bees). The sheets were placed in the colonies on May 1st. Observations taken on June 15th showed that comb was built on 12.5-50% foundation sheets, on 0-26% lined and plane sheets while 0-8% additional comb was formed in control colonies. Although the built up area on comb foundation sheets was much larger, but it appears better to use plane sheets when comb foundation sheets are not available.

18. COMB FORMATION ON SHEETS MADE FROM APIS DORSATA WAX

On the onset of major nectar flow, 17 A. cerana colonies each with 5 to 7 frame bees were provided comb foundation sheets in Islamabad in March, 1986. Each colony had 10 to 15 foundation sheets fixed in super and brood frames. Inspite of a heavy nectar flow the bees did not build combs on any of the foundation sheet in 21 days. Almost all the colonies developed burr combs in the empty spaces of the hive and also on the cloth placed over the brood chamber. The combs were not constructed on foundation sheets in any hive. The bees stored honey in burr combs. Consequently there was high reduction in honey and brood production. Reports of similar problems with A. cerana colonies were received from other apiaries where comb foundation sheets were used from wax bought from the same source. It was later found that the dealer supplied A. dorsata adulterated wax.

Further studies were made to confirm wether A. dorsata wax or adulteration in it made it unsuitable for A. cerana. Accordingly ten A. cerana colonies of variable strength (4.5 to 9 frame bees) and with ample honey stores were selected for the experiment in July, 1986.Each colony was provided 3 foundation sheets made of A. dorsata wax in the centre of brood chamber. The bees had maize (Zea mays) crop as main source of pollen and 'Itsit' (Trianthema monogyna) for both nectar and pollen. The colonies were also provided supplemental feeds (sugar and water 1:1) during the experiment. Results based on weekly check of the colonies for construction of new combs on sheets made from A. dorsata wax in the brood frames are given in Table 9.

Table 9

Comb formation by A. cerana on 'doomna' A. dorsata wax sheets

Colony Nos.	No. frames in the colonies					Additional comb area (No. frames)	
	Bee	Brood	Eggs	Honey frames	Pollen	After Ist week	After 2nd week
8 F	6.0	2.0	1.0	2.0	0.5	1.0	2.5
32 F	7.5	2.5	1.0	5.5	0.2	0.8	1.2
5 F	5.0	2.0	0.5	6.0	0.5	0.7	1.0
26 F	7.0	2.5	0.5	6.0	0.5	0.5	2.0
66 F	5.5	2.0	0.5	2.5	0.5	0.1	0.7
28 F	4.5	1.5	0.5	5.0	0.5	0.2	1.5
8 F	9.0	2.5	0.8	6.0	0.2	-	0.5
35 F	7.5	2.5	0.5	9.5	0.2	1.0	2.7
19 F	8.0	3.0	0.5	4.5	0.5	0.4	0.6
17 F	4.5	1.5	0.5	2.0	0.2	-	0.3

The data in Table 9 show that A. cerana colonies can easily build combs on A. dorsata wax sheets. On a second check after two weeks, it was observed that queens of all the colonies except colony Nos. 66 F, 19 F, and 17 F had laid eggs in the new comb cells while the workers had started storing honey as well. However, comb formation was accelerated when the simple rock bee wax sheets were dipped in melted wax of A. cerana or A. mellifera and passed through comb foundation machines. Building up combs by A. cerana on the rock bee wax sheets has valuable practical implications. The rate of A. dorsata wax ranges from Rs. 20 to 25 per kg while the wax obtained from A. cerana and A. mellifera colonies is sold at Rs. 60 per kg. Further, the rock bee wax is easily available in abundance in different forest areas. Some of the beekeepers who do not use comb foundation sheets owing to high priced hive bee's wax, can utilise cheaper rock bee wax for their colonies. Last year the bee failed to draw combs on the rock bee wax sheets supplied by a dealer to several beekeepers. It seems that the rock bee wax was either adulterated or partly burnt by the dealer.

19. MIGRATION OF COLONIES

Some five hundred plant species were known to constitute bee flora in Pakistan (Rahman and Singh, 1941; Haq *et al*., 1963; Shahid and Qayyum; 1977; Ahmad *et al*.,1978 and Ahmad, 1981) but none of the areas were known to provide nectar and pollen throughout the year. A survey conducted to find suitable floral belts for higher honey production showed that honeybee flora was abundant in some areas either in winter, spring, summer or autumn, and was scarce in other locations in these seasons. Most of the beekeepers, except a few progressive ones, keep their colonies at one place or shift them at short distances in the same area throughout the year. Thus, the bees are subjected to starvation during dearth periods resulting in very low honey yield. Migration of bee colonies is essential for commercial beekeeping so as to make use of available bee flora at various locations during different seasons. Therefore schedules for migration of *A. cerana* colonies to different floral belts were developed (Table 10).

Table 10

Migration schedule for honeybee colonies

Plant source	Locations	Months
'Sarson' and 'Toria' (*Brassica* spp.)	Lahore, Faisalabad, Sahiwal, Jhang, Sargodha, Gujranwala, and Gujrat	Nov.-Jan.
'Sarson'(*Brassica campestris*)	Sialkot, Gujrat, Jhelum, Rawalpindi and Islamabad	Dec.-Feb.
	Havelian, Haripur, Swabi, Tarbella and Peshawar valley	Jan.-Mar.
	Swat, Murree, Dir, Bajawar, Mansehra and Abbottabad	Feb.to mid Apr.
Eucalyptus (*Eucalyptus* spp.)	Islamabad, Abbottabad, Peshawar and Lahore	Oct.-Mar.
Loquat (*Eriobotrya japonica*)	Rawalpindi, Hazara,Peshawar, Nowshera, Malakand Division and Islamabad District	Nov.-Feb.
'Bhaikar' (*Adhatoda vasica*)	Islamabad, Rawalpindi, Marghalla, Hazara, Swat and Azad Kashmir	Nov.-Apr.
Plum (*Prunus bokhariensis*),apricot (*P. armeniaca*),peach (*P.persica*) and pear (*Pyrus communis*)	Murree Hills, Azad Kashmir, Nowshera, Hazara, Swat and Peshawar	Feb.-Mar.
Citrus (*Citrus* spp.)	Punjab and NWFP	Feb.-Mar.
Bottle brush (*Callistemon citrinus*)	Islamabad, Rawalpindi, Abbottabad and Peshawar	Apr.-May and Aug.-Sep.
Clovers (*Trifolium* spp.)	Punjab and NWFP	Apr.-Jun.
Sunflower(*Helianthus annuus*)	Punjab and NWFP	Apr.-Oct.

1	2	3
Sissoo (*Dalbergia sissoo*)	Punjab and NWFP	Mar.-Apr.
'Garanda' (*Carissa opaca*)	Rawalpindi, Islamabad, Peshawar valley and Hazara Division	Mar.-Jun.
'Ain-ul-asl'(*Robinia pseudoacacia*)	Hazara and Azad Kashmir	Apr.-May
Red cedar (*Cedrela toona*)	Islamabad, Rawalpindi, Murree, Abbottabad and Peshawar	Apr.-May
'Phulai' (*Acacia modesta*)	Punjab and NWFP	Apr.-May
Mesquite (*Prosopis* spp.)	Northern and southern Punjab, Foot-hills in NWFP	Apr.-Jun.
Lucerne (*Medicago sativa*)	Punjab and NWFP	May- Jun.
Maize (*Zea mays*)	Punjab and NWFP	Jul.-Sep.
Cotton (*Gossypium* spp.)	Punjab	Aug.-Nov.
'Shain'(*Plectranthus rugosus*)	Kaghan, Swat, Dir, Chathar plain, Nathia Gali,Murree and Azad Kashmir	Sep.-Oct.
'Shain shobae' (*Perovskia atri-plicifolia*)	Ziarat, Razmak, Kurram, Wana, Parachinar, Chitral, Gilgit and Baltistan	Aug.-Sep.
Cosmos (*Cosmos* spp.)	Islamabad, Rawalpindi, Peshawar, Mingora and Abbottabad	Oct.-Nov.
'Ber' (*Ziziphus* spp.)	Rawalpindi, Islamabad, Khairabad, Peshawar and Malakand	Aug.-Oct.
'Asl-e-amir' (*Vitex negundo*	Islamabad, Hazara and Azad Kashmir	May-Nov.

The colonies migrated in accordance with these schedules developed very well and produced 15-28 kg honey per annum depending upon the management methods applied by the beekeepers.

20. HONEY YIELD OF MIGRATED AND NON-MIGRATED COLONIES

Twenty colonies of *A. cerana* each having 8 frame bees in the beginning were placed in four sets of five colonies each in different floral belts. The colonies of the first set were migrated to Swat, Rawalpindi, Islamabad and adjoining areas; second set to Rawalpindi-Islamabad while third and fourth sets were placed, respectively, in Swat and Islamabad area. The honey production of each set of these colonies in different floral belts is given in Table 11.

Table 11

Honey yield of migrated and non-migrated colonies

Set No.	Locality	Bee flora		Period (1986)	No. honey producing colonies	Honey production (kg)	
		Major	Minor			Range	Total
1.	Ganghal (Islamabad)	*Brassica campestris*	*Eucalyptus* spp., *Eriobotrya japonica*, *Adhatoda vasica*, *Dahlia* spp., *Asphodelus tenuifolius*, *Calendula arvensis*, *Verbena officinalis*, *Citrus* spp. and *Raphanus sativus*	Jan. 1 - Mar. 31	5	3.2-7.5	22.5
	Daman-e-Koh (Islamabad)	*Acacia modesta*	*Carissa opaca*, *Althaea rosea*, *Dalbergia sissoo*, *Hartmannia rosea*, *Melilotus indicus*, *Senebiera didyma*, *Lagerstroemia indica* and *Carthamus oxyacantha*	Apr. 1 - May 10	5	4.5-10.2	29.5
	Tarnol (Rawalpindi)	*Trifolium alexandrianum* and *Medicago sativa*	*Zea mays*, *Cassia fistula*, *Clarkia* spp., *Cedrela toona*, *Lagerstroemia indica* and *Helianthus annuus*	May 11 - Jun. 15	5	1.2-4.4	10.6

1	2	3	4	5	6	7	8
	Bahrain (Swat)	*Plectranthus rugosus* and *Zea mays*	*Cichorium intybus*, *Digera arvensis*, *Epilobium hirsutum*, *Hibiscus cannabinus*, *Nepeta* spp., *Origanum vulgare*, *Polygonum hydropiper* and *Verbena officinalis*	Jun. 16 - Oct. 31	4	2.6-6.2	22.2
	Chathar (Rawalpindi)	*Eriobotrya japonica*	*Cosmos* spp., *Eucalyptus* spp., *Adhatoda vasica*, *Helianthus annuus* and *Poinsettia* spp.	Nov. 1 - Dec. 31	-	-	-
Average honey yield/colony/annum							16.9
2.	Mandra (Rawalpindi)	*Brassica campestris*	*Fumaria indica*, *Anagallis arvensis*, *Asphodelus tenuifolius*, *Eruca sativa*, *Salix* spp., *Cicer arietinum*, *Foeniculum vulgare*, *Citrus* spp. and *Trigonella foenum-graecum*	Jan. 1 - Mar. 20	3	2.0-4.1	9.1
	Daman-e-Koh (Islamabad)	*Acacia modesta*	*Brassica oleracae*, *Carissa opaca*, *Carthamus oxyacantha* and *Adhatoda vasica*	Mar. 21 - May 10	4	2.1-4.1	13.4

1	2	3	4	5	6	7	8
	Ganghal (Islamabad)	Trifolium alexandrianum and T. rasupinatum	Zea mays, Carissa opaca, Prosopis spp., Lagerstroemia indica and Helianthus annuus	May 11 - Jun. 30	4	2.0-6.4	12.8
	Daman-e-Koh (Islamabad)	-	Vitex negundo, Sapium sebiferum, Ligustrum lucidum and Lannea coromandelica,	Jul. 1 - Aug. 31	-	-	-
	Saidpur (Islamabad)	-	Ziziphus spp., Vitex negundo, Cosmos spp., Eucalyptus spp., Helianthus annuus, Salvia spp. and Solidago spp.	Sep. 1 - Nov. 12	One colony expired		-
	Shakkar-parian (Islamabad)	Eucalyptus spp.	Adhatoda vasica, Callistemon citrinus, Vitex negundo, Dahlia spp. and Poinsettia spp.	Nov. 12 - Dec. 30	3	1.1-2.4	5.3
Average honey yield/colony/annum							8.1

1	2	3	4	5	6	7	8
3.	Chail (Swat)	Brassica spp.	Anemone polyanthes, Salix aegyptiaca and Ulmus villosa	Jan. 1 - Mar. 31	-	-	-
			Trifolium spp., Cornus macrophylla, Sorbaria lindleana, Ribes orientale, Quercus dilatata, Pyrus communis, Rubus biflorus, Salix alba and Ranunculus spp.	Apr. 1 - May 30	-	-	-
			Apium pubiflora, Rubus fruticosus, Zea mays, Polygonum spp., Andropogon sorghum, Epilobium hirsutum, Datisca cannabina and Butea frondosa	Jun. 1 - Jul. 31		-	-
		Plectranthus rugosus	Asyneuma glomerata, Amaranthus spinosus, Cannabis sativa, Nepeta spp. and Origanum vulgare	Aug. 1 - Oct. 31	5	4.3-7.4	28.6
			Cichorium intybus, Celosia argentea and Stachys sericea	Nov. 1 - Dec. 31	One colony expired	-	-
Average honey yield/colony/annum							5.7

1	2	3	4	5	6	7	8
4.	Rawat (Islamabad)	Brassica campestris	Asphodelus tenuifolius, Adhatoda vasica, Dahlia spp., Eriobotrya japonica, Eucalyptus spp., Althaea rosea, Eruca sativa, Pyrus communis, Prunus spp., Citrus spp., Raphanus sativus, Fumaria indica, Dahlia spp., Salix spp. and Borago spp.	Jan. 1 – Mar. 15	-	-	-
	Daman-e-Koh (Islamabad)	Acacia modesta	Carthamus oxyacantha, Clarkia spp., Carissa opaca, Adhatoda vasica, Althaea rosea, Borago spp., Dahlia spp., Eucalyptus spp., Rosa spp., Salix spp., Salvia spp., Trigonella foenum-graecum, Cedrela toona, Dalbergia sissoo, Lonicera japonica and Terminalia arjuna	Mar. 16 – May 5	5	2.0-6.4	16.4

Daman-e-Koh (Islamabad)	-	Acacia modesta, Althaea rosea, Carthamus oxyacantha, Centaurea cyanus, Cedrela toona, Lagerstroemia indica, Helianthus annuus, Vitex negundo, Portulaca spp., Rosa spp. and Salvia spp.	May 6 - Jun. 30	4	1.1-3.5	7.1
Rawat (Islamabad)	-	Adentostemma lavenia, Vitex negundo, Ligustrum lucidum, Zea mays, Cucurbita spp. and Luffa spp.	Jul. 1 - Aug. 31	One colony expired	-	-
		Portulaca spp., Salvia spp., Cosmos spp., Eriobotrya japonica, Eucalyptus spp., Helianthus annuus, Salvia spp. and Solidago spp.	Sep. 1 - Oct. 31			
Daman-e-Koh (Islamabad)	-	Eucalyptus spp., Adhatoda vasica, Dahlia spp., Vitex negundo and Poinsettia spp.	Nov. 1 - Dec. 31	One colony expired	-	-
Average honey yield/colony/annum						4.7

The data in Table 11 indicate that colonies migrated in different floral belts were in good condition with 7 to 10 frame bee strength and produced on an average 17 kg honey per colony per annum. The colonies of set No. 2-4, with little or no migration, had low yield of honey and 20-40 percent of these colonies became queenless and expired due to scarcity of flora in late summer, autumn and winter.

21. HONEY PRODUCTION POTENTIAL ON IMPORTANT FLORA

Honey production potential of some colonies was studied on important flora at Peshawar and Mingora. The detail of honey production by six colonies each having six frame bees are given in table 12.

Table 12

Honey produced from six colonies each at Peshawar and Mingora

Plant species	Duration	Honey produced (kg) from different colonies					
		1	2	3	4	5	6
	Peshawar						
Eriobotrya japonica	Dec. 1- Jan. 20	1.75	2.25	1.25	1.50	2.00	1.50
Brassica campestris	Jan. 1- Feb. 28	2.75	3.75	2.38	1.50	1.75	2.25
Trifolium spp.	May 15- Jun.30	2.50	3.25	3.50	1.75	2.75	3.38
	Total	7.00	9.25	7.13	4.75	6.50	7.13
	Mingora						
E. japonica	Jan. 12- Jan. 30	1.13	1.13	1.37	1.25	1.00	1.25

		1	2	3	4	5	6
B. campestris	Feb. 15- Mar. 3	-	1.00	1.00	1.50	2.50	-
Trifolium spp.	May 1- Jun. 30	4.37	4.37	3.00	2.75	3.00	3.75
	Total	5.50	6.50	5.37	5.50	6.50	5.00

The yield of honey was higher at Peshawar where flora were abundant.

22. HONEY YIELD OF FERAL COLONIES IN BALUCHISTAN

The colonies of A. cerana were present in hilly areas of Baluchistan. It seemed that local flora have been supporting a fairly large number of colonies of this bee since the time immemorial. A survey was conducted to determine the honey yield per colony of A. cerana in the province. The colonies of this species were found in Quetta, Ziarat, Muslim Bagh, Turbat, Kohlu Barghan, Lesbela and Kalat areas. A small number of colonies of this bee were reared in walls, rocks and pitchers. The details of honey yield per colony with various beekeepers on local flora in Baluchistan are presented in Table 13.

Table 13

Honey yield (kg) per colony on various flora in the province

Locality	Honey bee flora	Harves-ting time	No. colonies harvested	Honey*/ colony
1	2	3	4	5
Sibi	Zea mays, Brassica spp., Eruca sativa, Helianthus annuus, Vigna spp., Citrus spp., Prosopis spp., Trifolium spp. and Sesamum indicum	Oct.-Dec., Apr.-May	3	2-3
Dahdar	-do-	-do-	3	2-5
Khajak	-do-	-do-	3	2-5
Ghazi	-do-	-do-	2	3-5
Mithri	-do-	-do-	2	1-2
Haji Shehar	-do-	-do-	2	2-3
Osta Mohammad	-do-	-do-	3	2-3
Dera Bughti	-do-	Oct.-Nov., Jun.-Jul.	2 3	2-3 2-4
Nasirabad	-do-	-do-	2	3-5
Sunny	-do-	Oct.-Dec., Jun.-Jul.	2	1-3
Quetta	Malus pumila, Vitis vinifera, Prunus armeniaca, P. persica, P. amygdalus, P. cerasus, Pyrus communis,	Apr.-Jul.	1	2

*Based on enquiries made from beekeepers.

1	2	3	4	5
	Brassica campestris, E. sativa, H. annuus, Rosa, spp. and Vitex negundo incisa			
Turbat	Mangifera indica, Brassica spp., E. sativa, Z. mays and Phoenix dactylifera	Jul.-Aug.	2	1-3
Kohlu Barghan	M. pumila, P. dactylifera, E. sativa, B. campestris and H. annuus	Jul.-Aug., Dec.-Feb.	2	2-3
Othal (Lesbela)	-do-	-do-	3	1-3
Ziarat	M. pumila, P. amygdalus, P. persica, P. cerasus, P. armeniaca, and B. campestris	Mar.-Apr.	2	2-4
Muslim Bagh	M. pumila, P. armeniaca, B. campestris, E. sativa, Z. mays and H. annuus	-do-	3	2-6
Kalat	M. pumila, P. armeniaca, P. persica, Morus alba, Z. mays and Brassica spp.	-do-	3	2-4

Honey yield was low because the beekeepers are not using modern methods for management of colonies and also due to scarcity of flora. Thus honey yield per colony can be considerably increased by adopting better management practices.

23. LOCAL STRAINS

i. Swat and Marghalla Strains

The oriental bee colonies captured from Swat and Marghalla areas showed marked difference in size and behaviour. The bees of Swat strain are slightly larger in size than that of Marghalla area. The former strain made about five worker brood cells and the latter strain six worker brood cells per cm^2. The colonies procured from Swat had lesser tendency for absconding than those from Marghalla Hills. Five colonies of each of these strains having about 7 frame bees were placed in 'shain' *Plectranthus rugosus* area during September-October, in sarson *Brassica campestris* crop from mid-December to March and in berseem (*Trifolium* spp.) fields during April-June. Honey yield of these colonies on different flora is given in Table 14.

Table 14

Honey yield (kg) of various strains of bees in 1986

Colony No.	Swat strain: Shain	Sarson	Berseem	Total	Colony No.	Marghalla strain: Shain	Sarson	Berseem	Total
1	5.7	-	5.4	11.1	11	-	3.5	9.3	12.8
2	9.4	-	6.7	16.1	17	2.4	3.0	8.2	13.6
3	9.2	1.4	4.8	15.4	19	-	2.7	5.0	7.7
4	8.0	-	7.2	15.2	20	-	4.7	6.8	11.5
5	7.6	1.2	5.6	14.4	23	0.5	1.4	7.4	9.3
Tot.	39.9	2.6	29.7	72.2	Tot.	2.9	15.3	36.7	54.9
Av.	7.9	0.5	5.9	14.4	Av.	0.5	3.0	7.3	10.9

Tot. = Total; Av. = Average

The data (Table 14) indicate that average annual honey production per colony was 14.4 kg in Swat strain and 10.9 kg in Marghalla strain and that the former strain produced larger quantity of honey from Plectranthus and the latter from berseem.

ii. Swat strain queens reared in *A. mellifera* colonies

A. cerana bees of Swat strain had fairly high honey yield than that of Marghalla strain (Table 14). Moreover the bees of Marghalla strain were more prone to swarming, absconding, robbing and developing a large number of laying workers as compared with the Swat strain.

The colonies of Swat strain were selected for raising their better quality queens. The Italian strain of A. mellifera produces much larger quantity of royal jelly than A. cerana. Keeping this characteristic in view, queens of A. cerana were reared in A. mellifera colonies. Two frames of unsealed honey and two frames of pollen were placed in a five-frame hive with a wire-mesh bottom board for ventilation. The entrance of the hive was closed and three frame nurse bees of A. mellifera were shaken in the box. Moisture was provided in a sponge piece on top bars and this 'shaker box' was kept overnight. Next day, one brood frame with two bars having 30 queen cups, with 24-hour larva in each cup, was put in the box. After 24-hours it was found that 70 percent of the grafted larvae had success. These were taken from this box and put in the 'finishing' colony simultaneously prepared for this experiment. The queen of the 'finishing' colony is confined in the brood chamber by queen excluder and all the unsealed brood with at least two frames each of honey and pollen placed in the top box. The frame with successful grafts was placed in this top box and the sealed queen cells removed on the seventh day after starting operation. The newly sealed queen started egg-laying within a few days after mating flight. These queens were larger in size and weight (average 0.26 g, one week after mating; n= 7) than those of Marghalla and Swat strains (average 0.14 g; n=7). Their weight was up to 0.09-0.14 g more than those of the two respective strains. The colonies headed by these queens were studied for their honey yield. Average annual honey production of five 8-frame colonies of these bees, kept along with the Swat and Marghalla strains, in 'shain' P. rugosus, sarson (B. campestris) and berseem (Trifolium spp.) is given in Table 15.

Table 15

Honey yield (kg) of
on different flora

Colony No.	'Shain'	Sarson	Berseem	Total
1	5.4	1.9	6.3	13.6
2	9.2	5.0	9.3	23.6
3	8.7	2.4	6.6	17.9
4	7.6	3.9	7.7	19.2
5	7.3	4.9	6.2	18.5
Total	38.4	18.2	36.2	92.9
Average	7.6	3.6	7.2	18.5

It is evident from Table Nos. 14 and 15 that the colonies having queens produced in *A. mellifera* hives were more productive than those of normally produced queens, placed in the similar floral and climatic conditions.

24. BROOD REARING AND CANNIBALISM

It was found that the queens of *A. cerana* colonies laid eggs, but some of these did not develop to larvae or pupae. Woyke (1971) has reported that the worker bees of *A. mellifera* feed on eggs and young larvae in the colony. Studies were therefore conducted on brood rearing and cannibalism in *A. cerana* colonies.

Some 300 cells with eggs on three frames in three *A. cerana* colonies, foraging on clovers in June, were marked for noting down the daily rate of destruction of the brood in the comb. The number of cells with eggs, egg-shells or empty cells, larvae, pupae, nectar and pollen on the area under observation are given in Table 16.

Table 16

Destruction of brood in the comb

Date	No. of cells marked on three frames					
	Eggs	Larvae	Pupae	Empty	Nectar	Pollen
Jun.7	300	-	-	-	-	-
8	292	8	-	-	-	-
9	195	100	-	5	-	-
10	9	282	-	9	-	-
11	-	290	-	10	-	-
12	-	289	-	11	-	-
13	-	289	-	11	-	-
14	-	289	-	11	-	-
15	11	288	-	1	-	-
16	11	192	97	-	-	-
17	10	192	98	-	-	-
18	4	129	163	4	-	-
19	-	10	285	-	4	1
20	1	8	285	-	6	-
21	-	9	285	-	6	-
22	3	6	258	27	6	-
23	7	6	260	10	17	-
24	7	6	260	10	17	-
25	6	6	260	10	17	1
26	-	9	263	10	17	1
27	-	7	240	36*	17	-
28	2	8	9	264*	17	-

*Adults emerged

The data in Table 16 (number of empty cells before emergence of adults till 26th July) indicates that the bees destroyed the young brood to a considerable extent and this may possibly be due to inbreeding as mentioned by Mackensen (1951 and 1955) in _A. mellifera_ colonies.

Observations on 6000 eggs and the individual larvae and pupae reared from them showed that the youngest brood was most likely and the oldest least likely to be eaten. Brood survived to adult stage was 79% (158 out of 200), 84% (168 out of 200) and 63% (126 out of 200) in spring, summer and autumn, respectively. The number of drone brood eaten was 6-11 percent more than that of worker brood.

Survival rate of brood was also investigated in queen-right and queenless colonies. Brood survived was 72% in queenless colonies and 58% in queen-right colonies. Dequeening of colony resulted in higher efficiency of drone rearing in autumn (78 percent) than in spring (59 percent) and summer (64 percent).

25. WINTER PACKING IN COLONIES

The bees were adversely affected by severe cold in Mingora during December-February and these were packed to save them from the adverse effects of cold weather. Keeping it in view, some packing materials such as rice straw, dry grass and old gunny bags were tried for protection of bees during winter. Sixteen colonies of almost equal strength (5 frame bees) were selected and placed in rape and mustard crop. Each packing material was provided to four colonies and the other four colonies were left as control (without packing). Observations by the end of February showed that the packing of rice straw (increase in bees 2 frames per colony) was most suitable and economical as compared with dry grass (increase in bees 1½ frame per colony), old gunny bags (increase in bees 1 frame per colony) and control (reduction in bees 1½ frame per colony) when sarson flora was available.

To study the bee activities, three colonies each of eight frame bees were kept at Mingora in November. The flora was very scarce, and there was also severe cold during night. It was found that 13-18 (average 14.5) kg honey was consumed by bees, and the colony strength also reduced from 8 to 3-5 frames by the end of February. The bee strength increased during rape and mustard flow in March, but no surplus honey was produced even in summer (May-August). The colonies were shifted to Plectranthus rugosus plantation in September-October, and some 5.20 kg surplus honey per colony was extracted during this period.

26. MONSOON PROBLEMS

There is an acute scarcity of honeybee flora in the foot-hills and plains during monsoons in July-August when high humidity and temperature coupled with rising activities of the bee enemies create unfavourable environment for bees. Sometimes pollen in the cells becomes mouldy, and thin honey in uncapped cells suffers fermentation. Bee enemies weaken the colonies and the tendency to rob is accentuated. It is often noticed during monsoons that some weak colonies become queensless and laying workers appear. This apparently was due to the activities of robber bees. In most cases, it was difficult to make such colonies accept new queens. Therefore, these were united with others.

Most of the beekeepers migrate their colonies to hilly areas where wild flora meet their requirements to some extent. However, there are difficulties of a different nature in these areas during monsoon. The bees were unable to stir out for long intervals owing to clouds, rainfall and low temperatures. They become lethargic and listless and occasionally suffer from dysentry. In an apiary of 21 hives having 5-8 frame bees, the strength of the colonies decreased to the extent of 1.5 frames each in 8 colonies, 2.5 frames in each 7 colonies and about 3 frames each in 6 colonies during August 1-31 at Murree indicating that possibly a large number of field workers were lost in clouds, sudden storms or downpours during their foraging. At another location in the Murree hills the colony strength dwindled considerably and in three weak colonies the bees formed a cluster leaving uncovered brood to die due to sudden storms and rainfall. Thus migration of colonies to high rainfall hilly areas during monsoon is not safe.

CHAPTER IV

HONEYBEE FLORA

1. NECTAR AND POLLEN SOURCES

Honeybee flora has been studied by various workers in Pakistan. Some four hundred seventy eight plant species were known to constitute bee flora in the country. Most of these plant species are minor sources of nectar and pollen. Some plants produce nectar in large quantities, but these are not sufficiently plentiful. Thus these are not important for beekeeping. Honey production is dependent upon a few plant species which yield nectar abundantly and are sufficiently common to the bees. Among these, rape and mustard (Brassica spp.), alfalfa (Medicago sativa), berseem (Trifolium spp.), citrus (Citrus spp.), cotton (Gossypium spp.), mesquite (Prosopis spp.), 'phulai' (Acacia modesta), 'shain' (Plectranthus rugosus), 'shain shobae' (Perovskia atriplicifolia), ainul-asl' (Robinia pseudoacacia), 'asl-e-amir' (Vitex negundo), 'bhaikar' (Adhatoda vasica), eucalyptus (Eucalyptus spp.) and loquat (Eriobotrya japonica) are most important and furnish a major part of commerical honey in the country (Fig. 9).

Some of the economic crops and fruit trees, important for bee forage, are cultivated over a large area in the country. These include rape seed and mustard (Brassica campestris and B. juncea), sunflower (Helianthus annuus) and other oil-seed crops grown in about 457,200 ha, cotton (Gossypium spp.) in 2,241,600 ha, pulses (Phaseolus spp., Pisum sativum and Vigna spp. etc.) in 1,415,300 ha, vegetables (Brassica oleracea, B. rapa, Cucurbita spp. etc.) in 150,100 ha, fodders(Medicago spp., Trifolium spp.) in 1,004,000 ha, maize (Zea mays), millets

Ain-ul-Asl	*(Robinia pseudoacacia)*	Eucalyptus	*(Eucalyptus spp.)*
Alfalfa	*(Medicago sativa)*	Loquat	*(Eriobotrya japonica)*
Asl-e-Amir	*(Vitex negundo)*	Maize	*(Zea mays)*
Berseem	*(Trifolium spp.)*	Mesquite	*(Prosopis spp.)*
Bhaikar	*(Adhatoda vasica)*	Phulai	*(Acacia modesta)*
Brassica	*(Brassica spp.)*	Shain	*(Plectranthus rugosus)*
Citrus	*(Citrus spp.)*	Shain Shobae	*(Perovskia atriplicifolia)*
Cotton	*(Gossypium spp.)*	Sunflower	*(Helianthus annuus)*

Fig.9. Major sources of nectar and pollen for bees in Pakistan

(Panicum spp. and Echinochloa spp.) and sorghum (Sorghum spp.) in 1,809,300 ha, castor (Ricinus communis) in 26,545 ha, fruit plants such as apple (Malus pumila), almond, apricot, cherries, peach, plum (Prunus spp.), citrus (Citrus spp.), dates (Phoenix spp.), grapes (Vitis spp.), guava (Psidium guajava), loquat (Eriobotrya japonica), pear (Pyrus spp.), and pistachio (Pistacia spp.), etc. in 407,700 ha (Anon., 1985). Of these crops, rape and mustard, pulses and fodders are mainly concentrated in NWFP, Punjab and Sind, cotton in the Punjab and Sind and temperate fruits in Baluchistan and NWFP.

There are different forests spread over an area of 10,597,000 ha in the country (Anon., loc. cit.). In these forests, several plant species valuable to honeybees abundantly occur depending upon the climatic factors (temperature, rainfall and vegetation Figs. 2.5). These species include some fairly important honey plants such as acacia (Acacia spp.),'siris' (Albizia lebbeck), ash (Fraxinus spp.), eucalyptus (Eucalyptus spp.), 'shain' (Plectranthus spp.), wild olive (Olea cuspidata), mesquite (Prosopis spp.), 'jaman' (Syzgium cumini), tamarix (Tamarix spp.), 'ainul-asl' (Robinia pseudoacacia), 'shisham' (Dalbergia sissoo), 'ber' (Ziziphus spp.) and mulberry (Morus alba).

However, none of the areas provde bee flora throughout the year. The flora is abundant in some areas during April-June, in others in September-October and in still others in November-February. The honeybee populations dwindle to variable extent during the period of scarcity of flora and partly suffer a crash at some locations. The surviving colonies, owing to their small populations, produce very low honey yield in the next season and pollination of entomophilous crops and fruit trees is adversely affected in some areas.

2. ADDITIONAL BEE FLORA

During the present studies, three hundred and seventy nine additional honey plants were recorded from different ecological areas. Most of these plants yield nectar and pollen in small quantities but are considered to be valuable because of their support to bees during the dearth periods between main honey flows. These plants, categorised for their relative importance as a major, medium, minor or rare sources of nectar or pollen or both for the bees, are listed here along with their flowering period and distribution (Table 17).

Table 17

Plants foraged by honeybees for nectar (N) and pollen (P) in different areas

S.No.	Name of plant	Flowering Period	Source	Status	Distribution
1	2	3	4	5	6
1.	Adentostemma lavenia (L.) O. Ktze.	Jul.-Aug.	N	Minor	Punjab, NWFP and Azad Kashmir
2.	Agave americana L.	Oct.-Nov.	N	-do-	Rawalpindi, Abbottabad and Murree
3.	Ailanthus altissima (Mill.) Swingle (Tree of Heaven)	May -Jun.	N P	-do-	Azad Kashmir, Baluchistan, Gilgit and Hazara
4.	A. excelsa Roxb.	Feb.-Mar.	N P	-do-	Sind and Punjab
5.	Ainsliaea latifolia (D. Don) Schultz.-Bip.	Jun.-Jul.	N P	-do-	Murree Hills and Azad Kashmir (1600-3000 m)
6.	Alisma lanceolatum (With.)	Jun.-Sep.	N	-do-	Sind and Azad Kashmir
7.	A. plantago-aquatica L.	Jun.-Aug.	N	-do-	Rawalpindi, Murree, Hazara, Swat, Wah and Azad Kashmir
8.	Allium chitralicum Wang and Tang	Jul.-Aug.	N	-do-	Chitral
9.	Amorpha fruticosa Linn. (The 'Bastard indigo')	Apr.-May	N P	-do-	Punjab and NWFP
10.	Anagallis arvensis L. ('Pimpernal','Billi booti')	Feb.-Apr.	N P	-do-	Punjab, Sind and Azad Kashmir (up to 2300 m)

1	2	3	4	5	6
11.	Anemone polyanthes D. Don.	Mar.-Apr.	P	Minor	Hazara, Swat, Kaghan, Chitral, Dir and Azad Kashmir (3000-4000 m)
12.	A. vitifolia Ham.	Sep.-Oct.	P	-do-	Murree, Hazara, Kaghan and Azad Kashmir (1600-3300 m)
13.	Anthemis gayana Boiss.	Apr.-May	N	-do-	Rawalpindi, Murree, NWFP and Baluchistan
14.	A. odontostephana Boiss.	Apr.-May	N	-do-	NWFP and Baluchistan
15.	Apium graveolens L. (Wild celery)	Mar.-Jul.	N	-do-	Sind, Baluchistan, NWFP, Gilgit, Baltistan and Azad Kashmir
16.	A. leptophyllum (Pers.) Muell.	Apr.-May	N	-do-	Hazara (Oghi)
17.	A. nodiflorum (L.) Reichb.	May-Jun.	N	-do-	Wana
18.	A. pubiflora Wall. ex Royle ('Columbine')	Apr.-Aug.	N	-do-	Kurram valley, Swat, Hazara, Murree and Azad Kashmir
19.	Aralia cachemirica Dcne.	Jun.-Oct.	N	-do-	Hazara, Dir, Chitral and Azad Kashmir (2300-4000 m)
20.	Argyrolobium flaccidum (Royle) Jaub. and Spach	Jul.-Aug.	P	-do-	Murree, Islamabad, Rawalpindi and Wah
21.	Arnebia banthami (Wall. ex G. Don) I.M. Johnston	Jun.	N	-do-	Azad Kashmir, Kaghan and Kurram valley (300-4000 m)
22.	Asparagus deltae Blatter	Jul.-Aug.	N P	-do-	Sind

1	2	3	4	5	6
23.	A. dumosus Baker	Jul.-Aug.	N P	Minor	Baluchistan and Sind
24.	A. gharoensis Blatter	Jul.	N P	-do-	Sind
25.	A. neglectus Kar. and Kir.	Jun.-Jul.	N P	-do-	Baluchistan
26.	Asperula glomerata (M. B.) Griseb.	Jun.	N	-do-	Baluchistan and Kurram Agency
27.	Asyneuma thomsonii (Hook. f.) Bronm.	May-Aug.	N	-do-	Chitral, Dir, Swat, Hazara, Kaghan and Azad Kashmir
28.	Avicennia alba Blume	Feb.-Jun.	N	-do-	Baluchistan and Sind
29.	Berberis baluchistanica Ahrendt ('Karoskai', Zrolg' and 'Koae')	Mar.-May	N	Rare	Baluchistan
30.	B. brandisiana Ahrendt	Apr.-Jun.	N	-do-	Murree Hills, Hazara and Kaghan
31.	B. jaeschkeana C.K. Schn.	May -Jun.	N	-do-	Swat, Kaghan and Azad Kashmir
32.	B. calliobotrys Aitch. ex Koehne	Apr.-Jun.	N	Minor	Dir, Chitral, Gilgit, Parachinar, Hazara, Kaghan, Murree, Azad Kashmir, Waziristan, Quetta, Ziarat and Zhob
33.	B. pachyacanth Koehne('Simu')	Apr.-Jun.	N	Rare	Kaghan, Murree and Azad Kashmir
34.	Berchemia floribunda (Wall.) Brongn.	Jul.-Sep.	N	-do-	Poonch and Jhelum

1	2	3	4	5	6
35.	*Bidens pilosa* L.	Aug.-Sep.	N	Minor	Punjab and Azad Kashmir
36.	*Blainvillea acmella* (L.) Philipson	Jul.-Aug.	N	-do-	Sind, NWFP and Punjab
37.	*Butea monosperma* (Lam.) Taubert ('Dhak')	Mar.-Apr.	N	-do-	Foot-hill zone from Rawalpindi to 1400m and cultivated in the plains
38.	*Caesalpinia pulcherrima* (Linn.) Swartz	Apr.-Sep.	N P	-do-	Cultivated in Pakistan
39.	*Cajanus cajan* (L.) Millsp. ('Arhar' or Pigeon Pea)	Jul.-Aug.	P	-do-	Plains and lower hills
40.	*Calliandra inermis* (L.) Druce	Jul.-Sep.	N	Rare	Lahore
41.	*Callicarpa macrophylla* Vahl	Dec.-Jan.	N	Minor	Murree, Swat, Hazara, Poonch, Palandri, Kohala, Mirpur and Muzaffarabad
42.	*Campanula colorata* Wall.	Jul.-Aug.	N	-do-	NWFP, Chitral, Gilgit, Baltistan, Kurram, Swat, Murree and Poonch
43.	*C. latifolia* L.	Jul.-Aug.	N	-do-	Astor, Swat (Bishigram and Utror), Hazara, Murree Hills, Poonch and Azad Kashmir
44.	*C. leucoclada* Boiss.	May-Jul.	N	-do-	Sargodha, Quetta, Lora valley, Kalat, Urak, Wana, Kurram and Chitral

1	2	3	4	5	6
45.	*C. sulaimanii* E. Nasir	May-Aug.	N	Rare	Sargodha
46.	*Caragana ambigua* Stocks	Apr.-Aug.	N	Minor	Chamman, Urak, Ziarat and Waziristan
47.	*C. ulicina* Stocks	Apr.	N	-do-	Baluchistan and NWFP
48.	*Cardiospermum halicacabum* Linn. ('Balloon vine' or 'Heart-seed' or 'Lataphatkari')	Oct.-Dec.	N	-do-	Punjab, NWFP, Sind and Azad Kashmir
49.	*Cassiope fastigiata* (Wall.) D. Don.	Mar.-Apr.	N	-do-	Swat, Hazara, Kaghan and Azad Kashmir
50.	*Celastrus paniculata* Willd. ('Kangni', 'Sankhu')	Apr.-Jun.	N P	-do-	Jhelum and Mirpur
51.	*Celosia argentea* L.	Jul.-Oct.	N	-do-	Punjab, Baluchistan, Karachi, Dir, Hazara, Kurram, Swat and Azad Kashmir
52.	*Celtis caucasica* Willd.	Mar.-May	N	-do-	Jhelum, Baluchistan, Kurram, Parachinar, Swat and Kalam
53.	*C. tetrandra* Roxb.	Mar.-Apr.	N	-do-	Chattar, Rawalpindi and Azad Kashmir
54.	*Centaurea bruguieriana* (DC.) Hand. Mazz.	Jun.-Nov.	N	-do-	Quetta, Qila Saif-ullah Khan, Bostan, Ziarat, Peshawar, Dargai and Attock

1	2	3	4	5	6
55.	*C. cakcitrapa* L.	Jul.-Sep.	N	Minor	Punjab and Azad Kashmir
56.	*C. virgata* Lam.	Jul.-Nov.	N	-do-	Hanna and Kurram
57.	*Cercis siliquastrum* L. ('Judas') tree	Feb.-May	N P	-do-	Abbottabad
58.	*Chrozophora obliqua* (Vahl) Juss. ex Spreng.	Mar.-Apr.	N P	-do-	Baluchistan, Sind and Azad Kashmir
59.	*C. plicata* (Vahl) A. Juss.	Feb.-Apr.	N P	-do-	Karachi, Lahore and Multan
60.	*C. tinctoria* (L.) Juss.	Feb.-Apr.	N P	-do-	Baluchistan, Sind, Punjab and Chitral
61.	*Chrysanthemum griffithii* Clarke	Mar.-Apr.	N	-do-	Murree, Kurram, Chitral, Swat and Azad Kashmir (2800-4000 m)
62.	*C. leucanthemum* L.	Mar.-Apr.	N	-do-	Murree, Nathia Gali and Dunga Gali
63.	*C. falconeri* (Hk.f.) Petrak	May-Jun.	N	Rare	Swat and Azad Kashmir
64.	*Cichorium noeanum* Boiss.	May-Jun.	N	Minor	Urak
65.	*Clematis alpina* (L.) Miller	May-Jun.	N P	Rare	Chitral, Gilgit and Baltistan
66.	*C. barbellata* Edgew.	May-Jun.	N P	-do-	Waziristan
67.	*C. connata* DC.	Aug.	N P	-do-	Dir, Chitral, Swat, Hazara, Murree Hills and Azad Kashmir (1600-3000 m)

1	2	3	4	5	6
68.	*C. gouriana* Roxb.	Apr.-May	N P	Rare	Lower Hazara, Jehlum and Islamabad
69.	*C. grata* Wall.	Aug.-Sep.	N P	Minor	Swat, Bahrain, Chitral (Drosh), Malakand, Hasan Abdal, Murree, Hazara and Azad Kashmir (700-2700 m)
70.	*C. graveolens* Lindl.	Aug.-Sep.	N P	Rare	Baluchistan, Waziristan, Kurram, Dir, Swat, Jhelum, Tret, Rawalpindi and Azad Kashmir (1000-2300 m)
71.	*C. montana* Buch. Ham.	Apr.-Jun.	N P	-do-	Murree Hills, Dir, Chitral and Azad Kashmir
72.	*C. orientalis* L.	May-Jun.	N P	-do-	Baluchistan, Kurram, Chitral, Gilgit and Astor(2300-4700 m)
73.	*C. songarica* Bunge	May-Jun.	N P	-do-	Tabara Tangi, Urak, Sandeman Tangi, Chitral and Gilgit
74.	*Cleome brachycarpa* Vahl ex DC. ('Ponwar')	May-Aug.	N P	Rare	Sind, Lower Baluchistan, Rawalpindi, Multan, Lahore, Jhelum, Sargodha, Bannu and Peshawar
75.	*C. rupicola* Vicary	Jul.-Sep.	N P	Minor	Hala, Karachi
76.	*C. scaposa* DC.	Jul.-Aug.	N P	-do-	Karachi, Boogta Hills, Makran, Bannu, Peshawar, Thal, Hazara, Salt Range, Attock, Rawalpindi and Sangla Hill (1200 m)
77.	*C. viscosa* L.	Jul.-Aug.	N P	-do-	Sind, Baluchistan, Kurram, Chitral, Swat, Mingora, Saidu-sharif, Peshawar, Nowshera, Karakar Pass, Hazara, Jhelum, Lahore, Rawalpindi and Azad Kashmir (0-1300 m)

1	2	3	4	5	6
78.	*Consolida ambigua* (L.) Ball and Heywood (Rocket larkspur)	Mar.-Apr.	N	Rare	Punjab, NWFP, Sind and Baluchistan
79.	*Conyza canadensis* (L.) Cronquist	Jul.-Aug.	N	Minor	Hazara, Murree Hills, Astor and Azad Kashmir
80.	*Coronopus didymus* (L.) Sm.	Mar.-Apr.	P	-do-	Punjab, Sind, Baluchistan, Kurram, Swat, Waziristan and Chitral
81.	*Convolvulus gonocladus* Boiss.	May-Jun.	N	-do-	Baluchistan, Kurram and Landi Kotal
82.	*C. kotschyanus* Boiss.	Apr.-Jul.	N P	Rare	Quetta and Ziarat
83.	*C. leiocalycinus* Boiss.	Mar.-Jul.	N P	Minor	Quetta, Fort Sandeman, D.I. Khan and Tank
84.	*C. lineatus* Linn.	Apr.-Jul.	N P	Rare	Quetta, Ziarat, Wana and Kurram valley
85.	*C. rhyniospermus* Hochst. ex Choisy	Sep.	N P	Minor	Karachi and Hindu Bagh
86.	*C. scindicus* Stocks	Mar.-Dec.	N P	Rare	Karachi, Thana Bula Khan, Tandojam and Shah Bilawul
87.	*C. spinosus* Burm. ('Ritchak' or 'Sahsa')	Apr.	N P	Minor	Quetta, Kalat, Bolan Pass and Loralai
88.	*C. stocksii* Boiss.	Sep.-Oct.	N P	Rare	Shah Bilawul and Thana Bula Khan

1	2	3	4	5	6
89.	*Coreopsis atkinsoniana* Douglas	Sep.-Oct.	N	Rare	A garden favourite
90.	*Cornus capitata* Wall. ('Tharmal')	Apr.-Jun.	N	-do-	Muzaffarabad
91.	*C. macrophylla* Wall. ('Kandara' or 'Kandar').	Apr.-Jun.		Minor	Murree, Swat and Mirpur
92.	*C. oblonga* Wall. ('Ban Kukur')	Sep.-Dec.	N	-do-	Rawalpindi, Jehlum valley, Muzaffarabad and Kotli
93.	*Corylus colurna* (Hazlenut or 'Urni')	Mar.-Apr.	P	-do-	Dir, Swat, Changla and Azad Kashmir
94.	*Cotoneaster afghanica* Klotz.	Sep.-Oct.	N	-do-	D.I.Khan, Kurram, Chitral, Ziarat and Waziristan
95.	*C. falconeri* Klotz.	Oct.-Nov.	N	-do-	Dir, Khawaja Khela, Shangla, Chitral, Mir Karim and Tangi (1300-1900 m)
96.	*C. integerrima* Medik.	Sep.-Nov.	N	-do-	Swat, Gilgit, Baltistan, Dras, Astor, Hazara and Azad Kashmir (2600-4000 m)
97.	*C. lindleyi* Steud.	Sep.-Nov.	N	-do-	Swat, Abbottabad, Uri, Jehlum valley, Astor and Azad Kashmir (1400-3600 m)
98.	*C. microphylla* Wall. ex Lindl.	Sep.-Oct.	N	-do-	Chitral, Kaghan, Mokhshpuri, Bahrain, Changla and Dunga Galis, Murree and Azad Kashmir

1	2	3	4	5	6
99.	C. obovata Wall. ex Dunn	Sep.-Oct.	N	Minor	Chitral, Dir, Gilgit, Utror and Azad Kashmir
100.	C. pruinosa Klotz.	Oct.	N	Rare	Kalat, Chitral, Khawaja Khela, Shangla, Utror and Azad Kashmir
101.	C. rechingeri Klotz.	Sep.-Nov.	N	-do-	Fort Sandeman
102.	C. rosea Edgew.	Sep.-Nov.	N	-do-	Kalam, Ushu, Nathia Gali, Changla Gali and Azad Kashmir
103.	Crataegus songarica C. Koch ('Hawthorn')	Apr.-Jun.	N P	Minor	Kalat, Kurram, Chitral, Swat, Astor, Gilgit, Hazara, Murree Hills and Azad Kashmir(1000-3000 m)
104.	C. wattiana Hemsl. and Lace	Apr.-Jun.	N P	Rare	Chitral and Urak-Zarghun (2400 m)
105.	Crotalaria albida Heyne ex Roth	Jul.-Sep.	N	-do-	Rawalpindi, Salt range, Jehlum, Hazara and Azad Kashmir (700-2300 m)
106.	C. burhia Buch.-Ham. ex Benth.	Jan.-Feb.	N	Minor	Sind,Baluchistan, NWFP and Salt range
107.	C. calycina Schrank	Oct.	N	Rare	Rawalpindi, Mansehra,Hazara and Kotli
108.	C. juncea Linn. ('San hemp')	May-Sep.	N	Minor	Cultivated in plains and Sind
109.	C. medicaginea Lamk.	Mar.-Aug.	N	-do-	Sind, Baluchistan, Punjab, Swat, Hazara and Poonch
110.	C. mysorensis Roth.	Oct.	N	-do-	Wah, Poonch, Attock, Sialkot, Hazara and Murree hills

1	2	3	4	5	6
111.	C. prostrata Rottl.	Oct.-Nov.	N	Rare	Hazara and Batrasi
112.	Croton plicatum Roxb.	Mar.-Apr.	N P	-do-	Sind
113.	C. sparsiflorus Morong	Feb.-Apr.	N P	-do-	NWFP and Punjab
114.	Cucumis callesus (Roettl.) Cong. ('Kachri')	Jul.-Nov.	N P	Minor	Baluchistan, Sind, NWFP, Punjab and Azad Kashmir
115.	C. sativus Linn. ('Khira', cucumber)	Almost throughout the year	N P	-do-	Baluchistan, Sind, NWFP, Punjab and Azad Kashmir
116.	Cydonia oblonga Mill. ('Quince' or 'Bihi')	Dec.-Jan.	N P	-do-	Baluchistan, Chitral and Azad Kashmir
117.	Datisca cannabina L.	May-Aug.	N P	-do-	Swat, Dir, Chitral, Kaghan and Azad Kashmir (1300-3000 m)
118.	Delphinium denudatum Wall. ex H. and T.	Apr.-May	N	-do-	Madyan, Bishigram, Kaghan, Chitral and Ziarat
119.	D. kohatense (P. Briihl) Munz	Aug.-Sep.	N	-do-	Swat, Kohat, Dadar, Mansehra, Salt range, Hansan Abdal, Abbottabad, Ziarat, Chitral (Kala Drosh), Poonch and Waziristan
120.	D. suave Huth	Apr.-May	N	-do-	Kurram, Ziarat, Chitral and Kohat

1	2	3	4	5	6
121.	D. uncinatum H. and T.	Mar.-May	N	Minor	Dir, Mingora, Manglaur, Madyan, Hazara, Hasan Abdal, Murree, Marghalla, Kach, Kurram, Khyber, Waziristan, Kotli, Domel and Banihal (500-2300 m)
122.	D. vestitum Wall.ex Royle (Bluish purple Larkspur)	Aug.-Sep.	N	-do-	Abbottabad, Naran, Dunga Gali, Ziarat, Chitral and Azad Kashmir
123.	Diervilla florida Sieb. and Zucc.	Jun.-Aug.	N	Rare	Cultivated in Abbottabad
124.	Digitalis lanata Ehrh.	Jun.-Jul.	N	-do-	Azad Kashmir
125.	D. purpurea L.	Jun.-Jul.	N	-do-	Planted for use as a medicine or for its handsome flowers
126.	Diospyros kaki Linn. (Persimmon or 'kaki')	May	N	-do-	Swat
127.	Dipsacus sativus (Linn.) Honck. ('Teasel')	Jun.-Jul.	N P	-do-	Abbottabad
128.	D. inermis Wall. ('Uppalhak')	Aug.-Sep.	N P	Minor	Dir, Swat, Drosh, Kaghan, Changla Gali, Dunga Gali and Nathia Gali, Murree Hills and Azad Kashmir (2800-4000 m)

1	2	3	4	5	6
129.	*Dodonaea viscosa* (L.) Jacq. ('Sanatha')	Jan.-Mar.	N	Minor	Sind, Baluchistan, north and south Waziristan, Thal to Kurram, Dir, Swat and Hazara eastwards (ascending to 1600 m)
130.	*Duchesnea indica* (Andr.) Focke (Strawberry)	Mar.-Apr.	N P	-do-	South Waziristan, Kurram, Dir, Chitral, Swat, Gilgit, Hazara, Murree Hills, Rawalpindi, Hasan Abdal, Poonch and Azad Kashmir (600-2700 m)
131.	*Echinops cornigerus* DC.	Jul.-Aug.	N	Rare	Gilgit, Hunza, Chitral, Skardu and Azad Kashmir
132.	*E. niveus* Wall. ex DC.	Jul.-Aug.	N	Minor	Dunga Gali, Changla Gali, Murree and Ghora Gali (1300-2700 m)
133.	*Eclipta prostrata* (L.) L.	Jul.-Aug.	N	-do-	Punjab, Sind, Baluchistan, Kurram valley, Swat, Hazara and Azad Kashmir (1700 m)
134.	*Elaeagnus angustifolia* L. ('Russian olive')	Apr.-May	N	-do-	Quetta Valley, Mastung, Kalat, Sibi, Zhob, Sanjawi, Razani, Miram Shah, Razmak, Wana, Kurram and Chitral (Mirkhani, Sharbat)
135.	*E. orientalis* L.	Apr.-May	N	-do-	Swat, Astor, Gilgit, Kurram, Wana and Boya
136.	*E. umbellata* Thunb.	Apr.-May	N	-do-	Kalam, Madyan, Shangla, Gilgit, Mansehra, Kaghan, Murree, Kurram, Azad Kashmir and Poonch

1	2	3	4	5	6
137.	Elsholtzia ciliata (Thunb.) Hylander	Sep.-Oct.	N P	Minor	Dir, Gilgit, Baltistan, Shyok valley, Nubra, Hazara, Murree, Poonch and Azad Kashmir
138.	E. densa Bth.	Sep.-Oct.	N P	-do-	Chitral, Gilgit, Astor and Azad Kashmir, common in fields (2700-4700 m)
139.	E. eriostachya Bth.	Sep.-Oct.	N P	Rare	Chitral, Astor, Kaghan and Azad Kashmir (3000-5000 m)
140.	E. fruticosa (D. Don) Rehder	Sep.-Oct.	N P	-do-	Hazara, Poonch beyond Bagh and Azad Kashmir (1600-3000 m)
141.	Ephedra ciliata Fisch. and Mey. ex C.A. Mey.	Jan.-Feb.	N P	Minor	Changa Manga, Muzaffargarh, Salt range, Multan, Faisalabad, Karachi, Baluchistan and NWFP
142.	E. gerardiana Wall. ex Stapf.	Feb.	N P	Minor	Urak, Razmak, Chitral, Swat, Gilgit, Baltistan and Azad Kashmir (1800-5600 m)
143.	E. intermedia Schrenk	Feb.-Mar.	N P	Rare	Ziarat and Chaman
144.	E. procera Fisch. and Mey.	Jan.-Feb.	N P	-do-	Ziarat, Razmak, Kurram and Chitral
145.	Epilobium angustifolium L.	Jul.-Sep.	N	Minor	Kurram, south Waziristan, Swat, Gilgit, Hazara, Poonch and Azad Kashmir (2300-4850 m)
146.	E. cylindricum D. Don	Jun.-Sep.	N	-do-	Nathia Gali, Waziristan, Chitral, Baltistan and Azad Kashmir (1850-3300 m)

1	2	3	4	5	6
147.	E. hirsutum L.	Jun.-Sep.	N	Minor	Rawalpindi, Wah, Attock, Kurram, Chitral, Swat, Hazara, Poonch and Azad Kashmir (500-2500 m)
148.	E. laxum Royle	Jul.-Sep.	N	-do-	Chitral, Drosh, Kalam, Utror, Kaghan valley and Azad Kashmir (2000-4400 m)
149.	E. royleanum Hausskn.	Jul.-Sep.	N	-do-	Swat, Murree and Azad Kashmir (1500-3350 m)
150.	E. tibetanum Hausskn.	Jun.-Sep.	N	-do-	Swat, Kurram, Kaghan and Chitral (2000-3650 m)
151.	Erodium ciconium (L.) L'Herit ex Ait.	Mar.-Apr.	N P	Rare	Kohat Pass, Peshawar, Khyber Pass, Saidusharif and Mingora (600-1000 m)
152.	E. cicutarium (L.) L'Herit ex Ait.	Mar.-Apr.	N P	Minor	Sind, Baluchistan, Waziristan, Kurram, Chitral, Swat, Gilgit, Attock, Hazara, Murree hills and Azad Kashmir
153.	E. malacoides (L.) L'Herit ex Ait.	Mar.-Apr.	N P	Rare	Punjab and Abbottabad (300-1400 m)
154.	Eryngium biebersteinianum Nevski ex Bobrov.	May	N P	-do-	Baluchistan, Abbottabad, Swat, Mansehra, Haripur and Azad Kashmir (1600-2000 m)
155.	E. billardieri Del.	May	N	-do-	Baluchistan and Kurram
156.	Eschscholtzia californica Cham. ('Californian poppy')	Feb.-Jun.	N P	Minor	Punjab and Sind

1	2	3	4	5	6
157.	*Eupatorium reevesii* Wall. ex DC.	Aug.-Oct.	N P	Rare	Balakot and Azad Kashmir
158.	*Euphorbia pulcherrima* Willd. ex Kl (Poinsettia)	Nov.-Jan.	N	-do-	Plains of Punjab and Sind
159.	*Fagopyrum tataricum* (L.) Gaert. (Buckwheat)	Aug.-Oct.	N	Minor	Chitral, Swat, Astor, Gilgit and Azad Kashmir
160.	*Gaillardia pulchella* Fouger	May-Jun.	N P	Medium*	Punjab and Sind
161.	*Galinsoga parviflora* Cav.	Jun.-Nov.	N P	Minor	Murree, Hazara, Dir, Baluchistan, Gilgit and Azad Kashmir(1600-3000 m)
162.	*Gaultheria trichophylla* Royle	May	N P	-do-	Swat, Siran valley, Kaghan, Miranjani and Azad Kashmir (3000-4300 m)
163.	*Geranium lucidum* L.	Apr.-May	N	-do-	Rawalpindi, Swat, Bara Gali, Abbottabad,Murree Hills and Azad Kashmir (700-2000 m)
164.	*G. robertianum* L.	May-Jun.	N	Rare	Murree, Changla Gali and Azad Kashmir (1600-2700 m)
165.	*Gladiolus segetum* Ker-Gawl. (Gladiolus)	May	N P	-do-	Panjgur
166.	*Glycyrrhiza glabra* Linn.	May-Jun.	N	-do-	Sibi, Quetta, Pishin, Peshawar, Kurram, Chitral and Azad Kashmir

1	2	3	4	5	6
167.	Grevillea robusta A. Cunn. (Australian oak or Silver or silky oak)	Mar.-Apr.	N	Rare	Islamabad, Rawalpindi, Lahore and Peshawar
168.	Guaiacum officinale Linn.	Mar.-Oct.	N	-do-	Karachi
169.	Hedera nepalensis K. Koch ('Kurie' or The Himalayan ivy)	Oct.-Apr.	N	Minor	Kurram, Chitral, Swat, Abbottabad, Khanuspur, Murree hills, Poonch and Azad Kashmir (1600-2700 m)
170.	Humulus lupulus L. (Hop)	Jul.-Aug.	P	Rare	Azad Kashmir
171.	Ichnocarpus frutescens (Linn.) R. Br. ('Bakkar bel')	Aug.-Dec.	N	-do-	Azad Kasmir
172.	Indigofera heterantha Wall. ex Brand.	May-Jul.	N P	Minor	Nathia Gali, Kurram, Chitral and Swat
173.	Jacaranda mimosifolia D.Don	Apr.-May	N P	-do-	Islamabad, Rawalpindi, Lahore, Haripur, Hasan Abdal and Peshawar
174.	Jasminum grandiflorum L. (Spanish jasmin 'Chambeli')	May-Jun.	N P	Rare	All provinces (except high hills)
175.	Lactuca brunoniana (Wall. ex DC.) Clarke	May -Sep.	N	Minor	Dir, Chitral, Murree hills, Swat, Hazara, Gilgit and Azad Kashmir (1200-3000 m)

1	2	3	4	5	6
176.	Lamium album L.	Feb.-Mar.	P	Minor	Chitral, Swat, Hazara, Murree hills and Azad Kashmir
177.	L. amplexicaule L.	Feb.-Apr.	N P	-do-	Swat, Hazara, Chitral, Baluchistan, Peshawar and Azad Kashmir
178.	L. rhomboideum (Bth.) Bth.	Feb.-Mar.	P	-do-	Chitral and Kurram
179.	Lannea coromandelica(Houtt.) Merrill('Kamlai')	Mar.-Apr.	N P	-do-	Islamabad, Rawalpindi, Swat and Mirpur
180.	Lathyrus odoratus Linn.(Sweet Pea)	Feb.-Apr.	N	-do-	Azad Kashmir, Baluchistan, NWFP, Punjab and Sind
181.	Leonurus cardiaca L. ('Motherwort')	May-Nov.	N	Medium*	Murree, Chitral, Kurram, Dir, Ziarat and Azad Kashmir
182.	Leptorhabdos parviflora (Bth.) Bth.	Aug.-Sep.		Minor	Baluchistan, Kurram, Dir, Chitral, Swat, Hazara, Kaghan, Murree hills and Azad Kashmir
183.	Leucaena Leucocephala (Lam.) de Wit. ('Kubabhal')	Jun.-Nov.	N P	Rare	Punjab and Sind
184.	Limonium axillaris (Forssk.) O. Ktze.	Aug.-Sep.	N	-do-	Karachi and Thatta
185.	L. cabulicum (Boiss.) O. Kuntze	Jul.-Sep.	N	-do-	Quetta
186.	L. macrorhabdon (Boiss.) O. Kuntze	Jul.-Sep.	N	-do-	Chitral, Gilgit, Ziarat and Skardu

1	2	3	4	5	6
187.	L. gilesii (Hemsl.) Rech. f. & Koeie	Aug.-Sep.	N	Rare	Chitral and Dir
188.	Linum corymbulosum Reichenb.	Mar.-Jun.	N P	Minor	Baluchistan, Attock, Peshawar, Drosh, Lower Swat and Azad Kashmir
189.	L. grandiflorum Desf. (Flowering flax)	Mar.-Apr.	N P	Rare	Planted in flower gardens
190.	L. perenne L.	Apr.-Jun.	N P	-do-	Kurram, Chitral, Ziarat and Azad Kashmir
191.	Ludwigia perennis Linn.	Aug.	N	-do-	Peshawar and Hazara
192.	Lupinus polyphyllus Lindl.	Apr.	N P	Minor	Cultivated as a garden plant
193.	Lycium depressum Stocks	May-Jun.	N	-do-	Karachi, Fort Sandeman, Kalat and Pishin valley
194.	L. ruthenicum Murray	Jun.-Aug.	N	-do-	Pishin, Quetta, Mastung, Kalat, Baltistan and Skardu
195.	L. shawii R. and S.	Nov.-Jan.	N	-do-	Karachi, Changa Manga and Lahore
196.	Lycopus europaeus L.	Jun.-Oct.	N	Medium*	Punjab, Kurram, Peshawar, Dir, Chitral, Swat, Gilgit, Skardu, Hazara and Azad Kashmir
197.	Malva neglecta Wallr.	Aug.-Oct.	N P	Minor	Baluchistan, Sind, Chitral, Swat, Astor, Gilgit, Murree hills and Azad Kashmir
198.	M. parviflora L.	Sep.-Oct.	N P	-do-	Punjab, Sind, Baluchistan and Abbottabad

1	2	3	4	5	6
199.	M. sylvestris L.	Aug.-Sep.	N P	Rare	Punjab and NWFP
200.	Malvastrum coromandelianum (L.) Garcke	Jun.-Sep.	N P	-do-	Sind, NWFP, Punjab and Azad Kashmir
201.	Marrubium alternidens Rech.f.	May-Sep.	N P	Minor	Baluchistan, Wana, Kurram, Parachinar, Khyber, Chitral and Swat
202.	M. vulgare L. (Horehound)	May-Sep.	N	Medium*	Baluchistan, Waziristan, Kurram, Thal, Kohat, Swat and Drosh
203.	Medicago minima (Linn.) Grufb.	Apr.-Jul.	N	Minor	Chitral, Hazara, Rawalpindi, Kohala and Azad Kashmir
204.	M. orbicularis (Linn.) Bart.	Apr.-Jul.	N	-do-	Baluchistan, Swat and Azad Kashmir
205.	M. polymorpha Linn. ('Maina')	Mar.-May	N	Medium*	Sind, Baluchistan, Punjab and Chitral
206.	Melaleuca leucadendron L.	Nov.-Dec.	N	Rare	Punjab
207.	Melia azedarach L. (persian lilac, 'Dhrek')	Mar.-Apr.	N P	Minor	Sind, Punjab, Baluchistan, Kurram and Azad Kashmir
208.	Melilotus alba Desr.	Mar.-Sep.	N	-do-	Sind, Baluchistan, Gilgit, Hazara, Astor and Azad Kashmir
209.	M. indica (Linn.) All. ('Senji', 'Ran-methi')	Mar.-Aug.	N	-do-	Sind, Baluchistan, Punjab and Azad Kashmir (common to 1300 m)
210.	M. officinalis (Linn.) Pall.	Sep.	N	Medium*	Chitral and Gilgit

1	2	3	4	5	6
211.	Melissa officinalis L.	Jul.	N P	Rare	Abbottabad
212.	Mentha arvensis L.	Jul.-Oct.	N	Minor	Baluchistan and Azad Kashmir
213.	M. spicata L. (Spearmint)	Jul.-Oct.	N	Medium*	Quetta, Pishin, Parachinar, Kurram valley and Azad Kashmir
214.	Mesembryanthemum crystallinum Linn. (Ice plant)	Feb.-Apr.	N	Minor	NWFP, Punjab and Sind
215.	Micromeria biflora (Ham.) Bth.	Feb.-Jun.	N	-do-	Kurram, Parachinar, Dir, Malakand, Chitral, Swat, Hazara, Murree, Rawalpindi, Islamabad and Azad Kashmir, (plains to 2700 m)
216.	M. hydaspidis Falc. ex Bth.	Jul.-Oct.	N	-do-	Dunga Gali and Khanspur
217.	Mucuna nigricans (Lour.) Steud.	Jul.-Oct.	N	Rare	Mirpur
218.	M. pruriens (Linn.) DC. ('Gugli')	Nov.-Mar.	N	-do-	Mirpur
219.	Nepeta discolor Royle ex Bth.	May-Oct.	N	Minor	Kurram, Chitral, Gilgit, Astor, Hazara and Azad Kashmir
220.	N. elliptica Royle ex Bth.	Jun.-Oct.	N	-do-	Swat, Chitral and Azad Kashmir
221.	N. glomerulosa Boiss.	Apr.-Jun.	N	-do-	Baluchistan, Waziristan, Chitral, Swat and Gilgit

1	2	3	4	5	6
222.	N. govaniana (Bth.) Bth.	May-Oct.	N	Minor	Dir, Swat, Hazara, Kaghan and Azad Kashmir
223.	N. griffithii Hedge	Apr.-Jun.	N	Rare	Malakand and Chitral
224.	N. laevigata (D. Don) Hand-Mazz.	Apr.-Jun.	N	Minor	Kurram, Chitral, Swat, Hazara, Murree hills and Azad Kashmir (1700-4000 m)
225.	N. prainii Duthie	May-Jun.	N	-do-	Chitral, Waziristan, Kurram, Swat, Hazara, Mirpur and Azad Kashmir
226.	Nasturtium officinale R.Br.	Feb.-Mar.	P	-do-	NWFP and Ziarat
227.	Nymphaea alba L.	Jun.-Aug.	P	Rare	Abbottabad and Azad Kashmir
228.	N. nouchali Burm. f.	Jul.-Aug.	P	-do-	Jhelum and Sind
229.	Oenothera rosea L. Her.	Apr.-Sep.	N	-do-	Swat, Murree hills and Hazara
230.	Oligochaeta ramosa (Roxb.) Wagenitz.	Jul.-Aug.	N	Minor	Karachi, Chaman, Jhelum, Sangla Hills and Lahore
231.	Onobrychis cornuta (Linn.) Desv.	May-Oct.	N	Rare	Baluchistan, Kurram and Chitral
232.	O. micrantha Schrenk	Jun.	N	Rare	Quetta, Kach and Hindubagh
233.	O. stewartii Baker	Feb.-Apr.	N	-do-	Rawalpindi, Hasanabdal, Hazara and Campbellpur
234.	Opuntia compressa (Salisb.) Macbr.	Apr.-Jul.	N P	Minor	Sind
235.	O. dillenii Haw.	May-Jun.	N P	-do-	Punjab and Sind

1	2	3	4	5	6
236.	O. monacantha Haw.	Apr.-Jun.	N P	Minor	Swat, Jhelum, Kohala, Haripur, Hasan Abdal and Sind
237.	O. stricta Haw.	Apr.-Jun.	N P	-do-	Punjab and Sind
238.	Origanum marjorana L.	Sep.-Oct.	N	-do-	Swat and Gilgit
239.	Oxalis corniculata L.('Khatti booti')	Mar.-Dec.	N P	-do-	Punjab, Sind, Baluchistan, Chitral, Hunza, Hazara and Azad Kashmir
240.	Papaver decaisnei Hochst. and Steud. ex Boiss.	Mar.-May	P	-do-	Baluchistan, Waziristan, Kurram, Parachinar, Chitral, Peshawar and Punjab
241.	P. hybridum L. (Round pricklyheaded poppy)	Apr.-Jun.	P	-do-	Rawalpindi, Hasan Abdal, north Waziristan, NWFP and Azad Kashmir
242.	P. macrostomum Boiss. & Huet ex Boiss.	Apr.-Jul.	P	-do-	Kalat, Hasan Abdal, Hazara, Abbottabad and Azad Kashmir
243.	P. nudicaule L. (Iceland poppy)	May-Aug.	P	-do-	Waziristan, Kurram, Chitral, Gilgit, Baltistan and Azad Kashmir
244.	P. somniferum L. ('Afim')	Apr.-Jun.	P	-do-	NWFP, Punjab and Sind
245.	Parkinsonia aculeata Linn. ('Kabuli Kikar' or Vilayeti Kikar')	Mar.-Jul.	N	-do-	Punjab, Sind, NWFP and Baluchistan
246.	Parthenocissus quinquefolia (L.) Planch. (Virginia creeper)	Jun.-Aug.	N	Rare	Abbottabad

1	2	3	4	5	6
247.	P. tricuspidata (Seib. & Zucc.) Planch.	Jun.-Jul.	N	Rare	Abbottabad, Haripur and Mansehra
248.	Passiflora coerulea Linn. ('Ghari phul' or (Passion flower)	May-Oct.	N	Minor	Punjab, NWFP and Azad Kashmir
249.	P. foetida Linn.	Jul.-Aug.	N	Rare	Karachi
250.	Paulownia tomentosa (Thunb.) K. Koch	Jun.	N	-do-	NWFP and Azad Kashmir
251.	Peltophorum pterocarpum (DC.) Backer ex K. Heyne	Mar.-Jun.	N P	Minor	All provinces (road sides)
252.	Pentatropis spiralis (Forssk.) Decne. ('Ambevel')	Feb.	N P	-do-	Baluchistan, Sind, Punjab, NWFP and Kurram valley
253.	Pergularia daemia (Forssk.) Chiov.	Jan.-Apr.	N P	-do-	NWFP, Baluchistan, Sind, Punjab and Azad Kashmir
254.	Perilla frutescens (L.) Britt.	May	N	-do-	Hazara, Balakot, Kaghan, Murree hills and Azad Kashmir
255.	Peristrophe bicalyculata (Retz.)	Jul.-Aug.	N	-do-	Rawalpindi, Lahore, Multan, Karachi, Bela, Swabi and Peshawar
256.	Perovskia atriplicifolia Bth. ('Shain shobae')	Aug.-Sep.	N	Major	Ziarat, Razmak, Kurram, Wana, Parachinar, Chitral, Gilgit and Baltistan
257.	Peucedanum beluchistanicum Wolff.	May	P	Rare	Baluchistan

1	2	3	4	5	6
258.	P. ferulaefolium Gilli	May	P	Rare	Baluchistan
259.	Phaseolus lunatus Linn. (Lima bean or 'Lobia')	Jul.-Sep.	N	-do-	Baluchistan, Sind, Punjab and NWFP
260.	Phyla nodiflora (Linn.) Greene ('Makna', 'Wakan', 'Jal-nim')	Throughout the year	N	Medium*	Lahore, Rawalpindi, Islamabad, Karachi, Harnai, Fort Sandeman, Panjgur, Waziristan, Kurram, Thal, Parachinar, Khyber, Peshawar, Landi Kotal, Kohat, Tirah, Lower Hazara and Azad Kashmir
261.	Pisum sativum Linn. ('Mattar')	Dec.-Mar.	N	Minor	All provinces and Azad Kashmir
262.	Platanus orientalis L. ('Chinar')	Apr.-May	P	-do-	Baluchistan, Waziristan, Kurram and Chitral
263.	Pluchea arguta Boiss.	Jul.-Sep.	N	-do-	Sind, Baluchistan, NWFP and Punjab
264.	P. lanceolata Oliv. & Hiern.	Jul.-Sep.	N	-do-	Sind, Baluchistan, NWFP and Punjab
265.	P. ovalis (Pers.) DC.	Jun.-Sep.	N	Rare	Jhelum
266.	Plumbago zeylanica L. ('Chitrak')	Jul.-Sep.	N	Minor	Swat, Hazara, Haripur, Multan, Rawalpindi, Saidpur, Changa Manga and Azad Kashmir

1	2	3	4	5	6
267.	Polygonum convolvulus L. (Black Bindweed or wild buckwheat)	Aug.-Sep.	N	Minor	Nathia Gali, Kurram, Parachinar, Chitral, Gilgit, Astor and Azad Kashmir(2700-4300 m)
268.	P. nepalense Meissn.	May-Jun.	N	-do-	Hazara, Bahrain, Madyan, Kalam, Utror, Murree, Gilgit, Dras and Azad Kashmir (1300-3500 m)
269.	P. persicaria L.	Jul.-Nov.	N	Medium*	Quetta, Loralai, Kurram, Peshawar, Kohat, Thal, Chitral, Dir, Gilgit, Baltistan, Astor and Azad Kashmir (1300-3300 m)
270.	P. plebejum R. Br.	Jun.-Oct.	N	Minor	Sind, Baluchistan, NWFP, Punjab and Azad Kashmir
271.	P. rumicifolium Royle ex Bab.	Jul.-Oct.	N	-do-	Chitral, Swat, Gilgit, Baltistan, Astor, Dras, Hazara and Azad Kashmir
272.	Pongamia pinnata (Linn.) Pierre	Apr.-May	P	Rare	Punjab and Sind
273.	Praecitrullus fistulosus (Stocks) Pangalo ('Tinda')	Mar.-Sep.	N P	Minor	All provinces and Azad Kashmir
274.	Prunella vulgaris L. (Self-heal, Carpenter-weed)	May-Jun.	N	-do-	Kurram, Dir, Chitral, Swat, Gilgit, Baltistan, Astor, Dras, Hazara, Murree hills, Poonch and Azad Kashmir
275.	Psammogeton stocksii (Boiss.) E. Nasir	Feb.-Apr.	N	-do-	Baluchistan

1	2	3	4	5	6
276.	Psoralea corylifolia Linn. ('Bauchi')	Aug.-Dec.	N	Minor	Baluchistan and Peshawar
277.	P. plicata Delile	Apr.	N	-do-	Sind, Baluchistan and Punjab
278.	Pulsatilla wallichiana (Royle) Ulbr.	Feb.-Mar.	P	Rare	Chitral
279.	Quercus baloot Griff. ('Breh')	Apr.-May	P	-do-	Kurram, Dir, Chitral, Swat, Kaghan and Azad Kashmir
280.	Q. incana Roxb. ('Ban', 'Ringi')	Apr.-May	P	-do-	Dir, Swat, Hazara, Murree hills, Poonch and Azad Kashmir
281.	Q. robur Linn. (English oak)	Apr.-May	P	-do-	Quetta, Parachinar, Abbottabad, Murree and Azad Kashmir
282.	Reseda aucheri Boiss.	Feb.-Apr.	N P	Minor	Thatta, Hyderabad, Loralai, Fort Sandeman, Zhob and Sibi
283.	R. luteola Linn. (Dyers weed)	May-Jun.	N P	-do-	Kurram, Parachinar and D.I.Khan
284.	R. odorata Linn. (Sweet mignonette)	Apr.-May	N P	Medium*	Rawalpindi, Quetta and Karachi.
285.	R. pruinosa Delile	Oct.-Jun.	N P	Rare	Baluchistan, Kotri, Peshawar, D.I. Khan and Salt range
286.	Rhamnus triquetra Wall. ex Roxb. ('Girgithan', 'Gount', Gudlei')	Jul.-Aug.	N P	Minor	Azad Kashmir (600-1700 m)

1	2	3	4	5	6
287.	Rhoeo spathacea (Swartz) Stearn ('Chashm-e-Nargis')	Almost round the year	P	Rare	Sind
288.	Rhus mysurensis Heyne ex Wight and Arn.	Jun.-Jul.	N P	Minor	Sind, Baluchistan and Waziristan
289.	Robinia pseudoacacia Linn. ('Ain-ul-asl')	Mar.-Apr.	N P	Major	Baluchistan, NWFP, Azad Kashmir and some parts of Punjab and Sind
290.	Roystonea regia (H.B. & K.) O.F. Cook ('Royal palm, Bottle palm')	Throughout the year	N P	Minor	Karachi
291.	Rubus ulmifolius Schott	Jun.-Oct.	N P	-do-	Murree, Hasan Abdal, Swat, Chitral, Hazara and Baluchistan
292.	Sagittaria guayanensis H.B.& K.	Aug.-Nov.	N	-do-	Punjab, Abbottabad, Hazara and Swat valley
293.	S. sagittifolia L. (Arrow-head)	Apr.-Sep.	N	-do-	Sind, Punjab, Kurram valley, Dir, Swat, Hazara, Abbottabad and Azad Kashmir
294.	Salvia aegyptiaca L.	Oct.-Dec.	N	Major	Sind, Baluchistan, NWFP and Punjab
295.	S. bucharica M. Pop.	Apr.-Jul.	N	Rare	Baluchistan and Waziristan
296.	S. lanata Roxb.	May-Jun.	N	Minor	Dir, Swat, Abbottabad, Murree, Poonch and Azad Kashmir (1000-3000 m)

1	2	3	4	5	6
297.	*S. moorcroftiana* Wall. ex Bth. (Sages)	Almost through-out the year	N	Minor	Baluchistan, Taxila, Rawal-pindi, Chitral, Dir, Swat, Hazara, Waziristan and Azad Kashmir
298.	*S. nubicola* Wall. ex Sweet	May-Jun.	N	-do-	Baluchistan, Kurram, Dir, Chitral, Gilgit, Astor, Swat, Kaghan, Murree hills and Azad Kashmir
299.	*S. officinalis* L.(Sage)	Apr.-Jun.	N	-do-	Azad Kashmir
300.	*S. plebeia* R. Br.	Apr.-May	N	-do-	Sind, Punjab, Kurram, Swat, Peshawar, Kohat, Dir, Chitral and Azad Kashmir
301.	*S. santolinifolia* Boiss.(Sage)	Apr.-May	N	-do-	Sind, NWFP, Baluchistan and Waziristan
302.	*Sambucus nigra* L.	May-Jun.	P	-do-	Parachinar, Kurram valley and Nathia Gali
303.	*S. wightiana* Wall ex Wight & Arn.	May-Jun.	P	-do-	Chitral, Astor, Shishi, Kalam, Utror, Kaghan and Azad Kashmir(1600-3300 m)
304.	*Sapindus mukorossi* Gaertn. ('Ritha', Soapnut)	May-Jun.	N	-do-	Azad Kashmir
305.	*Sapium sebiferum* Roxb. (China tree, 'Pepli')	May-Jun.	N	-do-	NWFP, Rawalpindi, Islamabad, Jhelum, Hazara and Gilgit
306.	*Sarcostemma viminale* Linn. R. Br. ('Soma')	Jun.-Nov.	N P	-do-	Sind

1	2	3	4	5	6
307.	Satureia hortensis L. (Summer savory)	May-Jun.	N	Minor	Hazara and Baltistan
308.	Scaevola taccada (Gaertn.) Roxb. ('Bhadraksh')	Jun.-Dec.	N	Rare	Sind
309.	Schishkinia albispina (Bunge) Iljin	Jul.-Oct.	N	-do-	Quetta and Kalat
310.	Scilla griffithii Hochr.	Feb.-Mar.	N P	Minor	Peshawar, Khyber, Malakand, Chitral, Minogra, Saidu-sharif, Hazara, Marghalla, Hasan Abdal and Azad Kashmir
311.	S. indica Baker	Feb.-Apr.	N P	-do-	Sind
312.	Scrophularia calycina Bth.	Jun.-Jul.	N	-do-	Swat, Kaghan and Azad Kashmir
313.	S. koelzii Penn.	Jun.-Jul.	N	-do-	NWFP, Chitral, Baltistan, Kaghan and Azad Kashmir
314.	D. polyantha Royle ex Bth.	Jun.-Jul.	N	-do-	Swat, Hazara, Galis, Murree hills and Azad Kashmir (600-3000 m)
315.	S. scabiosifolia Bth.	Jun.-Jul.	N	-do-	Baluchistan, Peshawar, Dir, Chitral, Swat, Hazara, Baltistan, Jhelum and Azad Kashmir (700-3000 m)
316.	Sedum adenotrichum Wall. ex Edgew.	Aug.	N	-do-	Baluchistan, Waziristan, Kurram, Dir, Chitral, Swat, Abbottabad, Murree and Azad Kashmir

1	2	3	4	5	6
317.	*S. ewersii* Ledeb.	Aug.-Sep.	N	Minor	Kurram, Dir, Chitral, Swat, Gilgit, Baltistan, Hazara, Murree and Azad Kashmir
318.	*S. hispanicum* L.	Mar.-Apr.	N	-do-	Rawalpindi, Hasan Abdal, Wah, Peshawar, Abbottabad, Swat and Chitral
319.	*Senecio chrysanthemoides* DC.	Apr.-May	N P	-do-	Kurram, Chitral, Swat, Astor, Gilgit, Hazara, Murree and Azad Kashmir
320.	*S. desfontanei* Druce	Mar.-Apr.	N P	-do-	Baluchistan, Hasan Abdal, Attock, Waziristan, Kurram, Chitral, Swat, Gilgit and Astor
321.	*S. nudicaulis* Ham. ex D. Don	Mar.-Apr.	N P	-do-	Baluchistan, Kurram, Astor, Kaghan, Abbottabad, Murree, Jhelum and Azad Kashmir
322.	*Silene conoidea* L.	Jan.-Mar.	P	-do-	NWFP, Punjab and Baluchistan
323.	*Sisymbrium altissimum* L. ('Hedge mustard')	Apr.-May	N P	-do-	Chitral, Astor, Gilgit, Baltistan and Mirpur
324.	*S. brassiciforme* C.A.Mey.	Apr.-May	N P	-do-	Baluchistan, Kurram, Chitral, Swat, Gilgit, Baltistan and Azad Kashmir
325.	*S. erysimoides* Desf.	Mar.-Apr.	N P	-do-	Baluchistan, Punjab, Waziristan and Swat
326.	*S. irio* L.	Feb.-May	N P	-do-	Baluchistan, Punjab, Waziristan, Chitral, Swat, Hazara, Gilgit and Azad Kashmir

1	2	3	4	5	6
327.	Sonchus oleraceus L.	Apr.-May	P N	Minor	Sind, Baluchistan, Chitral, Swat, Gilgit, Hazara, Murree and Azad Kashmir
328.	Sorbaria tomentosa (Lindl.) Rehder	May-Jul.	P N	-do-	Murree hills, Chitral, Swat, Hazara and Azad Kashmir
329.	Sophora alopecuroides Linn.	Apr.-Oct.	N	-do-	NWFP and Baluchistan
330.	S. mollis (Royle) Baker	Mar.-May	N	Minor	NWFP and Baluchistan
331.	S. secundiflora (Ortega) DC.	Jul.-Aug.	N	Rare	Lahore
832.	Sorghum bicolor (L.) Moench ('Jawar', 'Chari')	Jul.-Aug.	P	Minor	Sind, Punjab and Baluchistan
333.	S. halepense (Linn.) Pers. ('Baru', 'Baran')	May-Oct.	P	-do-	Sind, Punjab, NWFP, Baluchistan and Azad Kashmir
334.	S. nitidum (Vahl) Pers. ('Chhota baru')	Sep.-Oct.	P	-do-	Baluchistan, NWFP, Punjab and Azad Kashmir
335.	Stachys alpina L.	Feb.-Apr.	N	-do-	Chitral, Swat, Hazara, Murree hills and Azad Kashmir
336.	S. floccosa Bth.	Jan.-Apr.	N	-do-	Kurram, Chitral, Swat, Hazara and Sind
337.	S. parviflora ('Bui')	Dec.-Apr.	N	-do-	Baluchistan, Punjab, Razmak, Wana, Kurram valley, Peshawar, Kohat and Swat

1	2	3	4	5	6
338.	S. sericea Wall. ex Bth.	Dec.-Apr.	N	Minor	Dir, Chitral, Swat, Astor, Hazara, Murree hills and Azad Kashmir
339.	Stellaria alsine Grimm	Jan.-Feb.	P	-do-	Chitral, Swat, Astor, Gilgit, Hazara and Azad Kashmir
340.	S. monosperma Buch. Ham. ex D. Don	Jan.-Feb.	P	-do-	Baluchistan, Kurram, Swat, Gilgit, Chitral, Dir, Baltistan, Dras, Kaghan and Azad Kashmir
341.	Tagetes patula L.	Mar.-Apr.	P	-do-	Throughout Pakistan
342.	Tanacetum artemisioides Sch. Bip. ex Hk. f.	Mar.-Apr.	N	Rare	Astor and Gilgit
343.	T. eriobasis (Rech.f.) RRS	Mar.-Apr.	N	-do-	Ziarat and Drosh(1500-2800 m)
344.	T. fruticulosum Ledeb.('Burtse')	Apr.-May	N	-do-	Ziarat
345.	T. longifolium Wall. ex DC.	Feb.-Apr.	N	Minor	Swat, Kaghan valley and Azad Kashmir (2800-4000 m)
346.	Tecoma stans (Linn.) H.B. & M. (Yellow alder)	Almost throughout the year	N	-do-	Punjab
347.	Tecomella undulata (Roxb.) Seem. ('Lahura')	Apr.-May and Jan.-Feb.	N	-do-	Sind, Baluchistan, NWFP, Punjab and Azad Kashmir
348.	Telosma cordata (Burm. f.) Merrill	Jul.-Aug.	N P	-do-	Punjab, Sind, Baluchistan, NWFP and Azad Kashmir

1	2	3	4	5	6
349.	*Teucrium royleanum* Wall. ex Bth.	Apr.-Jun.	N	Minor	Kurram, Chitral, Dir, Swat, Hazara and Kaghan
350.	*Torilis leptophylla* (L.) Reichb. f.	Mar.-Apr.	N P	-do-	Peshawar, Swat, Hazara, Murree hills, Jhelum, Rawalpindi and Azad Kashmir
351.	*Trichodesma indicum* (L.) R. Br.	Jun.-Nov.	N	-do-	Jhelum, Rawalpindi, Islamabad, Baluchistan, Karachi, Chitral, Swat, Hazara and Azad Kashmir
352.	*Trifolium repens* Linn.	Apr.-Jul.	N P	-do-	Baluchistan, Chitral, Swat, Gilgit, Baltistan, Dras and Azad Kashmir
353.	*Trigonella foenumgraecum* Linn. (Fenugreek, 'Methi')	Apr.	N P	-do-	Sind, Baluchistan and Punjab
354.	*T. pubescens* Edgew. ex Baker	Apr.-Aug.	N P	-do-	Swat, Hazara, Murree hills and Azad Kashmir
355.	*Trillium govanianum* Wall. ex Royle	Apr.-May	N P	-do-	Kurram, Chitral, Swat, Hazara, Kaghan valley, Nathia Gali, Changla Gali, Murree and Azad Kashmir (2300-4300 m)
356.	*Verbena officinalis* Linn. ('Karenta', 'Pamukh')	Jun.-Dec.	N	-do-	Baluchistan
357.	*Vernonia cinerascens* Sch.Bip.	Jun.-Jul.	N	-do-	Sind, Baluchistan, Punjab, Waziristan and NWFP
358.	*V. cinerea* (L.) Less.	May -Jul.	N	-do-	Sind, Baluchistan, Punjab, Hazara and Azad Kashmir (Plains to 2600 m)

1	2	3	4	5	6
359.	*Veronica anagallis aquatica* L.	Apr.-May	N	Minor	Baluchistan, Kurram, Chitral, Swat, Gilgit, Hazara, Murree and Azad Kashmir
360.	*V. arvensis* L.	Apr.-May	N	-do-	Swat, Hazara and Azad Kashmir
361.	*V. biloba* L. Mant.	Mar.-May	N	-do-	Baluchistan, Kurram, Chitral, Swat, Gilgit, Hazara, Murree and Azad Kashmir
362.	*V. didyma* Tenore	Feb.-Apr.	N	-do-	Baluchistan, Punjab, Kurram, Swat, Astor, Hazara, Chitral, Gilgit and Azad Kashmir
363.	*Viburnum cotinifolium* D. Don	Apr.-Jun.	N	-do-	Baluchistan, Waziristan, Kurram, Chitral, Swat, Astor, Kaghan, Nathia Gali and Azad Kashmir
364.	*V. foetens* Dcne.	Apr.-May	N	-do-	Chitral, Dir, Swat, Hazara, Murree hills and Azad Kashmir
365.	*V. mullaha* D. Don	Apr.-Jun.	N	-do-	Chitral, Swat, Kaghan, Nathia Gali, Murree hills and Azad Kashmir
366.	*Vigna radiata*(L.) Wilezek ('Mung')	Jul.-Sep.	N	-do-	Punjab
367.	*Vincetoxicum canescens* (Willd.)Dcne.	Jun.-Sep.	N P	-do-	Murree hills, Sargodha, Swat, Chitral, Waziristan and Azad Kashmir
368.	*V. hirundinaria* Medicus	May -Jul.	N P	-do-	Kurram valley, Razmak, Hazara, Kaghan valley,Murree hills, Swat and Azad Kashmir

1	2	3	4	5	6
369.	Vitex negundo Linn.('Nirgud', Nirgundi', 'Asl-e-amir')	Apr.-Nov.	N P	Medium*	Faisalabad, Rawalpindi, Peshawar, Haripur, Jolian, Murree hills, Abbottabad, Nowshera, Kurram, Swat, Hyderabad, Karachi, Mirpur and Azad Kashmir
370.	V. pseudo-negundo Hausskn.('Marwan')	May -Jul.	N	Minor	Jhelum, Loralai, Harnai, Fort Sandeman, Panjgur, Abbottabad and north Waziristan
371.	Wattakaka volubilis (Linn. f.) Stapf.	Mar.-Jun.	N P	-do-	Punjab and NWFP
372.	Wisteria sinensis (Sims) DC.	May -Aug.	N P	Rare	Abbottabad and Peshawar
373.	Xanthium strumarium L.	Aug.-Sep.	P	Minor	Sind, Baluchistan, Punjab, Peshawar, Chitral, Swat, Astor, Gilgit, Baltistan, Hazara and Azad Kashmir
374.	Yucca Sp.	Jun.-Jul.	N	Rare	Punjab and lower hills
375.	Zebrina pendula Schniz. (Wandering jew)	Almost round the year	P	-do-	Common ornamental in shady places
376.	Zygophyllum eurypterum Boiss. & Buhse. ('Kich', ('Aelung', 'Karagang')	Mar.-May	N	-do-	Baluchistan

1	2	3	4	5	6
377.	Z. fabago Linn. (Syrian bean-caper, 'Chashum'	May-Sep.	N	Medium*	Baluchistan
378.	Z. propinquum Decne.	Sep.-Jun.	N	Rare	Sind and Baluchistan
379.	Z. simplex Linn. ('Alethi', 'Putlani')	Aug.-May	N	Minor	Sind, Baluchistan, NWFP and Punjab

*Produce large quantity of nectar but found in small areas.

Among the honeybee flora, Gaillardia pulchella, Leonurus cardiaca, Lycopus europaeus, Marrubium vulgare, Medicago polymorpha, Mentha spicata, Melilotus officinalis, Perovskia atriplicifolia, Phyla nodiflora, Polygonum persicaria, Reseda odorata, Robinia pseudoacacia, Vitex negundo and Zygophyllum fabago are important sources of nectar, but are found over a small area in different beekeeping zones. These species can produce a fairly high quantity of honey when grown in large numbers in forest plantations, erodable lands, landscapes, agricultural farms and waste lands.

3. FLORAL CALENDAR OF MARGHALLA AREA

Honeybee flora available to bees in Marghalla (Hasan Abdal-Haripur) area were noted to identify main honey flow periods along with some minor plants valuable to keep the colonies in good condition for the surplus flows. Accordingly bee forage plants yielding nectar and pollen in Marghalla during different months are listed in Table 18.

Table 18

Honeybee floral calendar of Marghalla

Month	Names of plants
January	Adhatoda vasica, Brassica campestris, B. oleracea, Dahlia spp., Eriobotrya japonica and Eucalyptus spp.
February	Adhatoda vasica, Althaea rosea, Brassica campestris, B. oleracea, Citrus, spp., Dahlia spp., Eruca sativa, Eriobotrya japonica, Eucalyptus spp., Fumaria indica, Malus pumila, Pyrus communis, P. pashia, Prunus persica, P. bokhariensis, P. armeniaca, Raphanus sativus, Salvia spp., Salix spp. and Vicia sativa
March	Adhatoda vasica, Althaea rosea, Borago sp., Brassica spp., Callistemon citrinus, Citrus spp., Dahlia spp., Eucalyptus spp., Foeniculum vulgare, Fumaria indica, Prunus armeniaca, P. bokhariensis, P. persica, Pyrus communis, Rosa spp., Salix spp., Salvia spp., Trigonella foenum-graecum and Vicia sativa
April	Acacia modesta, Althaea rosea, Borago sp., Brassica oleracea, B. rapa, Callistemon citrinus, Carthamus oxyacantha, Centaurea cyanus, Citrus spp., Clarkia spp., Cosmos spp., Carissa opaca, Coriandrum sativum, Daucus carota, Dahlia spp., Dalbergia sissoo, Erythrina suberosa, Eucalyptus spp., Foeniculum vulgare, Jacaranda mimosifolia, Lonicera japonica, Malus pumila, Musa sapientum, Prunus persica, Raphanus sativus, Rosa spp., Syzygium cumini, Salvia spp., Sapindus mukorossi, Terminalia arjuna, Trifolium resupinatum and Verbena spp.

May	Althaea rosea, Acacia modesta, Brassica oleracea, B. rapa, Carissa opaca, Carthamus oxyacantha, Centaurea cyanus, Cedrela toona, Clarkia spp., Coriandrum sativum, Cucurbita spp., Daucus carota, Erythrina suberosa, Lagerstroemia indica, Musa sapientum, Portulaca spp., Psidium guajava, Raphanus sativus, Rosa spp., Salvia spp., Sapindus mukorossi, Syzygium cumini, Stenolobium stans, Trifolium spp., Verbena spp. and Vitex negundo
June	Althaea rosea, Centaurea cyanus, Clarkia spp., Cucurbita spp., Cedrela toona, Helianthus annuus, Lagerstroemia indica, Musa sapientum, Portulaca spp., Rosa spp., Saliva spp., Campsis grandiflora, Stenolobium stans, Trifolium spp., Vitex negundo and Zea mays
July	Acacia modesta, Cassia fistula, Cucurbita spp., Luffa spp., Musa sapientum, Portulaca spp., Salvia spp., Sorghum halepense, Campsis grandiflora, Vitex negundo and Zea mays
August	-do-
September	Aster spp., Antigonon leptopus, Cosmos spp., Eriobotrya japonica, Helianthus annuus, Musa sapientum, Pennisetum spp., Trifolium spp., Salvia spp., Campsis grandiflora, Vitex negundo and Zea mays

October	Antigonon leptopus, Aster spp., Cosmos spp., Eriobotrya japonica, Eucalyptus spp., Helianthus annuus, Musa sapientum, Psidium guajava, Salvia spp., Solidago spp. and Vitex negundo
November	Antigonon leptopus, Dahlia spp., Eriobotrya japonica, Eucalyptus spp., Helianthus annuus, Salvia spp., Solidago spp. and Vitex negundo
December	Adhatoda vasica, Antigonon leptopus, Brassica campestris, B. oleracea, Dahlia spp., Eucalyptus spp., Eriobotrya japonica and Poinsettia spp.

There are usually four honey flow periods. These are: (1) April on A. modesta, (2) May-June on Trifolium spp., (3) September-December on E. japonica and (4) December-March on B. campestris. Moreover, there appears to be a continuous supply of nectar and pollen in this area at times when there is serious dearth of flora in other beekeeping locations.

There is scarcity of honeybee flora in the foot-hill areas (Haripur, Rawalpindi, Islamabad) in late summer (July-August). The increased activity of natural enemies particularly the hornets (Vespa spp.) coupled with high temperature and humidity caused unfavourable environment for bees and resulted in collapse of some colonies during this period. In June-August, the bees were very active in the morning, when they were attracted mainly to Lagerstroemia indica as a pollen source and to Ligustrum lucidum for nectar. In the afternoon they collected some pollen and a small amount of nectar from some late flowering Acacia spp. (A. catechu, A. decurrens and A. gagoans). Some late flowering plants of Sapium sebiferum proved to be valuable for nectar throughout the day because the quantity of nectar available was higher than from any other plant at that time.

In August Zea mays became the main source of pollen and Helianthus annuus of both nectar and pollen. Phyla nodiflora, Jacaranda mimosifolia and Lannea coromandelica were present in small numbers and were occasionally visited by bees. The bees were attracted to species of honey Eucalyptus as a second choice which provided both nectar and pollen. L. indica which was still in flowering stage was relegated to third choice. This indicates that preferences of honeybees for different nectar and pollen yielding plants changed from month to month. The relative importance of different plants for the bees throughout the day during July-August is given in Figs. 10 and 11 (also see 'Material and Methods'). The results presented here show that drying of nectar due to high temperature in the afternoon inhibits the bee foraging activity to a considerable extent.

4. TOXIC FLORA

'Shain' (P. rugosus) is an excellent honey plant for A. cerana. Some mixed plantations of P. rugosus and Rumex hastatus occurred in some areas in Swat. Both plant species produced flowers during September-October. The local bee-keepers reported that R. hastatus is less favourable for bees. To test the suitability of this plant, three colonies (each with five frame bees) were placed at two locations - one having dominance of P. rugosus and the other of R. hastatus by the end of August, 1985. It was observed that the colony strength either remained the same or slightly increased (up to ½ frame bees) at the location dominated by R. hastatus whereas the colony strength increased by 3-5 frame bees at the location dominated by P. rugosus. No surplus honey was

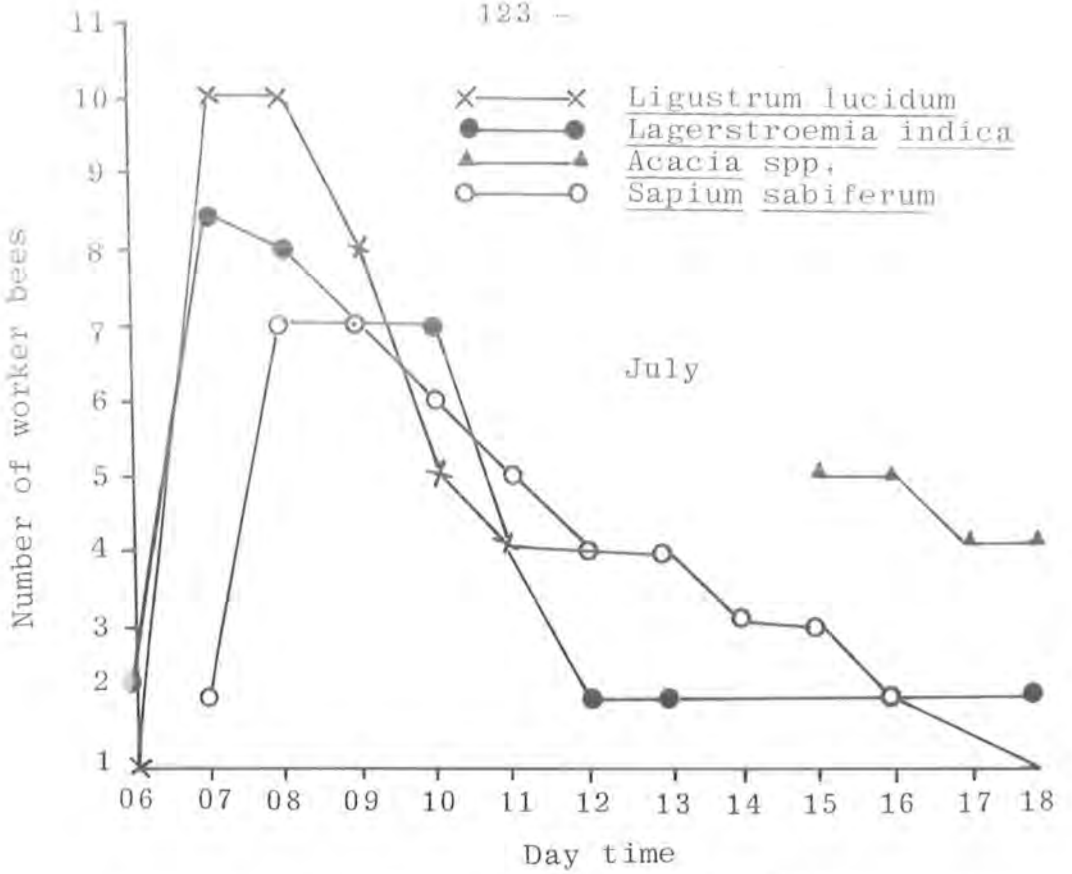


Fig. 10. Number of bees visiting different plants throughout the day in July

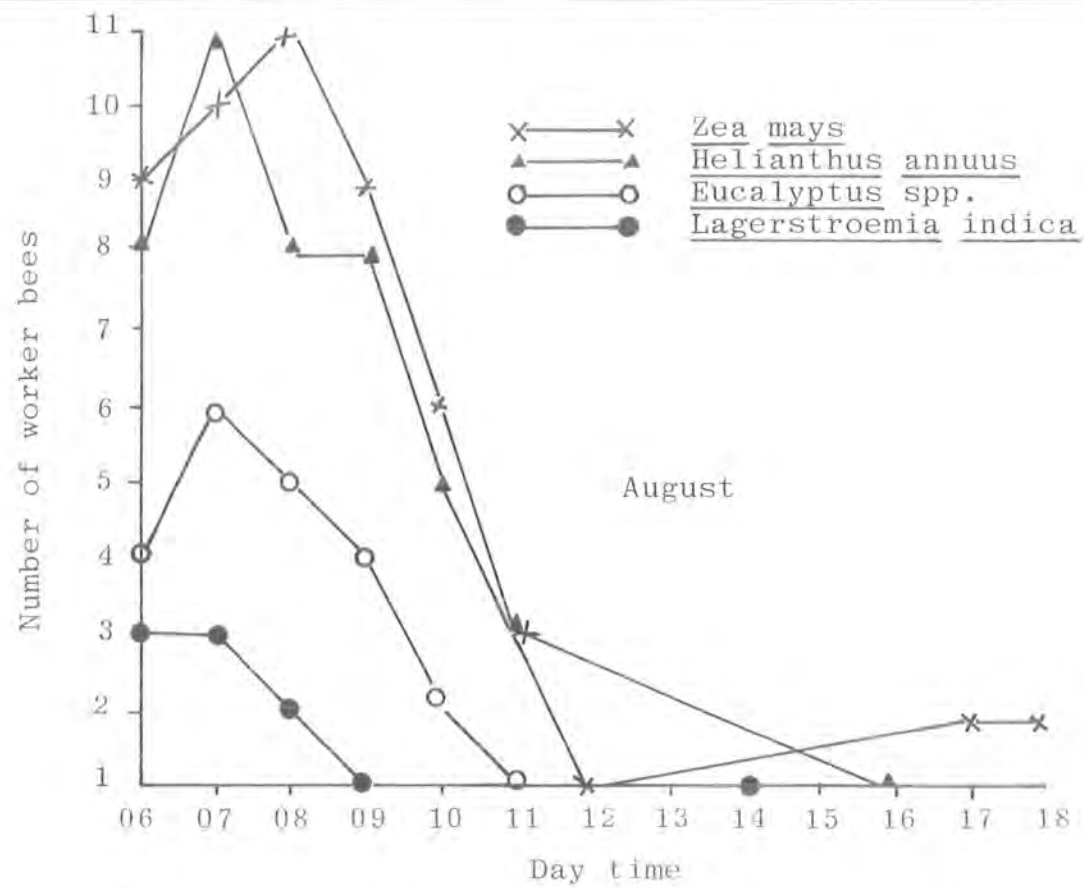


Fig. 11. Number of bees visiting different plants throughout the day in August

produced at the former location whereas 4.1-5.3 kg honey per colony was obtained at the latter. Mortality of bees per colony was also slightly higher at the former location (5-21 workers daily) than at the latter location (3-12 workers daily). This indicates that R. hastatus does not produce suitable nectar, pollen or both for honey production and development of bees.

Ranunculus muricatus occurs in wheat and sarson crops in the plains (Jhang, Faisalabad, Sargodha, Gujranwala, Bannu and Kohat), foot-hills (Rawalpindi, Texila and Haripur) and hills (Swat, Kashmir and Hazara). It starts blooming in the middle or end of flowering period of Brassica campestris, which provides excellent pollen and nectar for development of bees and honey production. The flowers of R. muricatus and B. campestris are yellow. At the end of flowering period of sarson, the bees started collecting pollen and nectar from R. muricatus and Asphodelus tenuifolius. Of these, A. tenuifolius is a useful honey plant. Two colonies placed in a field having a fairly good number of plants of R. muricatus reduced to about half of their strength within 22 days after flowering period of B. campestris. It appeared that mortality of the bees was probably due to some poïsonous constituents of R. muricatus.

5. EFFECT OF WEATHER ON NECTAR PRODUCTION

Observations were made to determine the effect of weather on nectar production of some bee plants. It was found that persistent rains (616 mm) at Simli Dam during monsoon season (July-August) increased the vegetative growth of Plectranthus rugosus and Antigonon leptopus resulting in delay in their blooming period and decreasing nectar production from the respective plants to 0.005 ml and 0.01 ml/50 flowers while mild rains (311 mm) and bright sunny days favoured the normal growth of these plants and increased their nectar secretion to 0.01 ml and 0.03 ml/50 flowers, respectively, at Khanpur.

At Rawalpindi, rains at frequent intervals favoured the nectar production from Eriobotrya japonica (0.03 ml/50 flowers) during January-February (rain 207 mm) but reduced the nectar secretion (0.001 ml/50 flowers) in October-December when there was very low rainfall (97 mm).

Bright sunshine and occasional rains (146 mm) increased the nectar (0.03 ml/50 flowers) production from Brassica campestris in Swat as compared with the nectar (0.01 ml/50 flowers) production from this crop at Peshawar (rain 58 mm) in March.

Sudden rise in temperature by the end of April reduced the prospects of good honey crop by evaporating the nectar from Acacia modesta, Trifolium alexandrianum and other plants (honey 4.5 kg/colony at Sargodha, n=3) in the plains of Punjab (mean monthly temperature 22°C min. and 39°C max.) as compared with that in the foot-hills (honey 6.7 kg/colony at Islamabad, n=3) in the same month (mean monthly temperature 15°C min. and 32°C max.).

The afore-mentioned data indicate that nectar production varies on plant species under different ecological conditions and that rainfall and temperature considerably influence nectar secretion.

CHAPTER V

INSECT AND PLANT SOURCES OF HONEYDEW HONEY*

The honeybees (Apis spp.) are known to collect honeydew- an excretion of insects- and store it as honey (Eckert and Shaw, 1960; Crane, 1975; Anon.,1978,1980;Pellet, 1978). Honeydew honey crops have been obtained in California and some other regions (Mussen at al., 1987). According to Anon.(loc.cit.) honeydew has been often collected by bees from insects attacking leaves of oak (Quercus spp.), beech (Fagus spp.),poplar (Populus spp.),ash (Fraxinus spp.), elm (Ulmus wallichiana),hickory (Hicoria spp.),maple (Acer spp.), tulip (Liriodendron tulipifera), willow (Salix spp.), linden (Tilia spp.), fir (Abies spp.), cedar (Juniperus virginiana) and spruce (Picea spp.). Honeydew honey is generally considered inferior to normal honey in Anglo-saxon countries and superior to normal honey in the central and eastern European regions.

A little was known about the insect and plant sources of honeydew honey of A. cerana in Pakistan. A survey was made to find out honeydew producing insects visited by A. cerana for collection of honeydew on various host plants in different ecological areas in the country. The details are presented in Table 19.

Table 19

Honeydew producing insects

Name of insect	Host plants	Locality
ADELGIDAE		
Adelges joshii S.O. & S.	Abies pindrow	Murree Hills
A. knucheli S.O. & S.	Abies pindrow and Picea smithiana	Murree Hills, Kaghan, Swat and Dir
Pineus spp.	Pinus roxburghii	Chikar, Dhirkot and Murree Hills
	P. griffithii	Mukshpuri

*Paper accepted, letter attached, appendix I.

1	2	3
ALEYRODIDAE		
Acandaleyrodes alhagii P. & H.	Bauhinia variegata	Rawalpindi and Islamabad
Aleurolobus citrifolii Corbett	Murraya panicul.ta	Peshawar and Mardan
A. niloticus P. & H.	Ehretia serrata, Salmalia malabarica, Ziziphus mauritiana, Murraya paniculata, Citrus acida, Olea cuspidata, Hedera nepalensis and Dodonaea viscosa	Rawalpindi, Kohat and Swat
Aleurolobus sp.? niloticus P. & H.	Murraya paniculata, Bauhinia variegata, Nerium indicum and Salmalia malabarica	Peshawar and Swat
Aleuroplatus sp. (nr. ficus-gibbosae Corbett)	Smilax spp.	Paras
Aleurotuberculatus sp.	Ficus sp.	Batrasi and Mingora
A. murrayae Singh	Murraya paniculata	Peshawar and Mardan
Aleyrodes sp.? hyperici Corbett	Murraya paniculata	Thall and Parachinar
Dialeurodes citri (Ashm.)	Erianthus sp.	Saidu Sharif
D. kirkaldyi Kot.	Jasminum bifarium	Peshawar and Mardan
D. sp. nr. citri (Ashmed)	Hedera nepalensis	Swat
APHIDIDAE		
Acyrthosiphon sp.	Sonchus oleraceus and Euphorbia helioscopia	Swat
A. pisum (Haris)	Pisum sativum, Lathyrus sp. and L. odoratus	Rawalpindi, Balakot and Mingora

1	2	3
Anuraphis helichrysi Kattenbach	*Prunus persica*	Peshawar and Murree Hills
Aphidura sp.	*Hordeum vulgare*	Bannu and Kohat
Aphis (*Brachyunguis*) sp.	*Tamarix articulata*	Peshawar
Aphis (=*buddleiae*) sp.	*Buddleia neemda*	Islamabad
Aphis (*Medoralis*) sp.	*Rubus fruticosus*	Swat
Aphis sp. (*nasturtii* *Kaltenbach* group)	*Withania somnifera*, *Euphorbia* sp., *Malvaviscus* sp. and *Jacaranda ovalifolia*	Kohat, Peshawar and Rawalpindi
Aphis craccivora Koch.	*Tribulus terrestris*, *Asparagus* sp., *Medicago hispida*, *Lens esculenta*, *Phaeseolus radiatus* and *Cestrum nocturnum*	Rawalpindi, Swat, Dir, Abbottabad and Peshawar
A. fabae Scop.	*Cestrum nocturnum*, *Solanum nigrum*, *Malva sylvestris*, *Cucurbita* sp., *Peganum harmala*, *Euphorbia* sp., *Chenopodium* sp., *Calendula officinalis*, *Zea mays*, *Capsella bursapastoria*, *Rumex dentatus*, *Eriobotrya japonica*, *Tagetes africana*, *Stellaria media*, *Salix acmophylla* and *Cassia fistula*	Islamabad, Rawalpindi, Wah, Peshawar, Kohat, Dir and Swat

1	2	3
A. gossypii Glover	*Althaea rosea*, *Raphanus sativus*, *Brassica oleracea*, *Gossypium herbaceum*, *Cestrum nocturnum*, *Rosa* sp., *Tecoma capensis*, *Convolvulus arvensis*, *Rumex dentatus*, *Albizia lebbek*, *Woodfordia fruticosa*, *Eriobotrya japonica*, *Mentha longifolia*, *Astragalus punjabicus*, *Hibiscus syriacus*, *Cucurbita pepo* and *Salvia plebeia*	Rawalpindi, Murree, Peshawar, Lahore, Kohat, Abbottabad, Rabat, Swat and Chitral
A. punicae Pass.	*Punica granatum* and *Duranta plumieri*	Abbottabad, Swat and Parachinar
A. ruborum Borner	*Rubus* sp. and *R. fruticosus*	Dir, Swat and Malakand
A. solanella Theobald	*Hibiscus rosa-sinensis*, *Calendula officinalis*, *Malvaviscus* sp., *Rumex dentatus* and *Solanum nigrum*	Bannu, Kohat and Peshawar
A. (*Brachyunguis*) sp. *tamaricis* (Licht.)	*Achyranthes aspera* and *Tamarix articulata*	Swat
Brachycaudus sp. nr. *helichrysi* Kalt.	*Stachys* sp., *Prunus persica* and *Pyrus sinensis*	Abbottabad, Islamabad and Peshawar

1	2	3
Brachyunguis carthami Das	Carthamus oxyacantha	Islamabad
Cavariella sp.	Salix acmophylla	Dir and Swat
Ceruraphis sp.	Viburnum nervosum	Swat
Chaitophorus sp.	Salix acmophylla	Islamabad, Murree, Peshawar, Haripur and Mardan
C. albus Mordwilko.	Populus alba	Murree Hills
Chaitophorus sp.? himalayensis Das	Salix acmophylla	Dir, Swat and Mardan
Cinara abieticolus Chol.	Abies pindrow	Murree Hills
Coloradoa rufomaculata (Wilson)	Chrysanthemum leucanthemum	Dir and Kohat
Dactynotus sonchi L.	Ageratum conyzoides and Sonchus sp.	Bannu and Kohat
Dactynotus (Uromelan) sp. (jaceae group)	Ageratum sp.	Swat
Diuraphis sp. (near D. noxius (Mdw.) often called (Brachycolus noxius V.F. Eastop)	Hordeum vulgare	Parachinar
Eriosoma lanigerum Haus.	Malus pumila and Andrachne cordifolia	Murree Hills
Hyadaphis sp. foeniculus (Pass.)	Unidentified plant	Abbottabad and Mansehra
Hyalopterus pruni (Geoffroy)	Prunus persica	Kohat and Peshawar
Hyalopterus sp.? amygdalis (Blanch.)	Prunus bokhariensis	Kohat and Peshawar
Lachnus sp.	Pyrus pashia	Mansehra
Lachnus sp.? oyri Buckton	Pyrus pashia	Dir and Swat

1	2	3
Lipaphis erysimi(Kltb.)	Artemisia scoparia, Brassica oleracea, B. campestris and Raphanus sativus	Islamabad, Peshawar and Malakand
L. (Lipahidiella) lepidii (Nevsky)	Cardaria draba and Chrysanthemum leucanthemum	Bannu and Kohat
L. pseudobrassicae (Davis)	Brassica campestris, B. oleracea, B. napus and Raphanus sativus	Islamabad
Longuinguis donacis (Pass.)	Arundo donax and Nerium indicum	Haripur, Abbottabad, Balakot and Kohat
Macrosiphoniella sanborni (Gillette)	Chrysanthemum leucanthemum	Kohat, Timurgaraha, Likora and Peshawar
Macrosiphum sp.	Malvaviscus sp.	Bannu and Kohat
Macrosiphum (Eomacrosiphum group)	Rosa sp.	Dir and Swat
Macrosiphum (Sitobion) sp.	Rosa sp. and R. indica	Peshawar, Dir, Swat and Abbotta-bad
M. (Sitobion) avenae (F.)	Hordeum vulgare and Triticum aestivum	Parachinar
M. rosae (L.)	Rosa sp. and Dipsacus inermis	Murree and Swat
M. (Sitobion) rosaeformis Das	Rosa sp.	Islamabad, Dir, Swat and Kohat
Mindarus sp.? abietinus Koch.	Abies pindrow	Murree Hills

1	2	3
Myzaphis rosarum (Kltb.)	Rosa sp.	Swat
Myzus sp.	Hibiscus rosa-sinensis, Rosa sp. and Spiraea vestita	Bannu, Kohat, Murree Hills and Swat
M. (Nectarosiphon) persicae (Sulzer)	Raphanus sativus, Brassica napus, Coriandrum sativum, Ipomoea palmata, Convolvulus arvensis, Malva parviflora, B. campestris, Chrysanthemum leucanthemum, Nicotiana tabacum, Hedera nepalensis, Euphorbia helioscopia, Althaea rosea, Salix acmophylla, Lactuca sativa and Cassia fistula	Peshawar, Dir, Swat, Mardan, Nowshera, Kohat, Abbottabad and Parachinar
Pemphigus lichtensteini Tullgran	Populus nigra	Islamabad
Pemphigus (Pemphiginus) sp.	Populus ciliata and P. nigra	Murree, Peshawar, Swat, Dir and Chitral
Prosiphilus sp.	Pinus griffithii	Murree
Prosiphilus nr. micheliae H. R. L.	Unidentified plant	Murree
Pterochloroides persicae (Cholodkovsly)	Prunus bokhariensis, P. persica, P. armeniaca, Pyrus communis and P. pashia	Islamabad, Kohat, Mansehra, Abbottabad and Swat
Pterocomma sp.	Salix acmophylla	Swat
Rhopalosiphum maidis (Fitch)	Hordeum vulgare, Peganum harmala, Zea mays, Rosa sp. and Sorghum sp.	Murree, Peshawar and Swat

1	2	3
Rhopalosiphum nymphaeae (L.)	Rumex sp., Cyperus sp. and Colocasia esculenta	Peshawar and Wah
Schizaphis graminum Rond.	Hordeum vulgare	Parachinar
Schizaphis sp. ? cyperi V. d. G.	Pyrus sp.	Kaghan
Schizaphis sp.? celti Das	Celtis eriocarpa	Islamabad
Therioaphis (Pterocollaidium) maculatum Buckton	Medicago sativa	Islamabad
Tuberolachnus sp.	Salix acmophylla	Haripur and Taxila
Xanothoracaphis sp.	Quercus incana	Dir and Swat
CICADELLIDAE		
Empoasca sp.	Albizzia lebbek, Hibiscus esculentus, Spinacia oleracea, Trifolium resupinatum and Allium cepa	Dir, Swat, Malakand and Mardan
E. formosana Paoli.	Ricinus communis	Mardan and Peshawar
Erythroneura sp.	Acacia modesta and Cnicus arvensis	Swat
Evacanthus repexus Dist.	Rumex dentatus, Pinus roxburghii, Brassica napus, Hibiscus esculentus, Foeniculum vulgare, Amaranthus viridis, Conyza crispus, Sorghum halepense and Cynoglossum lanceolatum	Dir, Balakot, Swat and Garhi Habibullah

1	2	3
FULGORIDAE		
Pyrilla perpusilla Wlk.	Saccharum officinarum	Peshawar and Faisalabad
PSYLLIDAE		
Diaphorina sp.	Cordia obliqua	Islamabad, Haripur and Mardan
D. citri Kuw.	Citrus sinensis and C. acida	Faisalabad and Islamabad
Euphyllura sp. nr. olivina Costa	Olea sp. and O. cuspidata	Islamabad, Murree, Swat and Peshawar
Idioscopus clypealis Leth. (Idiocerus clypealis Leth.)	Mangifera indica	Leiah and Multan
PSEUDOCOCCIDAE		
Adelosoma phragmitidis Borch.	Saccharum bengalense and Arundo donax	Rawalpindi, Lahore and Sahiwal
Centrococcus insolitus (Green)	Abutilon indicum and Adhatoda vasica	Rawalpindi and Muzaffarabad
Chaetococcus sp.	Erianthus munja	Quetta
Dysmicoccus carens Williams	Sorghum sudanense	Rawalpindi
Ferrisia virgata (Ckll.)	Mangifera indica, Citrus spp., Iresine spp. and Morus alba	Hyderabad, Karachi and Sahiwal
Maconellicoccus hirsutus Green	Ziziphus mauritiana and Cordia obliqua	Peshawar and Haripur
Nipaecoccus sp.	Unidentified plant	Murree

1	2	3
N. vastator (Mask.)	Citrus acida, C. sinensis, Morus alba, Ziziphus mauritiana, Acacia modesta and Althaea rosea	Faisalabad, Peshawar, Lahore and Islamabad
Phenacoccus sp.	Olea cuspidata and Ficus infectoria	Dir, Swat and Peshawar
Planococcoides robustus Ezz. and McC.	Acacia nilotica, Albizzia lebbeck, Ficus benghalensis and F. religiosa	Rawalpindi, Jolian, Taxila, Haripur and Peshawar
Planococcus citri (Rissoo)	Vitis vinifera	Quetta
Ripersia sp.	Arundo donax	Bannu
R. sacchari Green	Saccharum officinarum and Sorghum nitidum	Faisalabad, Leiah and Peshawar
Saccharicoccus sacchari (Ckll.)	Saccharum officinarum	Peshawar, Faisalabad and Lahore
Spilococcus sp.	Citrus sp. and C. sinensis	Faisalabad and Mardan
DACTYLOPIIDAE		
Dactylopius sp.	Opuntia sp.	Islamabad and Abbottabad
COCCIDAE		
Ceroplastes sp.	Ficus sp., F. carica, F. infectoria, Cordia obliqua and Mangifera indica	Peshawar, Kohat and Karachi

1	2	3
Ceroplastes actiniformis Green	*Ficus* sp., *F. carica*, *F. palmata*, *Mangifera indica*, *Psidium guajava*, *Acacia* sp. and *Carissa spinarum*	Murree, Peshawar, Swat and Islamabad
C. floridensis Comst.	*Syzygium cumini*, *Carissa opaca*, *Eriobotrya japonica*, *Nerium indicum*, *Mangifera indica*, *Psidium guajava* and *Schinus molle*	Islamabad, Peshawar and Karachi
Ceroplastodes chiton Green	*Mangifera indica*, *Ficus* sp., *F. carica*, *F. palmata*, *Morus alba* and *Ziziphus mauritiana*	Islamabad, Haripur, Peshawar and Swat
Coccus spp.	*Cedrela toona*, *Prunus bokhariensis*, *Mallotus*, *philippinensis*, *Mangifera indica*, *Citrus sinensis*, *Syzygium cumini* and *Psidium guajava*	Parachinar and Swat
C. hesperidum L.	*Diospyros lotus* and *Dalbergia sissoo*	Swat and Peshawar
C. viridis (Green)	*Carissa opaca*	Abbottabad and Swat
Eriochiton amygdalae Rao	*Prunus amygdalus*	Quetta
Eulecanium sp.	*Pyrus* sp., *Prunus* sp., *P. armeniaca*, *Ficus* sp., *F. carica* and *Pistacia integerrima*	Abbottabad, Azad Kashmir, Mansehra and Murree Hills

Eulecanicum sp.	Quercus incana	Murree
E. sp. nr. tiliae (L.)	Prunus armeniaca, P. persica and Cedrela toona	Azad Kashmir, Abbottabad, Murree Hills, Haripur and Wah
Lecanium sp.	Juglans regia, Prunus amygdalus, P. persica, P. cerasifera, P. bokhariensis, P. armeniaca and Pyrus communis	Abbottabad, Azad Kashmir, Murree, Parachinar, Peshawar and Swat
Pulvinaria loralaiensis Rao	Pistacia vera	Quetta
ASTEROLECANIIDAE		
Asterolecanium sp. nr. quercicola (Bouche)	Quercus incana and Q. dilatata	Murree Hills

A. cerana was found to collect honeydew produced by 117 species of Hemipterous insects on 165 species of plants in different areas in the country but no complete/full honeydew honey crop was harvested in any area.

CHAPTER VI

PESTS AND DISEASES

Among the natural enemies, two species of wax moths, five of hornets, three of mites, twenty one of birds, two of black ants, one of pseudoscorpion, two of fungi and two viruses have been found to attack honeybees. Of these, the wax moths, hornets, mites and birds are important and bring about fairly heavy losses to honeybee colonies. During the course of present studies some biological observations were made on these pests and diseases and some new techniques were developed for their effective control.

1. WAX MOTHS

i. Incidence

a. Wax moths

The impact of wax moths was studied in *A. cerana* colonies in earthen pitchers at Bahrain, Chamtalai and Madyan (Swat). The lesser wax moth attacked up to 9.3% colonies and the greater wax moth up to 14.8% colonies in 1986 as against 19.5 and 29.3%, respectively, mentioned by Ahmad and Muzaffar (1983) in the same areas in 1979-80. Some colonies had combined infestation of both species, but the greater wax moth was more abundant. The numbers of infested and expired colonies were counted in June, August, October 1986 and March 1987 (Table 20).

Table 20

Losses caused by both species of the wax moths to *A. cerana* colonies

Locality	Total colonies	No. of colonies in 1986 Infested Jun.	Aug.	Oct.	Expired Aug.	Oct.	No. of colonies in March 1987 Infested	Expired
Madyan	8	1	1	2	-	-	2	-
-do-	5	1	2	3	-	-	2	1
Bahrain	13	2	2	2	-	1	2	2
Chamtalai	6	2	2	2	1	1	1	1
-do-	7	-	1	1	-	-	1	-
-do-	6	1	1	1	-	-	1	1
Total	45	7	9	11	1	2	9	5
Infested and expired %		15.5	20.0	24.4	2.2	4.4	20.0	11.1

The data (Table 20) indicate that the wax moths destroyed 17.7% (1 colony in August, 2 in October and 5 in March) and damaged an additional 20% colonies reared in earthen pitchers in the Swat area during June, 1986 - March, 1987 as against 39% and 19.5%, respectively, reported by Ahmad and Muzaffar (loc.cit.) in the same area in 1979-80. Reduction in the incidence of wax moths was probably due to better management of the colonies and rearing and releases of the parasite *Apanteles galleriae* Wilk. in those areas by the local beekeepers.

b. Parasite

The wax moth larvae (both species) were sampled from different areas in Punjab and NWFP during 1987 and were reared for *A. galleriae* (Table 21).

Table 21

Incidence of A. galleriae on A. grisella and G. mellonella in A. cerana in colonies

Locality	Month	No. of wax moth larvae Sampled	No. of wax moth larvae Parasitised	Parasitism (%)
Rawalpindi	June	120	13	10.9
-do-	September	78	7	8.9
Hasanabdal	July	49	6	12.2
Swat	-do-	20	2	10.0
Haripur	June	100	5	5.0
-do-	August	100	13	13.0
Peshawar	-do-	50	8	16.0
	Total	517	54	10.4

It is clear from the data (Table 21) that the incidence of A. galleriae was fairly high (5-16%, average 10.4%) in 1987 as against up to 1.5% reported by Ahmad and Muzaffar (loc. cit.) in the same areas in 1979-80. Higher incidence of the parasite appears due to mass-releases of the parasite in A. mellifera apiaries by the beekeepers.

ii. Rearing technique

The technique developed by Ahmad and Muzaffar (loc. cit.) was modified and used for rearing the wax moths and the parasite larvae for releases in the apiaries.

Langstroth hive containing 6 frames of bees in the lower super were used for rearing the host and the parasite. In the hive the temperature was lower in the empty spaces (27° ± 3°C) than in the middle of the frames (31°-34°C) when the ambient temperatures were 0°-29°C. The rearing temperature, i.e. 27° ± 3°C, was maintained in the hives by using thermopore or other packing material depending upon the ambient temperature. The parasite was also reared well at colony temperatures ranging from 31°-36°C. Sometimes when the ambient temperatures were higher, the bees lowered the colony temperature by fanning. Thus the hive with little alteration or addition of bees was used as a thermostat or air conditioner for rearing the parasite without hibernating in the winter and aestivating in summer. The honeybee is known to reduce the temperature of the hive in summer if the ambient temperature is higher than 34°C. Thus hive temperature in hot summer weather was reduced by proper management of the colony.

The wax moth larvae A. grisella and G. mellonella were mass-produced in ground beeswax instead of a diet developed by Haydak (1936) containing maize flour, wheat flour, bran, dry yeast, dried milk, honey and glycerine (4:2:2:1:1:4:4 by weight) used by Ahmad and Muzaffar (loc. cit.). One gram each of terramycin (Tm-25) and multivitamins (Pfizer) were added to one kg ground wax to produce disease free and vigorous host larvae for parasite production. This diet was placed in glass jars in the colony for mass-production of the host larvae and the parasite.

iii. Biology

A. galleriae parasitised the third and fourth instar larvae of A. grisella and the second and third instar larvae of G. mellonella. The adult parasites showed a marked phototropic behaviour. The females, on emergence, started searching the host in tunnels made by the wax moth larvae. The adults of A. galleriae mated soon after emergence. Copulation lasted for 25 seconds to 4 minutes. The female began to oviposit within 20 hours after emergence. It laid one or two eggs in each host larva, but only a single parasite developed to adult stage. The host larva stopped feeding 5-7 days after being parasitised and also isolated itself from healthy larvae. It secreted a case or hibernacula without moulting. The full-grown parasite larva cut an opening through the host skin, fed for a short period and pupated leaving aside the thin host membrane and chitinous head in the silken cocoon spun in the cadaver of the host.

The adult female parasite showed a marked response to the mandibular gland (tissue with isolated mandibles) and also tapped the frass, produced by G. mellonella larvae, with its antennae. This indicates that a kairomone is possibly produced in the mandibular gland of G. mellonella. The wax moth larval frass contains the kairomone which induces the parasite female for oviposition in the host larvae as reported by Vinson (1968) and Lewis and Jones (1971) in Apanteles flavipes (Cameron) parasitising Heliothis spp.

The egg, larval, pupal and total developmental periods at 27°±3°C were 2-3 (average 2.6), 10-11 (average 10.4), 7-8 (average 7.6) and 20-22 (average 21.0) days, respectively (n=12). The adult female lived 7-18 (average 14) days and the male 4-13 (average 8) days (n=12). The females laid 19-82 (average 52) eggs (n=12). The number of males was slightly higher than the females (sex ratio 6:5).

A. galleriae hibernated in the plains during December - January, in the foot-hills from November to February and in the hills during October-March, and aestivated in the plains in May-August, in foot-hills from May to July and in lower hills during June-July. Thus the hibernation and aestivation periods seem to be the limiting factors responsible for the low effectiveness of this parasite as a biocontrol agent.

iv. Effect of inbreeding

Some haplodiploid Hymenoptera such as honeybees are known to lose 2-47 (average 24) percent of the brood due to successive inbreeding (Woyke, 1976). This parasite is also haplodiploid. It seems that its low incidence might be due to the adverse effect of inbreeding resulting possibly in low fecundity. Keeping it in view, studies were conducted on the parasite to determine the effect of inbreeding on its progeny. The parasites were collected from Haripur (foot-hills) (line A) and Muzaffarabad (high hills)(line B) and were reared for trial in separate cages in the laboratory. The adults produced by a single female (4 replicates) were counted in inbred and cross-bred lines (Table 22).

Table 22

Effect of inbreeding on A. galleriae

Generation	Average No. of offsprings per female								
	Line A			Lines A♀ x B♂			Line B		
	Min.	Max.	Av.	Min.	Max.	Av.	Min.	Max.	Av.
First	27	42	35	46	76	62	33	55	47
Second	24	39	32	34	79	58	35	59	49
Third	21	38	27	45	84	61	28	62	41

The number of offsprings in inbred lines A and B were lesser than that of cross-bred line A ♀ and B ♂ (Table 22). The incidence of the parasite was low in nature indicating that the parasite, owing to its small numbers, mostly inbred in the honeybee colonies resulting in both low fecundity and incidence.

v. Production of the parasite and releases

A cage for rearing the parasite was placed in the brood chamber of a colony. It consisted of a glass jar having a lid fitted with a wire-mesh, funnel and glass tube so that the wax moth larvae and adults were confined while the adult parasites passed through the wire-mesh, funnel and plastic tube and were released in the apiary (Fig.12). The cage (glass jar) was covered on three sides with black cloth to keep the bees in darkness. The hive was provided with a glass window on the front wall towards the glass jar so that the parasites and wax moths had sunlight. The glass tube was provided with a small container at the end so that the parasites are retained in and are counted before releases. Eight pairs of the wax moth G. mellonella were liberated for raising the host culture in each cage. These were provided with one kg ground beeswax and cotton moistened with 50% honey solution. The female moths laid their eggs and after about two weeks there were larvae of all instars in both cages. Six pairs of Apanteles were released in each jar and ½ kg ground wax as food was added at monthly intervals.

One month before starting releases, six honeybee colonies were infested each with 100 wax moth larvae of second and third instars (50 individuals of each A.grisella and G. mellonella). Eeach colony had 5-7 frames of bees.

Fig. 12.


BIOLOGICAL CONTROL OF THE WAX MOTHS ACHROIA GRISELLA (F.) AND GALLERIA MELLONELLA (L.) BY AUGMENTATION OF THE PARASITE APANTELES GALLERIAE WILK.
1. Hive showing window with glass.
2. The wax moth and the parasite rearing cage in the hive.
3. The cage containing food, the wax moth larvae and the parasite.
4. The wax moth G. mellonella pupae.
5. The parasite A. galleriae cocoons.
6. The parasite A. galleriae empty cocoons.
7. The parasite A. galleriae adults in the tube.

Of these, four colonies (No.1-4) were placed near the parasite rearing hive while the other two colonies (No.5-6) were placed as control* at a distance of 4 km to protect it from the parasite. The first observation, on the incidence of the parasite, was made 16 days after the first release. The degree of parasitism was noted by collecting a sample of the wax moth larvae and rearing them in ground wax in cages. The healthy larvae, after noting parasitism, were again liberated in the respective colony from which these were sampled. The number of parasite pairs released (based on control) and incidence of the parasite were noted during February-May, 1987 (Table 23).

Table 23

Release of *A. galleriae* and its incidence on both wax moths

Date		No. of parasite pairs	Number of wax moths			Parasitism (%)
			Colony number	Larvae sampled	Larvae parasitised	
Feb.	15	28	1	20	3	15.0
	23	25	2	20	4	20.0
	28	31	3	20	5	25.0
Mar.	8	33	4	20	7	35.0
	16	28	1	20	12	60.0
	25	41	2	18	15	83.3
Apr.	2	45	3	16	8	50.0
	9	26	4	12	3	25.0
	18	35	1	7	4	57.1
	28	36	2	9	8	88.8
May	3	29	3	8	5	62.5
	11	34	4	5	4	80.0
	19	37	1	3	2	66.6
	27	28	1-4	**	**	**

* Samples taken from control colonies(No.5-6) did not show any parasitism.

** No wax moth larvae present.

Fig. 13.

LOW COST HIVES BEING USED IN PAKISTAN

Straw hive Pitcher hive

Log hive

Cement hive Paper hive Clay hive

Wall hives with Langstroth frames

Wall hives with top bar frames

The bee populations of colony No. 1-4 increased considerably during February-May. There was a marked decline in the population of wax moth larvae in these colonies during this period (Table 23). Incidence of the parasite increased from 15% in February to 88% in April. Thereafter the host population declined and decrease in parasitism was possibly due to small samples of the host larvae. The bee strength in the control colony declined to a considerable extent during February-May. It appeared that A. galleriae was mainly responsible for controlling the wax moth larval populations. Besides, the increase in bee population during March-April also seemed to reduce the pest population to some extent.

Most of the beekeepers, except a few progressive ones, rear the local honeybee (A. cerana) colonies in earthen pitchers, logs of wood and hollow portions of mud-walls (Fig. 13) in the northern hills of Pakistan. A large number of colonies (25-65%) had small populations of bees. Most of the weak colonies were infested with wax moths. Releases of A. galleriae in the colonies proved very useful for the biological control of both wax moth species.

2. HORNETS

The hornets Vespa velutina pruthii Vecht., V. basalis Smith, V. tropica haematodes Beq., V. orientalis L. and Vespula germanica (F.) attacked A. cerana in Pakistan. A research paper on hornets published in Pakistan Journal of Agricultural Research is attached in the thesis. During the course of present investigations, observations were made on the biology of the hornet V. velutina pruthii and the mite Pyemotes ventricosus (Newp.) and on control of hornets attacking honeybees.

i. Biology of *Vespa velutina pruthii*

V. velutina pruthii is one of the most serious pests of honeybees in Pakistan. Its nests are usually aerial and are globular to spherical in shape. The size of the nest varies from 5 cm to 96 cm in diameter. However, some nests which remained inhabited for several seasons owing to their being in protected sites attained enormous proportions of up to 236 cm diameter and 122 cm length (Fig.14).

Some of the nests were removed from various locations in the vicinity of apiaries at Rawalpindi, Islamabad, Haripur and Peshawar. Depending upon the age, the nests had a series of 4 to 10 circular combs with 30-50 cm diameter in a horizontal position. The combs are enclosed with a substantially thick wall comprising propolis, chewed wood etc. and were attached together with several small perpendicular columns. The entrance was mostly at the bottom and seldom near the top or side. In some nests there were 2-4 entrances.

The *Vespa* spp. have almost a uniform yearly plan of life-cycle. The hibernating queens resume activity in spring and the solitary queens build nests by selecting suitable sites. The queen constructs a few cells, lays a single egg in each cell and rears brood. The eggs are, oblong, white in colour and are attached to the bottom or lateral walls of the cells by some adhesive substance.

The workers of the first brood, on emergence, start foraging, feeding and nest building activities while the queen is left with the sole function of oviposition. As the

FIG. 14. A NEST OF VESPA VELUTINA PRUTHII VECHT.

nest grew, the hornets expanded the brood combs,excavating larger holes and expanding the outer covering.

There were on average 2015 and 2945 adults in two nests in August-September. Adult hornet population declined at the end of November when the parent queens died, while the new queens hibernated in protected places in winter. Vespa spp. were cannibalistic and fed on their larvae, pupae and sealed brood.

The adults and larvae of hornets were fed minced meat and 50% honey solution in separate containers. Of the twelve newly hatched larvae, fed on a mixture of minced meat and 50% honey solution, five larvae completed development to adult stage. The developmental period from egg to adult was 21-23 (average 19) days (26°±2°C).

ii. Natural enemies

A mite Pyemotes ventricosus (Newp.) (Pyemotidae) and two species of Chalcidoid were found to attack larvae of V. velutina pruthii. Its incidence was very low. It occurred only in one nest in a sample of 42 nests.

The males and females of P. ventricosus were quite distinguishable. The full-grown female had a swollen and round abdomen. It passed the winter as a mature female. Seven generations of the mite were produced in the laboratory during April-September. The males died 1 or 2 days after mating. The female on searching its host attached itself to the body of the larvae, and started oviposition in a week. A female laid 5-28 eggs. Young larvae and pupae of hornets were the preferred hosts. The host body surface stuck with the mite developed few black specks. The infested host larvae became inactive. The severely parasitised host larvae vomitted yellowish-green fluid. The mite occurred in less than 2% nests in the fields.

iii. Control measures

a. Biological control

In the first trial, the hornet adults infested with mites were released during June 18-24, 1986 on the lines mentioned under 'Material and Methods' (Fig.15).Observations were taken on four hornet (V. basalis and V. velutina) nests after one month, three (V. tropica and V. velutina) nests after two months and two (V. velutina and V. orientalis) nests after three months of releases of infected adults. It was found that some 45-83% brood was attacked by the mite at Islamabad after one month; 81-100% brood was attacked and partly killed at Rawalpindi after two months; and all brood was killed at Haripur after three months. It was further observed that the number of adult hornets had been reduced to a great extent in all the nests after two months, and no adult hornet was found in any nest after 3 months. In the second trial, all the brood was attacked by mite and partly killed in one nest (V. velutina) after 30 days; and completely destroyed in two nests (V.tropica) after 45 days. The adult hornet population was considerably decreased after one month and there was not a single hornet in the nests after 45 days. These studies showed a fairly high degree of effectiveness of this mite in controlling the hornets.

b. Chemical control*

The experiment was conducted on the hornets Vespa basalis, V. orientalis and V. velutina in Islamabad and Rawalpindi area. In laboratory (28° ± 2°C),24 adults of each V. basalis and V. velutina fed on honey mixed with

*Paper accepted, letter attached, appendix III.

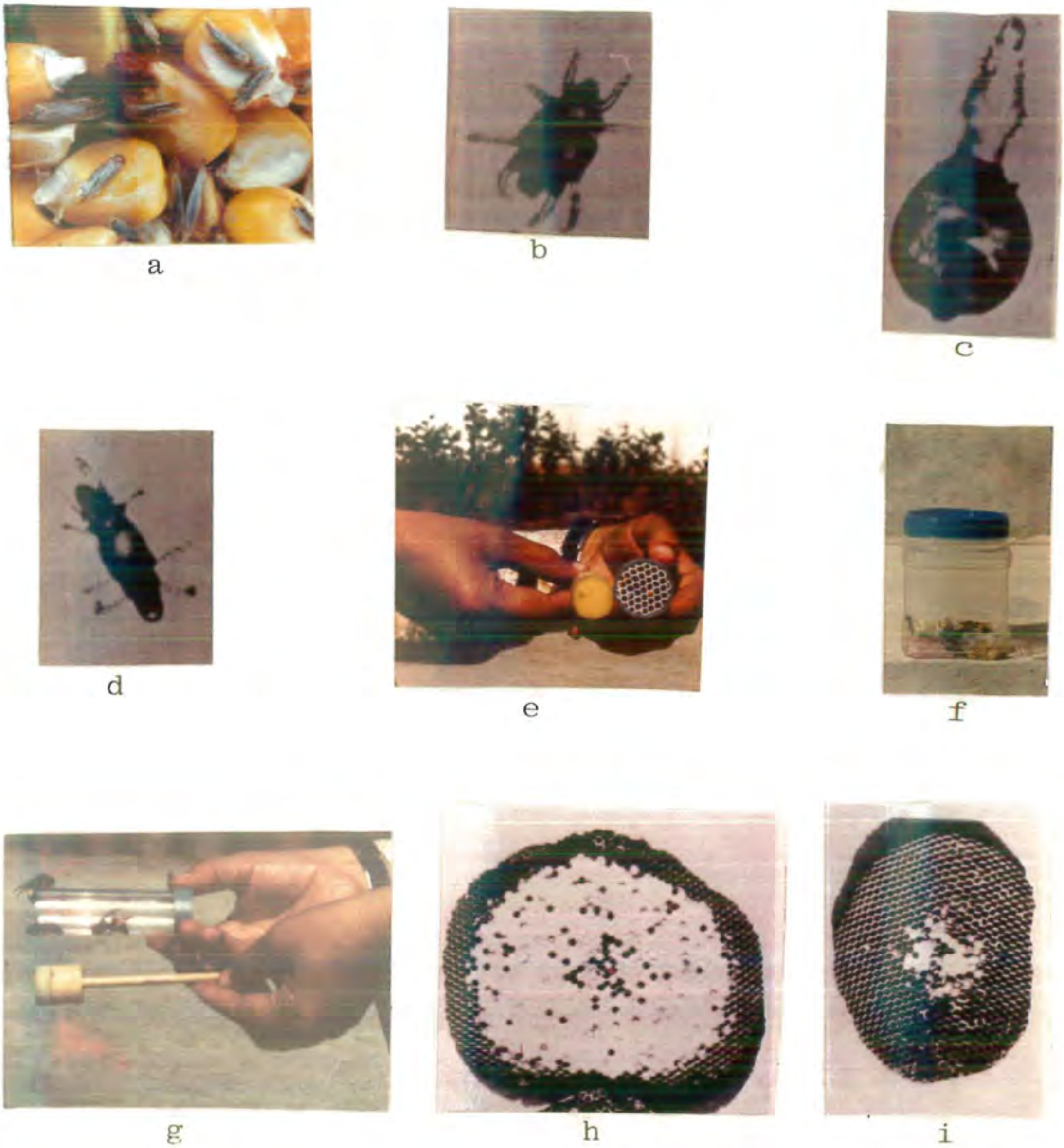


Fig. 15. Control of hornets by the parasitic mite <u>Pyemotes ventricosus</u>: (a) Mite reared on <u>Sitotroga cerealella</u> cultured on maize grains, (b) female mite, (c) full-grown female mite, (d) male mite, (e) apparatus (queen marking cage) used for infecting the hornets, (f) hornets, after capturing, in glass jar being fed on sugar solution, honey and minced meat, (g) mite infected hornets released before dusk, (h) healthy brood in mite free nest, (i) brood comb 30 days after release of mite infected hornets.

Table 24

Mortality of hornets caused by strychnine hydrochloride (St. hyd.) and zinc phosphide (Z. phos.) baits

	V. basalis			*V. orientalis*			*V. velutina*		
	St.hyd.	Z.phos.	Control	St.hyd.	Z.phos.	Control	St.hyd.	Z.phos.	Control
Observation	Saidpur	Rawal Dam	Zero Point	Tarnol	Ayub Park	Shakar Parian	Ghangal	Tarlai	NARC
1. No. poisoned adults released	265	287	275	218	300	245	255	281	257
2. Adults									
i. No. alive	3	15	128	25	13	97	4	25	137
ii. No. dead in nest	103	87	-	123	98	-	127	85	3
iii. No. dead under nest on ground	18	13	2	15	27	2	27	19	2
3. Brood									
i. No. alive pupae	23	19	38	16	21	35	15	16	37
ii. No. alive larvae	5	8	47	17	4	27	13	33	48
iii. No. dead pupae	9	5	-	11	7	-	17	30	-
iv. No. dead larvae	28	35	-	37	22	-	37	54	-
4. Total No. (adults & brood)	189	182	215	244	192	161	240	262	227
5. Overall mortality(%)	83.6	76.9	0.9	76.2	80.2	1.2	86.7	71.8	2.2

strychnine hydrochloride and zinc phosphide (ratio 1:20) lived for 8-24 hours as compared with those in control (fed on honey, fruit, minced meat and provided with water) for 27-43 days.

The mortality of hornets (adults and brood) caused by strychnine hydrochloride and zinc phosphide, applied by the technique mentioned under 'Material and Methods' is given in Table 24. The data in the Table indicate that overall hornet mortality was 76.2 to 86.7% in treatment with strychnine hydrochloride, 71.8-80.2% with zinc phosphide and 0.9-2.2% in control. It seems that these poisoned baits can be more useful in controlling the hornets provided duration of the operation is extended for a longer period.

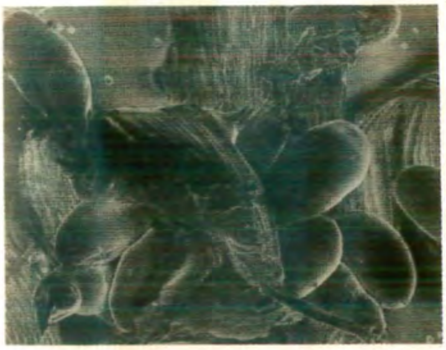
3. MITES

i. *Acarapis woodi* (Rennie)

a. Incidence

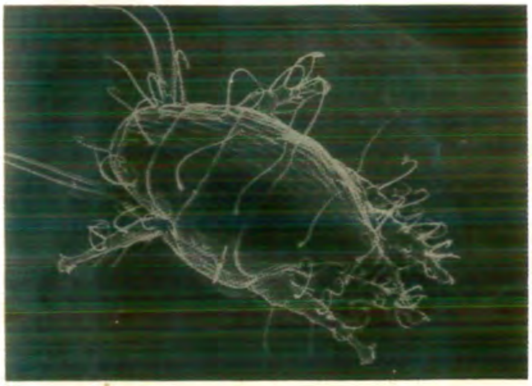
A survey for this mite was conducted in NWFP, Punjab and Azad Kashmir. It was found that the mite caused a mass destruction of *A. cerana* in the Lipa valley (Azad Kashmir) during 1981. The Lipa valley is quite close to Sirinagar in Indian held Kashmir where acarine disease had been prevailing for at least the last one decade.

This mite (Fig.16) was detected for the first time in Mr. Butt's apiary at Khanpur (NWFP) in April and in Mr. Riaz Ahmad's apiary at Haripur (NWFP) in June, 1982. Thereafter, most of the beekeepers (including M/S Riaz and Butt) of Punjab and NWFP shifted their bees for autumn honey to Swat. There were about seven thousand colonies in

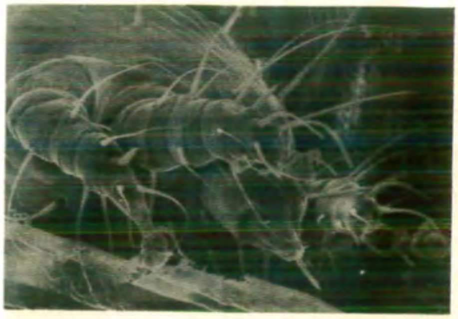


Eggs and nymph in
honeybee trachea

Nymph



Adult female mite



Head of female mite

Fig. 16. Acarapis woodi Rennie

modern hives in Swat during September-October, 1982. The concentration of honeybees resulted in spreading the mite in different apiaries in the area. The apiaries were again shifted to plains and foot-hill areas of Punjab and NWFP in the first week of November, 1982. The shifting of the apiaries resulted in spread of the mite to almost all the beekeeping areas in Pakistan and destroyed about 7250 (80%) out of 9100 colonies of A. cerana in modern hives with the progressive beekeepers and 252 (9.9%) colonies in a sample of 2555 wild or semi-wild colonies in Punjab and NWFP. This indicates that A. cerana colonies maintained in modern hives suffered greater mortality than those occurring in wild and semi-wild conditions.

Some beekeepers are of the opinion that approximately 200 infested colonies were brought from Afghanistan by an Afghan immigrant and were also destroyed by this mite in 1981-82. But this statement could not be confirmed as the bees had died before the Afghan refugee was contacted. It seemed that the mite entered into Azad Kashmir from Indian Kashmir possibly in 1981 and thereafter spread to different areas in Pakistan.

A survey was made to determine the incidence of acarine mite in A. cerana colonies in Swat, Mansehra, Murree and Abbottabad areas. A. cerana bees were sampled from 7 colonies in Swat, 11 colonies in Mansehra, 12 colonies in Murree hills and 11 colonies in Abbottabad District in September, 1985. The incidence of mite infestation is given in Table 25.

Table 25

Incidence of mite infestation in *A. cerana* colonies

Locality	Sample No.	Infested bees	Number of bees with 1-40 mites								Healthy bees
			1-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	
1	2	3	4	5	6	7	8	9	10	11	12
Swat	1	2	1	-	1	-	-	-	-	-	28
	2	0	-	-	-	-	-	-	-	-	30
	3	0	-	-	-	-	-	-	-	-	30
	4	3	-	1	1	-	1	-	-	-	27
	5	5	1	-	2	1	1	-	-	-	25
	6	0	-	-	-	-	-	-	-	-	30
	7	17	2	4	3	5	2	1	-	-	13
	Total	27	4	5	7	6	4	1	-	-	183
Mansehra	1	0	-	-	-	-	-	-	-	-	30
	2	0	-	-	-	-	-	-	-	-	30
	3	0	-	-	-	-	-	-	-	-	30
	4	1	-	-	1	-	-	-	-	-	29
	5	7	1	2	1	1	1	-	1	-	23
	6	2	-	1	1	-	-	-	-	-	28
	7	0	-	-	-	-	-	-	-	-	30

1	2	3	4	5	6	7	8	9	10	11	12
	8	0	-	-	-	-	-	-	-	-	30
	9	0	-	-	-	-	-	-	-	-	30
	10	3	-	2	1	-	-	-	-	-	27
	11	0	-	-	-	-	-	-	-	-	30
	Total	13	1	5	4	1	1	-	1	-	317
Murree	1	0	-	-	-	-	-	-	-	-	30
	2	0	-	-	-	-	-	-	-	-	30
	3	0	-	-	-	-	-	-	-	-	30
	4	0	-	-	-	-	-	-	-	-	30
	5	3	-	1	-	1	-	1	-	-	27
	6	1	-	-	1	-	-	-	-	-	29
	7	2	-	-	-	1	-	-	-	1	28
	8	14	1	3	2	4	-	1	2	1	16
	9	13	3	2	2	1	2	1	1	1	17
	10	0	-	-	-	-	-	-	-	-	30
	11	0	-	-	-	-	-	-	-	-	30
	12	0	-	-	-	-	-	-	-	-	30
	Total	33	4	6	5	7	2	3	3	3	327
Abbottabad	1	0	-	-	-	-	-	-	-	-	30
	2	1	-	1	-	-	-	-	-	-	29

1	2	3	4	5	6	7	8	9	10	11	12
	3	16	1	2	3	5	2	1	1	1	14
	4	0	–	–	–	–	–	–	–	–	30
	5	5	–	1	2	1	1	–	–	–	25
	6	0	–	–	–	–	–	–	–	–	30
	7	13	1	3	2	3	2	1	–	1	17
	8	2	–	–	1	1	–	–	–	–	28
	9	0	–	–	–	–	–	–	–	–	30
	10	0	–	–	–	–	–	–	–	–	30
	11	0	–	–	–	–	–	–	–	–	30
	Total	37	2	7	8	10	5	2	1	2	293
Grand Total		110	11	23	24	24	12	6	5	5	1230

The data in Table 25 indicate that acarine mite was present in 44% colonies. On the whole approximately 9% bees suffered from the disease. Some 10, 21,22,22,11, 5, 4.5 and 4.5% of the attacked bees had 1-5, 6-10, 11-15, 16-20,21-25, 26-30, 31-35 and 36-40 mites, respectively, in their tracheae. The colony No. 5 and 7 in Swat, No.5 in Mansehra, No.8 and 9 in Murree and No.3 and 7 in Abbottabad died before the first week of March while all other infested ones perished by the last week of April.

The incidence of the mite in the individual colonies varied with peaks and troughs in different seasons. In an apiary of 57 hives at Haripur, 30 colonies (52.5%) perished in late spring, 8 colonies (14%) in summer and 14 colonies (25%) in autumn and winter during Mar.1985-Feb.86. The summer and winter were poor seasons for bee breeding in nature. A few young bees were available to the mite for invasion. Thus it resulted in low incidence of acarine mite during these periods.

The seasonal occurrence of the mite *A. woodi* in *A. cerana* colonies sampled from six apiaries and some feral colonies was studied during 1986 and is given in Table 26.

Table 26

Seasonal incidence of *A. woodi* in *A. cerana* colonies
(Hea.=Healthy, Inf.= Infected)

Months	Number of colonies sampled for disease							
	Hived				Wild			
	Hea.	Inf.	Total	Percent	Hea.	Inf.	Total	Percent
February	45	15	60	25.0	22	12	34	35.3
March	49	9	58	15.5	17	5	22	22.7
April	55	10	65	15.3	13	3	16	18.7
May	30	13	43	30.2	7	8	15	53.3

	1	2	3	4	5	6	7	8
June	16	33	49	67.3	5	9	14	64.3
July	10	31	41	75.6	2	10	12	83.3
August	18	21	39	53.8	4	7	11	63.6
September	13	23	36	63.8	3	8	11	72.7
October	17	19	36	52.5	4	7	11	63.6
November	26	11	37	29.7	4	4	8	50.0
December	30	19	49	38.7	4	5	9	55.5
January	27	14	41	34.1	4	3	7	42.8

The data (Table 26) indicate that incidence of A. woodi was comparatively high in colonies maintained in hive than that in feral situations and that the mite destroyed 32% (19 out of 60) colonies in the apiaries and 21% (7 out of 34) feral colonies. Low incidence of the mite in feral colonies was possibly due to lesser concentration of honeybees.

The mite infestation was low in spring when bee population was building up owing to abundance of flora and favourable weather. There was heavey attack of the disease in late summer (monsoon seasons)at the time of lesser foraging by bees because of unfavourable weather and dearth of flora. The beekeepers migrated their colonies in the hills (Murree, Abbottabad, Swat) in autumn.The concentration of colonies resulted in rapid spread of the mite and the incidence of the disease increased markedly.

The European bee A. mellifera colonies were also sampled in different areas to ascertain the incidence of the acarine disease. Although both A. cerana and A.mellifera colonies were not placed far away from each other, no disease was found in colonies of the latter species except in a few hives at Peshawar and Islamabad. It seemed tha the European bee is somewhat resistant to the acarine mite.

ii. Control

In preliminary trials, Folbex VA(bromopropylate) was tried to control A. woodi in six A. cerana colonies with 5 to 7 frame bees. The doses of 1.2 and 1.4 smoke-strips (444 mg and 518 mg) per hive completely killed the mite in the post-embroyonic stages and also caused a considerable mortality of bees while 0.8 and 0.6 strips (dose 296 mg and 222 mg) per hive brought about mortality of all the post-embryonic stages of the mite without any harmful effects on bees.

Studies were conducted to dtermine comparative efficacy of three chemotherapeutic agents in controlling A. woodi and their subsequent effects on honey production of A. cerana colonies. Twenty four diseased colonies comprising 5-6 frame bees were isolated from apiaries and placed at Islamabad on July 1, 1986. These were grouped in four sets each of six colonies. Three sets were treated separately with vapours of 20 cc alcoholic solution of menthol (200 g menthol per liter of 75% ethyl alcolol) and 3/4 strip (277.52 mg) each of chlorobenzilate (Folbex) and bromopropylate (Folbex VA) per colony while 6 control colonies were kept without treatment. Each set of these colonies was placed at a distance of 2 km from each other. The colonies were treated for half an hour in the evening. In all, four treatments were given at four days intervals. These colonies were shifted to Swat by the end of August. Thirty bees per colony were sampled from each of the experimental colony before treatment and 2-3 and 16-17 weeks after treatment and were dissected and examined for mite. Honey produced by each colony was also estimated by the end of October. The details are given in Table 27.

Table 27

Effects of chemicals on the degree of infestation and honey yield of treated and control colonies

Treatment	Degree of infestation (%)			Honey yield (kg)
	Prior to treatment	After treatment 2-3 weeks	After treatment 16-17 weeks	
Menthol	13.3	6.7	13.3	2
"	10.0	0	3.3	3
"	3.3	10.0	13.3	1
"	16.7	3.3	10.3	1
"	10.0	6.7	33.3	0
"	6.7	16.7	30.0	0
Average infestation	10.0	7.2	17.2	7
Bromopropylate (Folbex VA)	6.7	0	6.7	6
"	13.3	0	0	8
"	23.3	0	3.3	4
"	20.0	0	0	9
"	26.7	0	3.3	2
"	16.6	0	13.3	7
Average infestation	17.8	0	4.4	24
Chlorobenzilate (Folbex)	20.0	0	13.3	4
"	30.9	0	16.7	2
"	10.0	0	3.3	2

1	2	3	4	5
"	3.3	0	6.7	3
"	16.7	0	6.7	2
"	10.0	0	3.3	3
Average infestation	15.0	0	8.3	16
Control	13.3	36.7	53.3	0
"	20.0	26.7	66.7	0
"	3.3	10.0	43.3	0
"	10.0	6.7	80.0	0
"	36.7	33.3	30.0	0
"	6.7	10.0	93.3	0
Average infestation	15.0	20.6	61.3	0

The data (Table 27) indicate that bromopropylate gave better results, but reinfestation of mites still remained a serious problem. Anyhow Folbex VA is effective against acarine disease, but it has been used by a few beekeepers owing to its high cost (Rs.30-32 per colony) and non-availability in the remote areas of the country. The treatment with this chemical is quite expensive and it is unlikely to be used by several beekeepers.

The mite A. woodi was observed for its biocontrol agents, but the efforts remained unrewarding. A colony infected by acarine disease was placed at a site surrounded by a water reservoir (70-95% relative humidity) in July-September. It was found that the colony recovered from the disease in about 3 months indicating the possibility of some active biocontrol agent working against the mite.

ii. Tropilaelaps clareae Delfinado and Baker

a. Incidence

This mite attacked A. cerana, A. dorsata, A. mellifera and A. florea almost throughout Pakistan. It infested sealed and unsealed brood cells and caused death and injuries to bees. In infested colonies, the mites were found running on the brood comb. Among the hive bees, its incidence was lower on A. cerana (5-11 adults per colony) than on A. mellifera (70-200 adults per colony) at Haripur in July 1986 (observations based on 10 colonies of each bee). The combs of the infested colonies had scattered, dead, dying or open pupae which were continuously thrown out of the comb by the workers, over the bottom board; while the affected young bees crawled, slowly dragging their bodies on the ground in front of the hive. The adult mites fed on larvae and pupae of the bees inside the cells. There was a rapid decline in colony population within three months during July-September, 1986. The data indicating rate of decrease in ten infested A. cerana colonies is given in Table 28. It is clear from the data that the bees and brood suffered considerably high losses owing to the attack of this mite.

Parasitism of T. clareae was slightly higher in drone cells (16-31%) than in worker cells (10-30%). One or two fecund female mites were usually found in open brood cells containing mostly fourth instar bee larvae and had laid eggs directly upon their body. The relative abundance of T. clareae on honeybee larvae in sealed and unsealed brood cells was observed in three infested colonies in an apiary at Islamabad and is presented in Table 29.

Table 28

Population decline in infested *A. cerana* colonies

Colony No.	July				August				September			
	Number of bee frames											
	Bees	Brood	Honey	Pollen	Bees	Brood	Honey	Pollen	Bees	Brood	Honey	Pollen
R1	12.0	5.0	4.0	1.0	10.0	3.5	0.2	0.1	5.0	2.0	1.5	0.5
R2	9.0	4.0	3.5	0.2	7.0	1.2	-	1.0	4.5	1.5	1.2	0.2
R3	12.0	5.0	4.0	0.5	9.5	3.7	2.5	0.5	3.5	1.0	1.0	0.2
R4	9.0	4.2	3.0	0.5	9.0	4.0	0.5	0.5	5.5	2.0	1.5	0.2
R5	7.0	4.0	3.2	0.5	6.0	-	4.0	0.5	4.0	1.5	1.0	0.2
R6	6.0	3.0	3.5	0.5	5.5	3.2	3.0	0.5	4.0	1.2	0.5	0.2
R7	4.0	2.5	2.5	0.5	4.5	2.5	1.5	0.5	4.0	1.2	0.5	0.2
R8	7.0	4.0	3.2	0.5	6.0	3.2	1.0	0.2	2.5	0.7	0.5	0.0
R9	12.0	4.5	3.2	0.5	10.0	4.5	2.5	0.5	4.5	2.0	1.5	0.5
R10	7.0	4.0	3.0	0.5	7.0	4.5	0.5	0.2	4.0	1.2	1.5	0.2

Table 29

Incidence of *T. clareae* on brood of *A. cerana* colonies

Total brood cells	Number of cells													
	Unsealed larvae							Sealed pupae						
	Without mites	1	2	3	4	5	Total No. infested	Without mites	1	2	3	4	5	Total No. infested
		mites on each individual							mites on each individual					
218	95	14	6	3	4	2	29	85	13	5	2	1	1	22
213	101	10	3	1	-	1	15	94	11	2	1	-	-	14
313	113	5	3	1	-	-	9	184	11	4	1	1	1	18
744	309	29	12	5	4	3	53	363	35	11	4	2	2	54
Percentage	41.5	3.9	1.6	0.6	0.5	0.4	7.0	48.8	4.7	1.5	0.5	0.3	0.3	7.3

The data indicate that its incidence was almost the same on larvae in open cells (7.0%) and on pupae in sealed cells(7.3%). One to five individuals of the mite were found per parasitised brood cell.

T. clareae and *Varroa jacobsoni* Oudemans occurred simultaneously in brood cells in some colonies of the oriental honeybee. Multiple parasitism occurred in one brood cell(n=107). *T. clareae* out-numbered *V. jacobsoni* with ratios of 5:1.

b. Life span

Life span of *T. clareae* on adults and pupae of *A. cerana*, *A. mellifera* and *A. dorsata* was noted in the laboratory. The experiments were carried out at Islamabad during April-October, 1986.

i. Survival time on honeybee pupae

Twenty *T. clareae* mites were placed in glass vial containing honeybee pupae and also in empty glass vial(control). These vials were examined for mortality of the mites after 6 hours for the first time, 15 hours for second time, hourly intervals from 16 to 30 hours, and after 48 hours. Thereafter observations were taken daily until the death of last mite. The hosts (pupae) were replaced with the fresh ones after 3 days in each vial. The details are given in Table 30.

Table 30

Survival of the mite on honeybee pupae

Time (hours)	No. of dead mites in cages(n= 20)	
	A. cerana pupae as host	Without host
6	-	2
15	-	10*
20	-	1
23	-	-
24	-	2
26	-	1
27	-	1
29	-	1
30	-	1
48	1	-
72	6	-
96	3	-
120	4	-
144	2	-
168	3	-
192	1	-
Mean survival	4.7 days	18 hours

* One mite missing.

The mites without any food survived for a short period (less than one day) while on *A. cerana* pupae survival period was fairly large(more than four days).

ii. Survival time on honeybee adults

Twenty adults each of *A. cerana*, *A. mellifera* and *A. dorsata* were released separately in cages. Ten *T. clareae* mites were introduced per cage of each bee and also in control (empty cage). The mortality of mites was noted at hourly intervals (Table 31).

Table 31

Survival time of *T. clareae*

Time (hours)	No. of mites died in cages *A. cerana*	*A. mellifera*	*A. dorsata*	Empty cage (control)
1	-	-	-	3
3	-	-	-	1
7	1	-	-	3
8	-	-	-	1
9	-	-	-	1
10	-	-	-	1
15	1	-	-	-
17	1	-	-	-
19	-	1	-	-
20	1	-	-	-
21	-	2	-	-
24	1	2	-	-
25	1	1	1	-
27	1	-	-	-
28	-	-	1	-
32	-	-	1	-
40	-	-	1	-
45	-	-	1	-
57	-	-	1	-
Mean survival (hours)	19.5	22.3	37.8	5.4

The data in Table 31 indicate that the duration of survival of the mite was highest on *A. dorsata* bees. In a cage with 20 A. cerana, the mean survival time for 10 T. clareae was 19.5 hours with the maximum time 27 hours while with A. mellifera, the mean survival time was 22.3 hours with the maximum time of 25 hours. In an empty cage the survival time is significantly shorter (mean =5.4 hours). This seems to be the effect of the higher running activity in the empty cage compared to a cage with bees. Some of the mites fell into the vaseline under the cage and died.

The mite on its natural host (A. dorsata) survived for longer period than that on other species of Apis. There can be two explanations. It seems that T. clareae takes up food from adult bees of A. dorsata and it can not get from bees of the other species. Koeniger and Koeniger (1985) suggested that differences in the structure of the cuticle among the honeybee species may restrict parasitic mites to one species. This implicates that T. clareae can penetrate the cuticle of A. dorsata and feed upon haemolymph of the bees. Another possibility would be that T. clareae participates in the social food exchange among the bees, like Braula coeca Nitzsch, and is adapted only to the food exchange behaviour of A. dorsata.

The mites died in these trials were examined for causes of their death. The mites in empty glass vials showed no injuries. Their all the body appendages were intact. Similarly the dead mites in A. mellifera cages had no signs of any injury. In cages of A. cerana, 18 adult mites were found intact while 2 mites had lost one leg each. In A. dorsata cages 2 mites showed no injuries, while the other 4 were damaged. Three mites had lost one or two legs and the anterior portion of one mite was missing.

The behaviour of A. dorsata to kill T. clareae seems to be a component of population regulation between the natural hosts and its parasite. A. mellifera does not seems to injure these mites. Peng (1986) reports similar results of her cage experiments with V. jacobsoni and its natural host species A. cerana (communicated by Dr. N. Koeniger). Apparently these bees injure Varroa with their mandibles. Further, one A. cerana bee groomed a nest mate and freed it from Varroa. There seems to be a special grooming behaviour in this bee species.

c. Control

Infested colonies were treated with powdered sulphur at the rate of twenty g per colony at 15 days interval by dusting the powder on the frame top bars (12 g), impregnating the cloth covering the frames with powder(4 g) and spreading the powder on a butter paper at the bottom of hive (4 g). The dead mites were counted on the butter paper placed over the bottom board after four days intervals (March 4-28). The results based on 10 infested colonies (3 to 9 frame bees) are given in Table 32.

Table 32

Mortality of T. clareae in A. cerana colonies

Dates	No. of mites			
	Dead	Moribund	Total	Average per colony
Mar. 4	777	178	955	95.5
8	497	42	539	53.9
12	120	13	133	15.3
16	157	10	167	16.7
20	67	5	72	7.2
24	4	-	4	0.4
28	-	-	-	-
Total	1622	248	1870	189.0

It was observed that the mites attacking honeybee larvae and pupae subsequently suffered mortality on their emergence from cells when came in contact with sulphur. The mite population declined gradually and almost complete control was achieved in 20 days.

Formic acid (65%) was tried for the control of T. clareae infestations. It was used at the rate of 20 ml per 10 frame colony and 30 ml per 15 frame colony (n=5 for each dose) during June, 1988. The acid was poured on a card board container and put inside the hive on the bottom board after sunset. The treatment, applied twice, at weekly interval gave complete control of the mite and killed all the brood and some bees. However, the lower doses such as 8, 10 and 12 ml (n=5 for each) gave partial control (45-85% mortality) of this pest and did not completely control the mites in the sealed brood. However, two treatments of 12 ml formic acid at 8 days interval gave complete control of the pest without any deleterious effect on brood and bees.

iii. Varroa jacobsoni Oudemans

This mite attacks A. cerana and A. mellifera in different areas in Pakistan. The latter bee has recently been introduced into Pakistan. Although the mite is not a pest of economic importance on A. cerana but its outbreak occurred in A. mellifera colonies in 1978-81 and a fairly large number of colonies of the bee were destroyed. But later on the mite population was suppressed and now this mite is not a pest of economic importance in contrary to its heavy population in other parts of the world. It seems that some pathogen particularly virus is responsible for keeping the mite population below economic threshhold. Such pathogen after isolation can be used for biological control of this mite. The most productive areas for such biocontrol agent seem to be Pakistan and some parts of Afghanistan.

iv. Neocypholaeps indica Evans

The mite N. indica is a pollen pest and was recorded for the first time from A. cerana colonies at Hasan Abdal. Studies on this mite showed that it was present in flowers of Althaea rosea and when the honeybee visits such flowers, the mite jumps over it and is transported to the hives. However, at present, it is not a serious pest, but may become important in the future.

v. Indet. mite

An unidentified mite was collected feeding on larvae and pupae of A. cerana. The adults were observed on combs as well. Usually one and rarely two mite adults were observed per pupa or larva in the sealed and open cells. It occurred in small numbers in February in an apiary at Rawalpindi.

4. BIRDS

During the course of survey, twenty one species of birds were found preying upon honeybees. The status of these birds as predators of honeybees, their distribution and active period were studied by watching their activities in the apiaries of A. cerana and other honeybee species in all the provinces including Azad Kashmir (Table 33).

*Paper accepted, letter attached, appendix IV.

Table 33

Bird predators of honeybees, their distribution and active period

S.No.	Name of birds	Host bees	Locality	Active period	Status
1.	Dicrurus adsimilis albirictus (Hodgson) (King crow)	Apis cerana, A. dorsata, A. florea and A. mellifera	Hyderabad, Sargodha, Islamabad, Haripur and Peshawar	May-August	Occasionally a serious pest of A. dorsata
2.	D. leucophaeus logicaudatus Hay (Grey drongo)	A. cerana and A. mellifera	Peshawar, Islamabad and Sargodha	March-August	A minor pest
3.	Lanius collurio collurio L. (Redbacked shrike)	A. mellifera	Karachi	April	A rare pest
4.	L. collurio isabellinus Hemprich and Ehrenberg (Pale brown shrike)	A. cerana and A. mellifera	Sargodha	January	A rare pest
5.	L. collurio phoenicuroides (Schalow) (Rufous shrike or'Lal latora')	A. mellifera	Quetta	March-April	A rare pest

1	2	3	4	5	6
6.	*L. excubitor aucheri* Bonaparte (Persian grey shrike)	*A. florea*	Karachi	April	A rare pest
7.	*L. excubitor homeyeri* Cabanis (Turkistan grey shrike)	*A. mellifera*	Quetta	December	A rare pest
8.	*L. excubitor lahtora* (Sykes) (Pakistani grey shrike or 'Dudiya latora')	*A. cerana* and *A. mellifera*	Sargodha, Peshawar and Hyderabad	March-June	A rare pest
9.	*L. excubitor pallidirostris* Cassin (Baluchistan grey shrike)	*A. mellifera*	Quetta	April	A rare pest
10.	*L. minor* Gmelin (Lesser grey shrike)	*A. mellifera*	Quetta	April	A rare pest
11.	*L. schach erythronotus* (Vigors) (Rufousbacked shrike)	*A. cerana*, *A. dorsata*, *A. forea* and *A. mellifera*	Almost throughout Punjab	April-October	A common pest
12.	*L. vittatus nargianus* Vaurie (Baluchistan baybacked shrike)	*A. mellifera*	Miani Forest (Sind)	May	A rare pest
13.	*L. vittatus vittatus* Valenciennes (Baybacked shrike)	*A. dorsata* and *A. florea*	Azad Kashmir	May	A rare pest

1	2	3	4	5	6
14.	Merops apiaster L. (European bee-eater)	A. cerana and A. mellifera	Baluchistan, Sind, Punjab, NWFP and Azad Kashmir	May-August	Occasionally a serious pest
15.	M. orientalis beludschicus Neumann (Sind small green bee-eater)	A. cerana, A. dorsata, A. florea and A. mellifera	Baluchistan, NWFP, Punjab and Sind	May-September	Occasionally a serious pest
16.	M. philippinus philippinus L.(Blue-tailed bee-eater)	A. cerana, A. florea and A. mellifera	Sargodha and Islamabad	June-July	Occasionally a serious pest
17.	M. superciliosus persicus Pallas (Blue cheeked bee-eater)	A. cerana, A. dorsata A. mellifera and A. florea	Sargodha	May-July	Occasionally a serious pest
18.	Pernis ptilorhynchus ruficollis Lesson (Crested honey bazzard)	A. cerana, A. florea, A. dorsata and A. mellifera	Baluchistan, NWFP and Punjab	April-November	Occasionally a common pest
19.	Picus canus sanguiniceps Baker (Blacknaped green wood pecker)	A. cerana and A. mellifera	Rawalpindi	April-July	A rare pest
20.	P. squamatus flavirostris (Menzbier)(Transcaspian scalybellied green wood pecker)	A. mellifera	Quetta	April	A rare pest
21.	P. squamatus squamatus Vigors (Himalayan scally-bellied green wood pecker)	A. cerana and A. mellifera	Islamabad	August	A rare pest

Although some birds were found to attack A. dorsata, A. florea and A. mellifera, but it is most likely that they also prey on A. cerana. Among these birds, D. adsimilis albirictus, L. schach erythronotus and P. ptilorhynchus ruficollis were of considerable importance as predators of honeybees almost throughout Pakistan while Merops spp. brought about heavy losses to honeybee colonies in some parts of NWFP and Punjab.

Control measures commonly used against birds include closing up nest burrows with mud, destruction of nests, use of poison baits, shooting, stringing bee-eater corpses on gibbets between the hives, catching birds with 'fishing lines', beating of drums, use of hooks baited with live bees and dangling from nylon lines threaded around the apiary (Fry, 1984; Ahmad and Muzaffar, 1984). These measures either have certain limitations or are expensive.

A device was developed for scaring the birds and protecting the bees (Fig.17). It consists of tinsel tapes (3-4 cm wide) of various colours (red, brown, blue, green and yellow) and bamboo or wooden poles of about two meter length and 3 cm diameter. Eight to twelve poles, depending upon the number of colonies, were fixed around the apiary. The poles were connected by tying tinsel tapes at the tops of them in the directions of north-south and east-west. The tapes were set in such a way so that there was one twist at about five meter distance. The bright and shining twisted tapes which were horizontally hanging over the hives reflected sunlight in the form of flash to various directions. Waving of tapes of different colours by wind and flash produced by them by reflection of sunlight created a frightening scene and scared D. a. albirictus,

Fig. 17.

PROTECTION OF HONEYBEES FROM BEE-EATERS WITH TINSEL TAPE

L. S. erythronotus and Merops spp. These proved very useful for scaring the birds and protected honeybees from the bird predators.

5. BLACK ANTS

The black ants Monomorium salmonis L. and M. indicum Morell caused losses by feeding on honey, brood and killed the adult bees in some weak colonies. In an apiary of 20 bee hives, three colonies with 4-5 frame bee strength succumbed to their attack in July when the bees were under stress due to high humidity and dearth of flora.

The nests of the black ants in and around the apiaries were destroyed by filling the nest holes with water and then applying kerosine oil. The hive legs of stands were placed in plastic bowls and filled with water to check the entry of the ants inside the hives.

6. DISEASES

a. Apis iridescent virus

Studies were conducted to determine the possibility of secondary invasion of acarine infested colonies by other pathogens especially virus or bacterium. Singh (1979) has reported that some colonies treated for acarine or nosema diseases did not recover and losses occurred due to the presence of Apis iridescent virus in Uttar Pradesh in winter and in humid summer months in Himachal Pradesh and Kashmir. Bailey and Ball (1978) observed that colonies showing disease symptoms had infections of both Apis iridescent virus and tracheal mite in northern India and Kashmir.

The presence of iridescent virus has also been reported by Kshirsagar *et al.* (1975) in bees which became sluggish and left the combs.

A virus infecting *A. cerana* bees has been detected at Madyan (Swat) and Peshawar. The colonies infected with virus had inactive and crawling bees and clusters of flightless individuals. Clark (1978) detected this virus in bees and mentions: "We found a small (20 nm) spherical non-occluded virus that formed crystalloid in body wall tissue, and that virion are somewhat smaller than those of either sacbrood or acute bee paralysis viruses" (personal communication).

Some samples of diseased bees were sent to Rothamsted Experiment Station (England) for detection of virus. The bees were found to be infected with *Apis* iridescent virus. Some of the bees infected by acarine and virus diseases had slowed down their foraging activities while others had stopped it. The bees were found clustered on frames or walls of hives. Some one-quarter of the bees per hive were occasionally seen crawling on the ground in front of the hive. It seemed that acarine mite in association with *Apis* iridescent virus caused disaster in *A. cerana* colonies.

b. *Fungi*

The infections caused by *Aspergillus flavus* Link and *A. niger* Van Tieghem, commonly known as stonebrood were detected in two *A. cerana* colonies (4-5 bee frames) during July at Taxila. About 5.3 sq cm of the brood was covered with green powdery spores of these fungi. The infected colonies became weak and bee population declined from 5-6 frames to 2.5 - 3 frames in four months.

CHAPTER VII

COMPARATIVE PERFORMANCE OF *APIS CERANA* AND *A. MELLIFERA*

Studies were made on the comparative performance of *A. cerana* (Marghalla and Swat strains) and *A. mellifera* (Italian strain) in Islamabad, Rawalpindi and Mandra area. Ten colonies of each of these bees were placed in sarson (*Brassica campestris*) crop in January, 'phulai' (*Acacia modesta*) plantation in April and clovers (*Trifolium* spp.) crop in May-June. Some observations were made on swarming, absconding, brood development, resistance to pests and diseases and honey yield. The results are given in Table 34.

Table 34

Comparative performance of *A. cerana* and *A. mellifera*

Characteristics	*A. cerana*		*A. mellifera*
	Marghalla strain	Swat strain	
Maximum foraging range	1100 m	1250 m	1600 m
Swarming	Swarming in more than 3 frame colonies	Swarming in more than 4 frame colonies	No swarming in up to 9 frame colonies
Brood rearing under sub-optimum conditions	Decreased to a great extent	Decreased to a great extent	Decreased to a lesser extent
Development of laying workers in queenless colony	Occurred in about 1-2 weeks	Occurred in about 1-2 weeks	Occurred after 3-5 weeks

1	2	3	4
Absconding habit	Absconded on starvation or at higher temperature (40°-44°C) or when attacked by natural enemies	Absconding less than in Marghalla strain	No or rarely absconding
Robbing	Robbing fairly common in dearth period	Robbing less than in Marghalla strain	Less than in *A. cerana*
Cleanliness	Do not maintain cleanliness	Cleanliness better than in Marghalla strain	Keep the hive clean
Bee enemies			
i. Hornets	Minor pests (better self-defence by bees)	Minor pests (better self-defence by bees)	Serious pests (no self-defence by bees)
ii. Wax moths	Major pest	Major pest	Minor pest
iii. Mites			
iv. *Acarapis woodi*	Major pest	Major pest	Minor pest
v. *Tropilaelaps clareae*	Minor pest	Minor pest	Minor pest
vi. *Varroa jacobsoni*	Rare	Rare	Rare
Effect of temperature	Active at a little broader temperature range (8°-40°C) than Swat strain	Temperature range (10°-38°C) lower than that of *A. mellifera*	Active at wider range of temperature (8°-41°C)
Collection of propolis per annum	Collects small amount (10-30 g) per colony	Collects small amount (20-60 g) per colony	Collects larger amount (90-510 g) per colony
Max. honey yield ratio from clovers	1 kg	1.5 kg	4.5 kg

A *cerana* (Marghalla and Swat strains) has lesser production potential than *A. mellifera*. However, the former species can withstand the attack of hornets. There are some areas where *A. mellifera* succumbs to the hornets. Thus bee-keeping with *A. cerana* is appropriate in high hornet population areas.

CHAPTER VIII

LOW COST HIVES

i. Hives

The low cost hives were manufactured on the lines given under 'Material and Methods'. The performance of *A. cerana* was tested in hives made up of (1) clay and chopped wheat straw (CCWS); (2) glauconite, newspapers and fine wheat flour (GNPWF); (3) glauconite, newspapers, fine wheat flour and dry agave leaves (GNPWFAL); (4) cement, sand and newspapers (CSNP); (5) clay and rice husk (CRH); and (6) clay and rice husk ash (CRHA). These low cost hives proved almost equally well for the performance of bees (Fig.18). However, temperature was about 1-1.5°C low in Glauconite and clay hives in May-June (summer) and 1-2°C high in December-January (winter) as compared with that in Langstroth hives. Anyhow transportation of all these hives was more difficult than that of Langstroth hives. The cement and sand hives were heavier than all others. Average bee strength and honey yield of *A. cerana* colonies (3 replicates) were studied in rape seed crop (*Brassica campestris*), "phulai" (*Acacia modesta*) and berseem (*Trifolium* spp.) in Islamabad and Rawalpindi areas from December, 1986 to May, 1987 and are given in Table 35.


Clay and chopped wheat straw (ratio 8:1) hive
Clay and rice husk (ratio 15:1) hive
Glauconite, newspapers and fine wheat flour (ratio 5:1:1) hive
Clay and rice husk ash (ratio 25:1) hive
Cement, sand and newspapers (ratio 2:5:2) hive
Glauconite, newspapers, fine wheat flour and dry agave leaves (ratio 16:4:2:1) hive
LOW COST HIVES

Fig. 18.

Table 35

Average honey yield in different hives

Hives	No. bee frames		Honey yield (kg)	
	Dec.	May	Range	Average
1. CCWS	5	9.2	4.3-5.3	4.9
2. GNPWF	5	8.8	5.2-6.1	5.7
3. GNPWFAL	5	9.5	4.7-6.2	5.2
4. CSNP	5	8.7	5.1-6.7	6.1
5. CRH	5	9.3	4.9-6.2	5.8
6. CRHA	5	8.9	5.2-6.5	6.1
7. Langstroth (control)	5	9.5	4.5-6.6	5.5

The data in Table 35 indicate that there was no marked difference in the development of bee strength and honey yield in low cost hives as compared with that in Langstroth hives. The cost of these hives was Rs.18-30 per unit as compared with that of Rs.500 of Langstroth hive.

Latif *et al*. (1956g) reported that *A. cerana* colonies were more susceptible to the attack of wax moths and also suffered due to low winter temperature in mud-wall hives. The present studies indicated that there was no marked difference in the incidence of wax moths in all these hives. Some 3-4 frame bees increased to 5-6 frames in rape seed (*B. campestris*) crop during December-January. The mortality of bees in winter was not higher in these hives than in Langstroth ones.

These low cost hives worked well when kept at one place and were not suitable for migratory beekeeping. The hives made up of glauconite('multani mitti'), newspapers and fine wheat flour were further improved by plastering these with thin layer of cement. These proved better than others with regard to firmness and quality.

ii. Frames and comb foundations

Beekeeping is practised as a cottage industry in the northern areas. Each beekeeper has 1-8 colonies of A. cerana. Comb foundation sheets are not available in these areas. Therefore studies were made to circumvent this problem by using different types of low cost frames prepared on the lines mentioned under 'Material and Methods'.

The colonies with about six frame bees having (1) frames of wooden piece tied with triangular comb foundation sheets supported with 1 mm thick wire (WPTCFS, cost per frame Rs.5), (2) standard full depth frames with 1 mm thick wire covered with wax (SFDWW, Rs.11), (3) super frames with 1 mm thick wire covered with wax (SFWW, Rs.7), (4) standard full depth frames with plastic or cloth sheets, having holes each of 1/2 cm diameter at 2 cm distance, coated with wax and passed through comb foundation machines (SFDFPSW, Rs.8), and (5) standard full depth Langstroth frames with normal comb foundation sheets (SFDFNCFS, Rs.18) drew combs fairly well in clay hives and produced 3.2-5.1 (average 4.2), 4.3-6.6 (average 5.9), 3.2-6.8 (average 4.8), 3.7-5.7 (average 4.6), 5.2-7.8 (average 6.7) kg honey, respectively, from Plectranthus rugosus plants in Swat during September-October. However, honey production in cavities of walls without frames (CWWOF) was 1.2-2.3 (average 1.6) kg per colony at that location in the same period. This indicates that colonies having these frames yielded fairly high honey as compared with those reared traditionally in cavities of walls without frames.

CHAPTER IX

HONEYBEE POLLINATION OF CROPS

Honeybees are known to increase the yield of several cross-pollinated crops and fruit plants to the value of 10-20 times more than the cost of honey produced by them (McGregor, 1976). Therefore, studies were conducted to determine the effect of honeybees and other insect pollinators on pollination of alfalfa, berseem, loquat, apple, pear, litchi, turnip, coriander, carrot and sunflower under local conditions. Frequency of the insects visiting these crops was studied and the yield of selected plants estimated.

1. ALFALFA AND BERSEEM

Failure of seed-setting in alfalfa (*Medicago sativa*) is a serious problem. Tripping (the release of staminal column from the restraining process on the wing and the keel petals) is essential for pollination of this crop (Armstrong and White, 1935) and is mainly performed by insects, particularly bees (Bolton, 1962). Ahmad (1976) studied insect pollinating fauna of alfalfa in Pakistan and reported that honeybees play an important role in pollination of this crop in the country. Similarly the pollination of berseem (*Trifolium alexandrianum*) by bees is quite well established. Shamel (1905) reported that bees are absolutely necessary for its pollination. This has been verified with caged and open plots by Hassanein (1953), Latif (1956) and Narayanan *et al*. (1961). These reports leave little doubt that insect pollination is absolutely necessary for profitable seed production of alfalfa and berseem. Studies on these crops were conducted on the peripheries of forest areas at Haripur, Khanpur and Taxila. The data on yield of crops visited and almost not-visited by bees are given in Table 36.

Table 36

Yield of seed per hectare (ha)

Locality	Crop	Not visited by bees		Visited by bees	
		Plot size (ha)	Yield (kg) per ha	Plot size (ha)	Yield (kg) per ha
Haripur	Berseem	0.20	378.5	0.10	736.3
	"	0.10	331.8	0.20	553.5
	Alfalfa	0.20	267.8	0.20	378.0
Khanpur	Berseem	0.10	322.7	0.07	1171.7
	Alfalfa	0.05	350.3	0.05	405.7
Taxila	Berseem	0.07	349.4	0.07	1228.8

It is quite obvious from the data (Table 36) that the honeybees played an important role in the seed production of these crops.

2. LOQUAT

Loquat (*Eriobotyra japonica*) is commercially grown in the foot-hills and hills in the country. Pollination requirements are known to vary with the varieties (McGregor, 1976). Mortensen and Bullard (1968) reported that cross-pollination was beneficial to all and necessary to some varieties. To determine the effect of honeybees on pollination of this crop, 4 colonies of _A. cerana_ were placed in 1.5 ha orchard of loquat at Jolian. Six loquat trees were selected in the first week of October. Three branches each having 50 flowers (before opening) were earmarked on each tree for various treatments. The first branch was covered with muslin cloth to exclude all insects, second branch with mosquito net cloth to exclude bees and larger insects and third branch left open for allowing the bees and other insects to visit the flowers. The number of fruits set on selected branches were counted by the end of February (Table 37).

Table 37

Number of fruits set on each twig

Replicates	No. of fruits set per 50 flowers		
	Muslin cloth	Net cloth	Open twigs
1	5	7	12
2	4	6	11
3	4	6	14
4	3	7	13
5	2	5	14
6	4	6	12
Total	22	37	76
Percentage	7.3	12.3	25.3

The data in Table 37 show that 3.5 times more fruits were set on open twigs as compared with those covered with muslin cloth indicating that the bees and other insects play an important role in setting of loquat fruits.

3. APPLE

'Red delicious' and 'Golden delicious' varieties constitute most of the apple plantations in the Murree Hills. These varieties flower in March. During this month, weather remains occasionally cloudy restricting the activities of honeybees and other insect pollinators. There were about 150-200 wild honeybee colonies and a small number of insect pollinators in apple area in Murree.The bees and other insect pollinators were not present in sufficient numbers for pollination of apple. The farmers, unlike those in advanced countries, are not aware of the importance of bee pollination in setting of fruits. Furthermore, the small population of honeybees visiting 'Red delicious' variety soon learn to obtain nectar from the side of the flower. These side-working bees stand on petals and avoid contact with the sexual parts of the flowers. It further enhances the pollination problem in this variety. However, in some other apple varieties such a 'Golden delicious', 'Sky spur', 'Nuggot' and 'Kashmiri Amri', the bees work down to the nectary from above; these top workers splatter themselves with pollen and brush some pollen onto the stigmas of the pistils and efficiently pollinate these varieties. Thus this situation in the Murree area results in lesser yield of apple fruits particularly in 'Red delicious' apple and to some extent in other varieties. In addition to poor yields, inadequate pollination usually results in the production of some misshapen fruits.

An experiment was conducted on five apple varieties namely 'Sky spur', 'Red delicious','Kashmiri Amri', 'Nuggot' and 'Mc-Intosh' in two fields of 0.40 ha each at Murree. Four *A. cerana* colonies were used to pollinate the crop. Two colonies were placed in the centre of each field. Four plants of each variety were selected. Three branches of uniform size and age bearing equal number of flower buds were selected on each plant. One of the branches was covered with muslin cloth bag, (no insects visited), the other with net cloth bag of 3.5 mm mesh size (insects smaller than bees visited) and the third was left open and tagged (bees and other insects visited). The number of flowers and fruit set on each branch were counted and are presented in Table 38.

Table 38

Number of flowers and fruit set

Variety	Flowers per branch in each bag	Fruit set		
		Muslin cloth	Net cloth	Open twigs
'Sky spur'	194	3 (1.5%)	9 (4.6%)	48 (24.7%)
'Red delicious'	308	0 (0.0%)	5 (1.6%)	91 (29.5%)
'Kashmiri Amri'	167	3 (1.8%)	10 (6.0%)	43 (25.7%)
'Nuggot'	205	5 (2.4%)	11 (5.3%)	55 (26.8%)
'Mc-Intosh'	197	6 (3.0%)	18 (9.1%)	44 (22.3%)

The data indicate that fruit setting was 0-3% in muslin cloth bags, 1.6-9.1% in net cloth bags and 22.3-29.5% in open twigs indicating a marked effect of honeybee and other insect pollinators on fruit setting of apple.

Thus it seems that either the honeybee colonies should be shifted at the time of apple blossoms or the level of natural honeybee or other insect pollinator populations be raised in the apple areas in the Murree Hills.

4. PEAR

Nine pear plants were selected at different places in field. Three branches each having 30 flowers (before opening) were earmarked on each tree for various treatments. First branch was covered with muslin cloth and second with netting cloth while third was left open. Average numbers of insects visiting each branch were 20 *A. cerana*, 25 *A. mellifera*, 5 *A. florea*, 4 *A. dorsata* and 3 other insects in 45 minutes during 8-9 a.m. The number of fruits set on selected branches was counted by the end of April (Table 39).

Table 39

Number of fruit set on each branch

Replicates	No. of fruits formed per 30 flowers		
	Muslin cloth	Net cloth	Open branch
1	2	2	4
2	1	3	3
3	1	3	4
4	1	2	4
5	2	2	4
6	2	2	2
7	1	3	3
8	2	3	4
9	1	2	4
Total	13	22	32
Percentage	4.8	8.1	11.9

The data (Table 39) show that 2.5 times more fruits were set on open twigs as compared with those covered with muslin cloth indicating a definite role of bees and other insects in fruit setting of pear plants.

5. LITCHI

Some 75 twigs (each 1/3 meter long and of almost equal breadth) were selected on 25 litchi plants in April. Of these, 25 twigs were left open and 25 twigs were covered with muslin cloth and 25 twigs with netting cloth. The frequncy of insects visiting each open branch was 7 A. cerana , 5 A. florea and 4 other insects in 45 minutes during 8-9 a.m. (three replicates). The fruit formation on open twigs and those covered with netting cloth was, respectively, 4.4 times (48 fruits) and 2.6 times (29 fruits) higher than those covered with muslin cloth (11 fruits) on 25 twigs in each treatment.

6. TURNIP

In a turnip field, 25 twigs (0.45 m long and of almost equal breadth) were covered with muslin cloth and 25 twigs with netting cloth, and 25 twigs of the same length and breadth were left open. Average number of insects visiting each twig having open flowers was 9 A. cerana, 7 A. mellifera, 8 A. dorsata and 4 A. florea per 45 minutes during 8-9 a.m. (three replicates). Seed yield of these twigs was measured after harvesting the crop. It was found that flowers left open and those covered with netting cloth produced 1.5 (652.0 grams) and 1.1 times (453.6 grams) more seed as compared with the flowers covered by muslin cloth (425.2 grams).

7. CORIANDER

Some 75 plants of coriander of almost equal size were selected. Of these, 25 plants were covered with muslin and 25 plants with netting cloth, and 25 plants were left open. The frequency of insects visiting each branch of open flowers was 6 A. cerana and 9 other insects per 45 minutes during 9-10 a.m. (three replicates). On harvesting the crop, it was found that plants left open for visits by all insects and those covered with netting cloth yielded 3.6 (303.3 grams) and 1.7 (141.7 grams) times more seed, respectively, than those covered with muslin cloth (85.0 grams).

8. CARROT

Three plots each having 24 plants of almost equal size were selected. Plants were left open in the first plot, covered with muslin cloth in the second plot and with netting cloth in the third plot. The frequency of insects visiting each open plant was 5 A. cerana , 6 A. florea, 2 A. dorsata and 3 other insects per 45 minutes during 9-10 a.m. (three replicates). The plants left open for the visits of all insects and those covered with netting cloth produced 2.2 times (311.8 grams) and 1.8 times (255.1 grams) more seed, respectively, than those covered with muslin cloth (141.7 grams).

9. SUNFLOWER

Sunflower (Helianthus annuus) has been cultivated on a small scale in the country, but occasionally the crop failed due to lack of pollination. Honeybees have been reported to be the primary pollinating agents of sunflower in most of its cultivation areas in the world (Cardon, 1922; Cirnu, 1960; Fomina, 1961; Glukhov, 1955; Pritsch, 1965; Radaeva, 1954). Shortage of honeybees in sunflower fields is known to result in small seed crop (McGregor, 1976).

Cultivation of sunflower has recently been started in Islamabad District. Among the pollinating insects Xylocopa fenestrata F., X. pubescens Spinola and Bombus haemorrhoidalis Smith occurred in sunflower fields, but their populations were very low. Hence these insects appeared to be of no considerable importance in pollinating this crop. Honeybees were therefore used to supplement the pollinating fauna in that area. Fourteen colonies of A. cerana were placed in the sunflower (cultivar 'Record') in an area of 7 ha during the flowering period from August 27th to September 10th, 1986. Four sites were selected for studies on the effects of insect pollinators on seed setting of the crop (four replicates). Ten heads were examined in each replicate. The diameter of each head was measured, and the mature, hollow and shrivelled (damaged by Nysius sp.) grains were counted (Table 40). The data indicate that fertilisation occurred in 76.3-84.2% florets in open heads, 0.3-3.5% florets in heads covered with muslin and 4.1-15.5% florets in heads covered with net cloth. This shows that the honeybees or other insect pollinators are most essential for successful cultivation of sunflower crop particularly the open pollinated varieties.

Table 40

Effect of honeybees on the yield of sunflower

Treatment	Replicates	Diameter of head (cm)		Mature seeds (fertilised)			Insect damaged seeds (fertilised)			Hollow seeds (unfertilised)		
		Range	Av*	Range	Av* No.	%age	Range	Av* No.	%age	Range	Av* No.	%age
Heads open	R 1	30.4-41.9	36.0	345-735	571	67.1	71-207	129	15.2	45-256	151	17.7
	R 2	29.4-45.7	35.8	213-851	681	66.5	24-222	116	11.3	61-930	227	22.2
	R 3	27.9-39.3	33.2	468-838	687	72.5	6-170	116	12.2	60-232	145	15.3
	R 4	27.9-40.6	35.0	488-1070	737	75.2	14-78	38	3.9	106-560	205	21.0
Heads covered with muslin cloth	R 1	27.6-44.4	37.0	4-168	32	3.2	-	-	-	954-1215	979	96.8
	R 2	26.6-42.1	33.0	7-78	34	3.2	-	-	-	615-1768	1023	96.8
	R 3	27.9-34.3	28.4	4-83	31	3.4	-	-	-	397-1346	888	96.6
	R 4	25.4-40.6	53.6	5-132	37	3.5	-	-	-	694-1560	1005	96.4
Heads covered with net cloth (mesh size 0.33 cm)	R 1	25.4-39.6	33.5	12-98	41	4.5	-	-	-	538-1363	878	95.5
	R 2	20.3-36.3	29.9	26-115	62	6.0	19-128	70	6.8	501-1223	901	87.2
	R 3	19.0-30.4	25.1	11-195	86	10.3	1-29	8	0.9	416-1133	741	88.7
	R 4	25.4-40.6	35.5	10-81	50	4.0	-	-	-	817-1580	1188	96.0

* Average

CHAPTER X

HONEYBEE POLLINATION AND PEST MANAGEMENT IN (BRASSICA CAMPESTRIS) CROPS*

Rape and mustard (Brassica spp.) crops are the most important sources of nectar and pollen in winter. In some areas insecticides are sprayed for the control of pests of these crops and cause heavy losses of honeybees. Studies were conducted to develop insect pollinator and pest management of these crops.

i. Insect pollinators

There has been considerable study of the pollinators of rape (Brassica campestris) crops in Pakistan. According to Mohammad (1935), 117 species of insects belonging to 7 orders visited this crop and that Andrena ilerda Cameron, Apis florea and Halictus sp. in descending order of abundance were important pollinators of this crop at Faisalabad. Rahman (1940) stated that Andrena ilerda was the primary pollinator and that rape and other oil-seed crops were frequently visited by Apis florea, Halictus sp., H. salsettemsis Ckll., Andrena leaena Cam., Andrena (4 spp.) and occasionally by two species of Colletes, Xylocopa sp., X. nasalis Westw., Ceratina sp., C. binghami Ckll., Nomada (3 spp.), Thyreus sp. and Anthophora vedetta Nur. Seed yield of this crop was greatly increased when hives of Apis cerana were placed in the fields (Latif et al., 1960e). Rape flowers were visited mainly by Apis cerana followed by Andrena ilerda, Apis dorsata, A. florea, Halictus spp., a Syrphid and Techinid flies, while 18 species of bees of the genera Colletes, Andrena, Lasioglossum,

*Paper accepted, letter attached. appendix V.

Sphecodes, Xylocopa, Ceratina, Nomada, Anthophora and Nomioides were occasional visitors (Latif et al., 1965).

During the present studies, Apis cerana, A. florea, A. dorasta, Amegilla comberi Ckll., Ceratina simillima Smith, Andrena ilerda, Pithitis smaragdula (F.), Tetralonia sp., Thyreus ramosus Lep., Xylocopa pubescens Spinola, X. fenestrata Fab., X. aestvans (L.), Eristalis tenax (L.), Eristalinus megacephalus (Rossi) and Megachile bicolor F. were collected from rape flowers in Rawalpindi area. A. mellifera, A. cerana, A. dorsata, A. florea, Andrena spp., Eristalis spp. and Halictus spp. constituted 35.2, 29.4, 14.5., 9.7, 4.8, 3.2 and 3.2% population of pollinating fauna in the experimental fields. The populations of non-bee pollinators was insignificant in this crop. The effect of these species on seed setting of this crop was investigated by counting the number of pods and seeds per open (visited by bees) and covered (not visited by bees) plants (Table 41).

Table 41

Effect of insect pollinators on seed setting of rape crop

Treatment		Number per plant		
		Pods		Seeds
		Developed	Total	
Covered plants (not visited by bees)	Min.	279	312	1765
	Max.	326	356	2205
	Av.	298	327.5	1958
Open plants (visited by bees)	Min.	292	313	3404
	Max.	343	359	4217
	Av.	319	328.2	3815
Average difference (%)		7.0	0.2	94.8

The number of developed pods and total pods was, respectively, higher 7.0 and 0.2% on open plants than on covered plants. Thus development of pods was significantly higher (6.8%) on open plants than on covered plants. Average number of seed set was 94.8% higher in open plants than in covered ones indicating almost two fold increase in yield due to bee pollination.

Honeybees or other insect pollinators increase the yield of this crop by cross-pollination (Downey et al., 1970 and McGregor, 1976). Seed production has been reported to be 2095 kg/ha with apiaries beside the field as compared with 1275 kg/ha with apiaries at 2.4 km distance (Koutensky, 1958). The yield of rape seed is low in Pakistan (618/kg ha) and India (589 kg/ha) as compared with that in France (2081 kg/ha), West Germany (2584 kg/ha) and Belgium (2737 kg/ha) (Anon., 1983). The population of honeybees has been reported to be less than 0.1 hive/sq km of agricultural land in Pakistan and India, 0.1-0.5 hives/ sq km in West Germany and Belgium (Crane, 1975). There are many factors responsible for variations in yield, but the honeybee population is one of the most important factors affecting yield of this crop in these countries. Thus raising the population level of honeybees should improve harvests of rape and other entomophilous crops.

ii. Effect of insecticides

a. Insect pests

Spraying was carried out on crop infested with aphid *Rhopalosiphum erysimi* K. at Gujar Khan in January. Mortality casued by various doses of insecticides is given in Table 42.

Table 42

Effect of three insecticides on the aphid R. erysimi

Observation period	Number of aphids per 30 plants				
	Pirimicarb 250 g	Permethrin 50 g	Permethrin 100 g	Monocrotophos 500 g	Control
Pre-treatment	3841	3115	4234	3288	3427
Post-treatment (4 days after spray)	148	576	208	42	3465
Mortality (%)	96.2	81.5	95.1	98.7	-

The data in Table 42 indicate that mortality was lower (81.5%) with Permethrin 50 g than the fairly high level (95.1-98.7%) with Pirimicarb 250 g, Permethrin 100 g and Monocrotophos 500 g indicating almost equal effectiveness of the last three chemicals at the dosages used.

Small infestation of sawfly (Athalia proxima Klug.), cabbage butterfly (Pieris brassicae Linn.), cabbage borer (Hallula undalis (Fab.) cabbage semi-looper (Plusia nigrisigna Wlk.), American bollowrm (Heliothis armigera HB.) and hairy caterpillar (Diacrisia obliqua Wlk.) also occurred in some fields. All the insecticides, except Permethrin 50 g, gave 95-100% control of these pests at the dosages used.

b. Insect parasites

Diaeretiella rapae (M'Intosh) parasitised the aphid R. erysimi. It was common throughout rape crop belt. Its parasitism was 0-5%. Aphidius matricariae Hal. also parasitised the aphid but it was localised in occurrence and its parasitism was 0-0.8%. The effect of insecticides on parasites was studied in sprayed fields (Table 43).

Table 43

Effect of three insecticides on the parasite *D. rapae*

Observation period	Parasitised individuals (pi) and parasitism (p) in samples each of 800 aphids									
	Permethrin				Pirimicarb		Monocrotophos		Control	
	50 g		100 g		250 g		500 g			
	pi	p%	pi	p%	pi	p%	pi	p%	pi	p%
Pre-treatment	38	4.8	43	5.4	33	4.1	37	4.6	34	4.3
Post-treatment										
4 days after spray	42	5.3	5	0.6	80	10.0	2	0.3	41	5.1
8 days after spray	28	3.5	0	0.0	61	7.6	0	0.0	36	4.5

The data in Table 43 indicate that Monocrotophos 500 g and Permethrin 100 g which caused 95-98% mortality of the aphid brought about a crash in the parasite population. The incidence of the parasite increased considerably after spraying in plots treated with Pirimicarb 250 g possibly due to the specific nature of the insecticide and the short duration of its residual effects.

The residual effect of Pirimicarb 250 g against the parasite was 4 days. Thereafter it did not affect the adult parasite in the field. The pupae and prepupae of the parasite were present in almost dry cadavers of the host and also in pupal shells. This situation inhibited penetration of the pesticide into the body of the parasite in prepupal and pupal stages. Thus the parasite in these stages was safe from pesticides. The toal life span of the parasite was 16 days; pupal and prepupal stages lasted for 6 days at the time of the spraying. Thus survival percentage of the parasite can be calculated: 6 (duration in days of prepupal stage)- 4(period in days of residual effect of Pirimicarb 250 g) X 100 ÷ 16 (life span of the parasite in days)=12,5%. Survival of the pest in field treated with Pirimicarb 250 g was 100-96.2 = 3.8% (Table 42) as compared with 12.5% of the parasite. Thus Pirimicarb 250 g gave fairly good control of the aphid with lesser hazards to the parasite.

c. Insect predators

Coccinella septempunctata L., Scymnus nubilus Muls., Chrysoperla carnea (Steph.) and Orius sp. preyed upon the aphid and were fairly common in rape crop and destroyed 41-85, 16-27, 9-25 and 8-13 aphids, respectively in a day.Effects of insecticides on the predators in relation to the pest population are given in Table 44. The data indicate that

Table 44

Effect of insecticides on *C. septempunctata* (Cs), *S. nubilus* (Sn), *C. carnea* (Cc) and *Orius* sp. (Os) predacious on *R. erysimi* (Re) in sarson crop

Observation period	Number of aphids and predators in each sample																			
	Permethrin										Pirimicarb					Monocrotophos					Control				
	50 g					100 g					250 g					500 g									
	Re	Cs	Sn	Cc	Os	Re	Cs	Sn	Cc	Os	Re	Cs	Sn	Cc	Os	Re	Cs	Sn	Cc	Os	Re	Cs	Sn	Cc	Os
Pre-treatment	3115	4	2	6	5	4234	4	3	8	11	3841	3	2	7	5	3288	5	4	7	12	3427	4	5	4	6
Post-treatment																									
4 days after spray	3095	5	3	8	7	4205	0	0	0	0	3824	6	7	5	8	3302	0	0	0	1	3405	6	4	3	8
8 days after spray	3102	6	4	9	5	4262	1	0	0	0	3851	7	6	8	8	3340	0	0	0	0	3446	7	4	5	5

Monocrotophos 500 g and Permethrin 100 g killed a significantly large population of the predators whereas Permethrin 50 g and Pirimicarb 250 g caused significantly lesser hazards to the predators than the pest. Permethrin also caused fairly low mortality of the pest. Therefore, Pirimicarb 250 g/ha seems to be suitable dose for controlling the pest with the least hazard to the predators.

d. Insect pollinators

There were several species of insect pollinators in the field at the time of spraying. Apis cerana and A. mellifera colonies were covered with muslin cloth bags to restrict the movement of bees and to protect them from insecticide hazards. A. florea and A. dorsata suffered some losses due to pesticides and some dead bees were found under their combs on the ground. Some adults of Andrena spp., A. florea, A. dorsata, Halictus spp. and Eristalis spp. were found dead on sampling spots (Table 45).

Table 45

Effect of three insecticides on insect pollinators of rape crop

Name of species	No.of dead adults/20 sq m sprayed area			
	Permethrin		Pirimicarb	Monocrotophos
	50 g	100 g	250 g	500 g
1. Andrena spp.				
Ist-4th day after spray	1	5	2	5
5th-7th day after spray	2	-	-	-
2. Apis florea				
Ist-4th day after spray	3	5	2	10
5th-7th day after spray	-	-	-	5
3. Apis dorsata				
Ist-4th day after spray	2	4	2	9
5th-7th day after spray	-	-	-	4

1	2	3	4	5
4. Halictus spp.				
Ist-4th day after spray	1	-	1	4
5th-7th day after spray	-	-	-	3
5. Eristalis spp.				
Ist-4th day after spray	-	2	1	2
5th-7th day after spray	-	-	-	-
Total	9	16	8	42

Mortality of pollinating bees was very low with Pirimicarb 250 g, low to medium with Permethrin 50 and 100 g, highest with Monocrotophos 500 g indicating least hazard to bees from the first insecticide. Some adults of insect pollinators were found to be dead at places other than the sampling sites. The nesting sites of some pollinating bees could not be found. Therefore, mortality of the insect pollinators could not be determined at their nesting places.

iii. Multi-purpose honeybee flora

Pakistan's honeybee population is among the lowest in the world (Crane, 1975). Therefore, pollination of entomophilous crops is adversely affected, resulting in low yields. The low honeybee population warrants some alteration in agro-forestry plantation programmes in order to provide a flora suitable for honeybees throughout the year, thus increasing the population and leading to better pollination in entomophilous crops and fruit trees, with the additional prospect of honey production.

Planting programmes have been undertaken for various purposes and some of the plants used for planting also produce nectar and pollen, enabling the bees to thrive. Thus there is the potential for improving the yield of many fruit and seed crops through bee foraging and pollinating activities with the additional production of honey. Some plants, grown for various other purposes, are also quite promising for honey production. Some of these, alongwith their uses, are listed in Table 46. It has been observed in certain areas that where these plants provided nectar and pollen throughout the year, the insect pollinators were abundant. Thus development of the sort of farm forestry which provides nectar and pollen all the year, thus raising the population levels of honeybees and other insect pollinators, helps alleviate the pollination problem and increases the yield of rape and other entomophilous seed crops.

iv. Economics of insect pests and pollinator management

Rape and mustard (*Brassica campestris*, *B. juncea*, *B. napus*, *B. carinata*, *B. alba*, *B. nigra* and *Eruca sativa* (syn. *Brassica eruca*) are cultivated on about 385,500 ha in Pakistan (Anon., 1984). These crops have been reported to be either self-sterile or benefitted by honeybees (McGregor, 1976 and Free, 1970). Some of these crops have shown up to two fold increase in seed yield when sufficient number of honeybees were provided in the field (Meyerhoff, 1954; Olsson, 1955; Koutensky, 1958; Free and Spencer-Booth, 1963; and Downey, 1964). In the present experiment the increase in the number of seeds was 94.8% due to honeybee pollination. Because some of the insect pollinators are already present in the field, it is presumed that honeybee pollination would at least bring about 12.5% increase in seed yield. Furthremore, insect pests mainly aphids have been reported to cause 33-40

Table 46

Multi-purpose honeybee flora

Species	Nactar	Pollen	Timber	Fire wood	Nitrogen fixation	Soil erosion control	Land scaping	Forage	Medicinal plant	Flowering period	Remarks
Albizia lebbeck (Siris tree)	+		+	+	+	+	+	+		Apr.-May	Provide shade, green manure.
Antigonon leptopus (Coral vine)	+	+					+			Jul.-Nov.	
Calliandra calothyrsus (Calliandra shrub)	+	+		+	+	+	+	+		Jul.-Oct.	Grown for hedge & fire break.
Cedrela tonna (Toon tree)	+		+	+			+	+	+	Apr.-May	Quick growing; flowers used for dye making.
Epilobium angustifolium (Willow herb)	+				+				+	May-Jul.	
Eriobotrya japonica (Loquat)	+	+				+				Oct.-Feb.	Fruit tree.
Eucalyptus camaldulensis (Red river gum tree)	+	+	+	+			+			Dec.-Mar.	Provide shade and shelter from blowing sands.
E. citriodora (Lemon scented gum tree)	+		+	+			+			May-Aug.	Produces non-edible oil, drought & frost resistant.
E. grandis (Blue green tree)	+	+	+	+			+			Nov.-Mar.	Grown for shade & wood pulp.
E. tereticonrnis (Red gum)	+		+				+			Nov.-Apr.	
Gleditsia triacanthos (Honey locust)	+	+		+		+		+		Mar.-Apr.	Grown for shade and as hedge, pods used for making bear.
Grevillea robusta (Silk oak tree)	+	+	+	+			+			Mar.-Apr.	Grown for shade in coffee and tea plantations.
Haematoxylon campechianum (Logwood tree)	+	+	+								Haematoxylon (adye) produced from the wood.
Lamium album (White dead nettle)	+	+					+		+	Jun.-Sep.	Used as resolvent and vulnerary.
Melilotus alba (White melilotus)	+	+				+		+		May-Jun.	
Medicago arborea (Wild alfalfa)		+				+		+		May-Jun.	Useful for rangelands.
Medicago falcata (Yellow flowered alfalfa)	+	+				+		+		May-Jun.	Resistant to cold and drought, useful for rangelands.
Plectranthus rugosus (Shain shrub)	+	+				+	+			Sep.-Oct.	
Prosopis juliflora (Honey locust tree)	+	+	+	+	+	+	+	+		Apr.-Jun.	Provide shade and shelter. Good plant for highly saline and sandy soils.
Robinia pseudoacacia (Ain-ul-asl tree).	+		+	+	+		+	+		Apr.-May	Grown for shade and wind break.
Sapindus mukorossi (Soapnut tree)	+	+	+	+			+			May-Jun.	Yields saponin used as substitute for soap.
Terminalia chebula (Yellow myrobalan)	+								+	Apr.-Jun.	Fruits used for dye and tanning.
Vitex negundo incisa (Asl-i-amir shrub)	+			+		+	+			May-Nov.	Grown for hedges, branches used for basket-making.
Ziziphus spina christi (Asle-sehra tree)	+	+	+	+		+		+		Aug.-Oct.	Grown for wind break, shelter belts.

losses to almost all the rape and mustard crops in Pakistan (Anon., 1975). Thus control of these pests would at least increase 12.5% seed yield of these crops.

Among the insecticides tried, Pirimicarb proved somewhat specific for aphid control. Spraying was done with knapsack sprayer in infested areas only. The insecticide dose for one ha was used for spraying infested patches for three times at about a fortnight interval. Rape crop is the most important pollen and nectar source. The beekeepers prefer to place their colonies in these crops for increasing bee strength and for honey production. The economics of aphid and pollinator management is presented in Table 47.

Table 47

Economics of insect pest control and pollinator management

1. Expenditure on insect pest and pollinator management		
A. A labourer for spraying/ha/day	Rs.	30
B. Depreciation of knapsack sprayer/day	Rs.	3
C. Cost of Pirimicarb 250 g/ha	Rs.	90
D. Rent of bees	Rs.	10
E. Expenses/ha	Rs.	133
F. Total expenses for 385,500 ha	Rs.	51,271,500
2. Increase in yield		
A. Pest management	Percent	12.5
B. Pollinator management	Percent	12.5
3. Area and production in 1982-83		
A. Total area under rape and mustard crops	Hectare	385,500
B. Yield per ha	Kg	638
C. Total production	Tonnes	246,000

4. Income

A. Total increase in yield @159.5 kg/ha	Tonnes	61,500
B. Sale price of rape seed per tonne (@Rs.412-450*/100 kg, November,(1987)	Rs.	4,120-4,500
5. Sale price of 61,500 tonnes rape seed (@Rs.4120/tonne)	Rs.	253,380,000
6. Saving owing to aphid and pollinator management in rape crop	Rs.	202,108,500

*Oil-seeds and vegetable oil worth US dollars 500 million are imported in Pakistan annually. Therefore, prices will not come down with the increased production of this crop.

The cost of spraying was about Rs.133 per ha and Rs.51,171,500 for the entire crop of 385,500 ha in the country. It would increase the seed yield at the rate of 159.5 kg per ha and 61,500 tonnes from 385,500 ha worth Rs.253,380,000 annually.

CHAPTER XI

CONCLUSIONS

Apis cerana coexits with three other species of *Apis* in some areas in Pakistan. It overlapped with *A. mellifera* at some locations and created serious mating problem for queens due to competition of their drones. Consequently *A. cerana* populations were adversely affected in areas where the number of its colonies was low and the area was dominated by *A. mellifera*. The present situation would require queen rearing of *A. cerana* and *A. mellifera* separately in isolated yards.

Migration of *A. cerana* bees in multiple-queen colonies from the hills to the foot-hills in September-October and vice versa in May-June due to severe cold and dearth of flora, survival of strong queens and mortality of weak ones in these colonies seem to support the maintenance of high bee population levels in these areas. Annihilation of colonies headed by weaker queens produced from subnormal queen cells in the Marghalla area and fairly high reduction in the population of honeybees in dearth period suggest that supplemental feeding is most essential for maintaining the desired strength of bees in the colonies and for production of high honey yield.

Some 20 kg sugar feeding per colony before and after honey flow and in dearth period continued brood rearing and maintained honeybee populations at higher levels and consequently resulted in better honey yield.

Major honey flow occurred in different areas at different times i.e. March-April, May-June, September-October and January-February. Thus the schedules developed during the present studies for migration of bee colonies proved very useful to increase honey yield to the extent of 3-5 times per colony as compared with the colonies stationed at one place.

A. cerana colonies procured from Swat had a higher honey yield than that of colonies from Marghalla area. Queens of A. cerana were produced from larvae of Swat strain, grafted in A. mellifera colonies. These colonies were more productive than those of Swat and Marghalla strains. Beekeepers can produce A. cerana queens in A. mellifera colonies for better build up of colony populations and high honey yield.

Wax moth infestation was suppressed by releases of Apanteles galleriae produced by the new technique developed during the course of studies. This parasite can be mass-produced and released for successful control of wax moths at a very low cost by the beekeepers. The control of hornets was achieved by the utilisation of the parastic mite Pyemotes ventricosus and by the use of baits of two chemicals namely strychnine hydrochloride and zinc phosphide applied to the hornets by the technique developed during these studies. These techniques for the control of wax moths and hornets can be practised by beekeepers on a large scale.

Acarapis woodi is very serious pest of A. cerana bees. Repeated applications of Folbex VA controlled the mite infestations, but this method of control has its own practical limitations. The chemical is quite expensive and is not easily available in the market. Some other inexpensive measures of control including development of resistance in the bee against the mite are required to be developed for its effective eradication.

The integration of some new and known management practices including supplemental feeding, migration of colonies on different flora, space reduction in brood chamber during nectar flow, prevention of swarming and absconding, control of pests and diseases and other miscellaneous manipulations proved very useful. The beekeepers can practice this integrated management system for the population build up and increased honey production.

Beekeepers are using traditional hives in the northern areas of Pakistan. They can not afford to buy the modern beekeeping equipment. The low cost hives (Rs.18-30 each) along with the frames (Rs.5-11 each) would prove useful for pursuasion of the beekeepers to use Langstroth hive (Rs.500 each) for higher honey yield during the transitional period until they start using Langstroth hives.

The flowers of different forage, fruit, vegetable and oil-seed crops were visited by various species of insect pollinators, but their populations were very low. The honeybee A. cerana used as pollinator brought about a fairly high increase in the yield of these crops. Therefore, it would be appropriate if the use of bees for pollination of crops is popularised among the farmers in the country.

The rape Brassica campestris is the most important honeybee flora during winter in Pakistan. Aphids inflict heavy damage to this crop and are controlled by insecticides in some areas. The pesticides commonly sprayed in this crop cause heavy losses to honeybee and other insect pollinators.

Consequently the pollination process is hampered resulting in low yield of the crop. The insecticide Pirimicarb was found to be somewhat specific for the aphid control. Honeybee pollination and pest management system developed for rape crops would solve the pollination problem with fairly high increase in the seed yield ameliorating the oil-seed situation in the country.

CHAPTER XII

SUMMARY

A survey was made to determine the distribution limits of the oriental bee *Apis cerana* and other *Apis* spp. in the country and a distribution map was prepared. Besides, studies were conducted on competition of *A. cerana* with other three species.

Investigations were made to develop integrated management of *A. cerana* colonies. Wild colonies of this bee migrated in single or multiple-queen swarms from the hills to the foot-hills and vice versa due to extremes of temperature and dearth of flora. This caused considerable mortality of the queens in the migrating multiple-queen wild colonies resulting in survival of strong queens for the next generation.

Some *A. cerana* colonies usually perished in Marghalla area. The queens in some colonies were found to be subnormal. Studies on development of queen cells showed that queens produced from subnormal cells laid lesser number of eggs and could not normalize bee strength of their colonies. Hence they did not survive the hazards of extremes of temperature and floral dearth periods.

Supplemental feeding resulted in fairly large build up of bee population required for higher honey yield. Six kg supplemental diet particularly plain candy fed to bees from mid-winter to early spring (January to March) built-up the colony population and produced 3 times

more honey yield in spring (18 kg) than that in control colonies (5.7 kg). The honeybees are under stress during mid-June to August because of high temperature and shortage of bee flora in the plains and foot-hill areas. Supplemental diets fed at the rate of 4 kg per colony during June - August resulted in three times increase in bee population and also prolonged the breeding and queen rearing for a considerable period. Provision of 10 kg sucrose solution (sugar and water 1:1) and 3 kg musk-melon extract during May - August induced the queens to produce drone brood and supersedure queens cells. This management practice not only improved the bee strength but also provided mated queens for the queenless colonies.

Reduction of space (frames) in the brood chamber induced the queen bee to lay lesser number of eggs and the bees to concentrate on nectar collection resulting in higher honey yield (6.3-9.7 kg) than that in control (2.3-4.6 kg) per colony.

The influence of comb construction on swarming and honey yield was determined in colonies having one year old queens. The colonies provided with drawn combs produced higher number of queen cells (15.7 per colony) as compared with those supplied with comb foundation sheet and drawn combs in the ratio of 1:1 (13.5 per colony). Honey yield in the former colonies was higher (23.2 kg) than that in the latter (13.2 kg).

Clustering of this honeybee commonly occurred on front walls of the hives in summer and resulted in reduction of honey yield. Addition of one empty super below brood chamber eliminated cluster possibly by increasing the air supply and releasing the stress condition in the hives.

None of the areas are known to provide honeybee flora throughout the year. Most of the beekeepers, except a few progressive ones, keep their colonies at one place or shift them at short distances in the same area throughout the year. Therefore, the bees are subjected to starvation during dearth periods resulting in very low honey yield. Schedules for migration of *A. cerana* colonies to different floral belts were developed for maximum exploitation of available flora for higher honey yield.

Honey production of migrated and non-migrated *A. cerana* colonies was studied in some parts of Punjab and NWFP. Average honey yield of honeybees migrated to Rawalpindi, Islamabad and Swat was 16.9 kg per colony; those shifted in Rawalpindi and Islamabad areas produced 8.1 kg honey per colony. Average honey production of the colonies placed in Swat and Islamabad was 5.7 kg and 4.7 kg, respectively. This indicates that migration of honeybee colonies to productive floral belts are essential for commercial beekeeping.

The colonies of *A. cerana* procured from Swat and Marghalla areas were studied for their production potential. Average annual honey production per colony was 14.4 kg in Swat strain and 10.9 kg in Marghalla strain. The queens of *A. cerana* Swat strain were reared in *A. mellifera* colonies, which produced comparatively larger quantity of royal jelly. These colonies, were more productive than those headed by normally produced queens.

In addition to 478 already known honeybee flora, some 379 additional nectar and pollen plant species were recorded and their usefulness was noted by categorising them as major, medium and minor sources of nectar and pollen. The flowering periods of these plants were studied in different ecological areas.

Studies on honeydew honey sources showed that *A. cerana* collected honeydew honey produced by 117 species of Hemipterous insects on 165 species of plants. These insects belong to the families Adelgidae (4 species), Aleyrodidae (11 species), Aphididae (62 species), Cicadellidae (4 species), Fulgoridae (1 species), Psyllidae (4 species), Pseudococcidae (15 species), Dactylopiidae (1 species), Coccidae (14 species) and Asterolecaniidae (1 species).

Among the natural enemies, two species of wax moths, five species of hornets, three species of mites, one species of pseudoscorpion, twenty one species of birds, two species of black ants, two species of fungi and a virus have been found to attack honeybees in Pakistan. In addition, a mite was recorded feeding on pollen in the hive.

Of these, the wax moths *Achroia grisella* and *Galleria mellonella* are serious pests of *A. cerana* in the northern hills of Pakistan. *Apanteles galleriae* parasitised the larvae of both pest species. A technique developed by Ahmad and Muzaffar (1984) for mass production of this parasite was further improved. It has been based on rearing the parasite in the honeybee colony by making some alterations and additions to the bee strength to maintain temperature at 27° ± 3°C in the hive and rearing the wax moth larvae on ground beeswax and the parasite for releases for biological control wax moths in the apiaries. The parasite released at the rate of 25-45 pairs per week, eradicated the wax moth infestation in *A. cerana* colonies in about 4 months.

The hornets *Vespa basalis*, *V. orientalis*, *V. tropica haematodes*, *V. velutina pruthii* and *Vespula germanica* preyed upon *A. cerana* and other species of *Apis* in Pakistan.

Of the five hornet species, V. velutina pruthii and V. basalis were important and brought about heavy losses by feeding on honeybee adults, brood and honey reserves in the hive during the crucial floral dearth period extending from July to October.

A mite Pyemotes ventricosus was found parasitising the larvae and pupae of V. velutina. It was mass produced on Galleria mellonella and Sitotroga cerealella larvae in cages under field condition in spring, summer and autumn. A technique was developed for biological control of hornets by infecting them with the mite and releasing them at dusk so that the infected hornets spread the mite infestation in their nests. This technique proved useful for destroying the hornets in one to one and a half month.

The effect of two chemotherapeutic agents,strychnine hydrochloride and zinc phosphide was noted against hornet adults and brood in the nests located in the vicinity of apiary. These chemicals (each mixed with honey in 1:20) applied to hornet adults in the apiary with the above mentioned technique proved very useful for controlling these pests.

Acarine mite (Acarapis woodi) possibly introduced in Pakistan from Indian Kashmir in 1981 was very serious pest of this honeybee. Seasonal incidence of this mite was studied in apiaries and wild colonies. There was some seasonal variation in the degree of the mite infestations. The attacked colonies suffered fairly high mortality within a short span of time. Although four applications of Folbex VA gave complete control of the mite, yet the colonies got re-infested in a short period because of the occurence of the mite in a large number of wild colonies. It seemed that repeated applications of Folbex VA were necessary for controlling this mite.

Studies on the mite Tropilaelaps clareae showed that its incidence was slightly higher on drone cells than on worker cells and that superparasitism (1-5 mites per host) occurred on larvae and pupae of bees. Comparative longevity of T. clareae on Apis spp. adults was studied in the laboratory at 26° ± 4°C in April. The life span was 27 hours on A. cerana, 57 hours on A. dorsata and 25 hours on A. mellifera as against 22 hours in control.

Varroa jacobsoni attacked A. cerana but its incidence was low. The mite appeared to be under some natural check and did not inflict significant damage to this honeybee.

A survey of bird predators of honeybees was carried out in different ecological areas of the country. During the survey, twenty one species of birds were found preying upon honeybees. Their status as predators of honeybees, distribution and active period were studied by watching their activities in the apiaries of A. cerana and colonies of other Apis spp. Among these, Dicrurus adsimilis albirictus, Lanius erythronotus and Pernis ptilorhynchus ruficollis were of considerable importance as predators of honeybees almost throughout Pakistan while Merops spp. brought about heavy losses to honeybee colonies in some parts of NWFP and Punjab. A tinsel tape device was tried for scaring the birds and protecting the bees. Waving of the tapes of different colours by wind and flash produced by reflection of sunlight created a frightening scene and proved very useful in protecting honeybees from these predators.

The oriental bee was kept mostly in traditional hives in most of the beekeeping areas in Pakistan. The cost of modern hives is very high and is out of the reach of beekeepers in the permanent beekeeping areas. An abrupt change to the Langstroth hive, which is quite expensive, was not easily acceptable by most of the beekeepers in some areas in Peshawar Division, Hazara, Swat, Dir and Azad Kashmir. Some low cost Langstroth type of hives of clay, glauconite ("multani mitti"), newspaper, cement, etc.and comb foundation sheets were developed and tested in these beekeeping areas for increasing honey yield per colony. These low cost equipment proved very useful to pursuade the beekeepers for using Langstroth hive.

Honeybee pollination of alfalfa, berseem, loquat, apple, pear, litchi, turnip, coriander, carrot and sunflower was studied in different areas. The honeybees played an important role in the fruit and seed production of these crops. The number of fruit/pod/seed set was higher on open plants/branches visited by bees and other insect pollinators than on sleeved plants/branches not visited by bees.

The impact of seed pollinators on seed yield of rape (sarson) and effect of three insecticides of different persistencies on the aphid and beneficial insects including pollinators (honeybees), parasites and predators of aphid were studied. Honeybees and other pollinators seemed to bring about 6.8% increase in the number of developed pods and 94.8% increase in the number of seed set in B.campestris crops visited by bees. The insecticides Pirimicarb 250 g, Permethrin 100 g and Monocrotophos 500 g caused almost equal mortality of aphid (95-98%), but Pirimicarb 250 g was considerably safer for the parasite, predators and pollinators than Permethrin 100 g and Monocrotophos 500 g. Spraying of the crop with Pirimicarb cost Rs. 133 per ha and Rs.51,271,500 for the entire area of 385,500 ha under these crops in the country. It is estimated that pest and pollinator management of these crops would increase seed yield to the extent of 61,500 tonnes resulting in an additional income of Rs.253.38 million with a net saving of Rs.202.308 million per annum.

Keeping in view the economic importance of honeybees and other insect pollinators in pollination of crops, some multi-purpose honey plants, important for checking soil erosion, reforestation, nitrogen fixation, fodder, firewood, timber, fibre, etc. have been recommended for including in various agro-forestry programmes.

ACKNOWLEDGEMENTS

This research has been financed by Honeybee Research Programme of Pakistan Agricultural Research Council,Islamabad.

Deepest thanks are due to Dr. Rafiq Ahmad, Chief Scientific Officer, Natural Resources, PARC/NARC for his guidance during the course of studies, helpful comments and valuable criticism on thesis.

I am highly grateful to Dr. M. Irslan, Professor, Department of Biological Sciences, Quaid-i-Azam University, Islamabad, for his encouragement, kind guidance and suggestions.

I am sincerely thankful to Dr. Amir Muhammed, Chairman, Pakistan Agricultural Research Council, Islamabad, and Secretary Agricultural Research Division, Ministry of Food, Agriculture and Cooperatives, Government of Pakistan, for his continuous inspiration to complete my work for Ph. D.

I am indebted to Dr. H. Shimanuki, Chief, Bioenvironmental Bee Research Laboratory, BARC, Maryland, USA; Dr. Lloyd Knutson, Director, Biosystematics and Beneficial Insects Institute, USA; Dr Robert S. Jacobson, Vespa Laboratories, Inc., USA; Dr. Brenda V. Ball, Rothamsted Experimental Station, U.K.; Dr. M. Afzal of Pakistan Natural History Museum and of Dr. E. Nasir of National Herbarium, Pakistan for identification of pests, diseases and honeybee flora.

Finally I have to thank all my well-wishers, who helped and encouraged me during all the phases of this work.

REFERENCES

Adam, B. 1968 "Isle of Wight" or acarine disease: Its historical and practical aspects. Bee World, 49 (1) : 6-18.

Ahmad, R. 1976 A note on insect pollinators of alfalfa in Pakistan. N.Z. Entomologist, 6 (2) : 190-191.

Ahmad, R. 1981 A guide to honeybee management in Pakistan. Misc. Publ., Pak. Agri. Res. Council, 38 pp.

Ahmad, R., Anwar, R.,Khan,S., Makhdoomi, S.M.A. and Qayyum, A. 1978 Honeybee flora of Pakistan. Agriculture Pakistan, 29 (4) : 337-367.

Ahmad, R. and Muzaffar, N. 1983 Biological control of the wax moths *Galleria mellonella* (L.) and *Achroia grisella* (F.) (Lep., Galleridae) by augmentation of the parasite *Apanteles galleriae* Wilk. (Hym., Braconidae) in Pakistan. Apiacta, 18:15-20.

Ahmad, R. and Muzaffar, N. 1984 Modern Beekeeping (Urdu version). Misc. Publ. Pak. Agric. Res. Council, 350 pp.

Alam, M.M., Beg, M.N., Syed, R.A., Hafiz, I.A. and Shah, S. 1969 Survey of parasites of insect pests of cultivated and useful plants and survey of insects destroying weeds and their parasites. Final Report. Pak. Station Commonw. Inst. biol. Control, 243 pp.

Ali, S. and Ripley, S.D. 1968 Handbook of the birds of India and Pakistan. 1 : 222-224. Oxford Uni. Press, Oxford.

Ali, S. and Ripley, S.D. 1970 Handbook of the birds of India and Pakistan. 4 : 102-108, 182-188. Oxford Uni. Press, Oxford.

Ali, S. and Ripley, S.D.	1972	Handbook of the birds of India and Pakistan. 5 : 79-95, 114-121. Oxford Uni. Press, Oxford.
Anon.	1959	Outbreaks and new records. FAO Plant Prot. Bull., 8 : 11-12 (R.A.E. (A) 48 : 176).
Anon.	1975	Report of Agriculture Enquiry Committee for Plant Protection. Min. Food. Agri. and Cooperatives, Islamabad, 24 pp.
Anon.	1978	The hive and the honevbee. A Dadant publication. Dadant and Sons. Hamilton. Illinois, 740 pp.
Anon.	1983	FAO production year book. Vol. 37, statistics series No.55:145.
Anon.	1984	Agricultural statistics of Pakistan Min. Food,Agric. and Cooperatives (Planning unit.), Islamabad, 441 pp.
Anon.	1985	Agricultural statistics of Pakistan. Min. Food, Agric. and Cooperatives (Planning unit), Islamabad, 237 pp.
Armstrong, J.M. and White, W.J.	1935	Factors influencing seed setting in alfalfa. Jour. Agric. Sci., 25: 161-179.
Bailey, L.	1969	The signs of adult bee diseases. Bee World, 50 : 66-68.
Bailey, L.	1981	Honey bee Pathology (second edition). Academic Press, London, UK, 124 pp.
Bailey, L. and Ball, B.V.	1978	Apis irridescent virus and "clustering disease" of Apis cerana. Jour. Invert. Pathol., 31 (3) : 368-371.
Baker, E.C.S.	1924	The fauna of British India including Ceylon and Burma. Birds, 2 : 285-289. Taylor and Francis, Red Lion Court, Fleet Street, London.

Baker, E.C.S.	1930	The fauna of British India including Ceylon and Burma. Birds, 7 : 148-426; 8 : 634. Taylor and Francis, Red Lion Court, Fleet Street, London.
Blanchard, E.E.	1936	New or little known Argentine Microgasterinae. Part II. Physis, 12 : 137-152 (R.A.E. (A) 25 : 378).
Bodenheimer, F. S. and Swirski, E.	1957	The Aphidoidea of the Middle East. Weizmann Science Press, Jerusalem, 378 pp.
Bolton, J.L.	1962	Alfalfa botany, cultivation and utilization. London Leonard Hill Ltd., London: 106-107.
Borchert, A.	1962	Abjas; Explotacion y Enfermedades. Zaragoza, Espana; Editorial Acribia.
Burgett, M., Akratanakul, P. and Morse, R.A.	1983	Tropilaelaps clareae a parasite of honeybees in south east Asia. Bee World, 64 (1) : 25-28.
Butler, C. G., Calam, D.H. and Callow, R.K.	1967	Attraction of Apis mellifera drones by the odours of the queens of two other species of honeybees. Nature, 214 : 423-424.
Cardon, P.V.	1922	Sunflower studies. Amer. Soc. Agron. Jour., 14: 69-72.
Cherian, M.C. and Mhadevan, V.	1945	Preliminary studies on the flight range of the Indian bee (Apis indica F.). Indian Bee Jour., 7 : 79-80.
Cirnu, I.	1960	Results of bee pollination of sunflowers. Apicultura, 33 (1): 18-20.
Clark, T.B.	1978	Personal communication. Bioenviron. Bee Lab., Plant Prot. Inst., Beltsville, Maryland, USA.
Clements, F.E. and Long, F.L.	1923	Experimental pollination: an outline of the ecology of flowers and insects. Carnegie, Washington. In 'Insect pollination of crops', Ed. J.B. Free. Academic Press, London, 544 pp.

Crane, E. 1968 Mites infesting honeybees in Asia. Bee World, 49 (3) : 113-144.

Crane, E. 1973 Honey sources in some tropical and subtropical countries. Bee World, 54 : 177-186.

Crane, E. 1975 Honey- A comprehensive survey. William Heinemann Ltd. London, 608 pp.

Crane, E. 1978 The *Varroa* mite. Bee World, 59 (4) : 164-167.

Cristobal, U.L. 1936 *Apanteles galleriae*, the Braconid parasite of wax moths. Its inefficiency in biological control. Bol. inf. Zool. Ent. agric., Fac. Agron. Univ. nac. la Plata (R.A.E. (A) 25 : 166).

De Jong, D. 1978 Insects : Hymenoptera (ants, wasps, and bees). pp. 138-157. In 'Honeybee pests, predators, and diseases'. Ed. R.A. Morse. Comstock Cornell University Press, Ithaca, New York.

De Jong, D., Morse, R.A. and Fickwort, G.C. 1982 Mite pests of honey bees. Ann. Rev. Entomol., 27 : 229-252.

Delfinado-Baker, M. and Baker, E.W. 1982a A new species of *Tropilaelaps* parasitic on honey bees. American Bee Jour., 122 : 416-417.

Delfindo-Baker, M. and Baker, E.W. 1982b Notes on the honeybee mites of the genus *Acarapis* Hirst (Acari: Tarsonomidae). Int. Jour. Acarol., 15 : 61-65.

Delfinado-Baker, M., Underwood, B.A. and Baker, E.W. 1985 The occurence of *Tropilaelaps* mites in brood nests of *Apis dorsata* and *A. laboriosa* in Nepal, with description of the nymphal stages. American Bee Jour., 125 (10): 703-706.

Dhaliwal, H.S. and Sharma, P.L. 1974 Foraging range of the Indian honeybee. Jour. apic. Res., 13 (2) : 137-141.

Downey, R.K.	1964	Effect of bees on seed yield of arlo rapeseed. Forage notes, 10 :1.
Downey, R.K., Fawlowski, S.H. and Mcansh, J.	1970	Rape seed- Canada's 'cinderalla' crop. Ed. 2. Rape seed Assoc. of Canada. Pub., 8 : 1-40.
Drescher, W.	1983	Beekeeping in Pakistan and recommendations on its promotion. German Agency for Tech. Coop., 22 pp.
Eckert, J.E. and Shaw, F.R.	1960	Beekeeping. The Macmillan Company, New York, 536 pp.
Fomina, K.Y.	1961	The influence of a field protective forestation on the nectar productivity and seed yield of sunflower. In Moskov. Qrdena Lenina Sel' skokhoz. Akad.im. K.A. Timiryazeva, Dok. TSKHA, 62 : 531-536.
Free, J. B.	1970	Insect pollination of crops. Academic Press, London and New York, 544 pp.
Free, J.B. and Spencer-Booth, Yvette	1963	The pollination of mustard by honeybees. Jour. apic. Res., 2 : 69-70.
Fry, C. H.	1984	The bee-eaters. T & AD Poyser Ltd. Town Head House, Calton, Waterhouses, Staffordshire, England, 304 pp.
Gassparian, S.	1977	Studies on Apis cerana in eastern part of Iran. Proc. International Cong. Apic. Apimondia, 26 : 293-296.
Ghani, M.A.	1971	Basic studies of parasites of the green peach aphid in northern Pakistan. Pak. Station Commonw. Inst. biol. Control, 42 pp.
Glukhov, M.M.	1955	Honey plants. 512 pp., Izd. 6, Perer. i. Dop. Noskva, Gos. Izdvo. Selkhoz Litry.
Gupta, G.A.	1967	Varroa jacobsoni : a mite pest of Apis indica. Bee World, 48 (1) : 17-18.
Hansson, A.	1980	Bin och Bioding. Lt's forlag, Stockholm : 585.

Haq, K.A. 1968 Annual Report of the Ayub Agricultural Research Institute, Lyallpur, for 1966-67 : 255-256.

Haq, K.A. 1969 Beekeeping ('Magus Bani'). Uni. Agric. Faisalabad, 68 pp.

Haq, K.A. and Aslam, S.M. 1962 Preferential behaviour of bees to different flowers. Proc. Pak. Sci. Conf., 14 Sec. Biol. : 47.

Haq, K.A. and Chohan, M.S. 1964 Study of the effect of repeated extractions in a honey-flow season on total honey yield in a bee colony. Proc. Pak. Sci. Conf., 16 Sec. Biol. : 49-50.

Haq, K.A.,Haq, M. and Aslam, S.M. 1961a Insect pollinators of cauliflower and radish. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 27.

Haq, K.A., Haq,M. and Aslam,S.M. 1961b Role of *Apis indica* F. bees in the pollination of cauliflower and radish. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 28.

Haq, K.A., Haq,M. and Gill, M.T. 1961c Some studies on the extraction and bleaching of beeswax. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 30.

Haq, K.A., Haq,M. and Gill, M.T. 1961d Studies on the relationship between moisture content and specific gravity of honey. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 30.

Haq, K.A., Haq,M. and Hussain, H.F. 1961e Comparison of different packing materials and packing methods on colony development in *Apis indica* F. bees. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 28.

Haq, K.A., Haq,M. and Khan, M.M. 1961f Role of *Apis indica* F. bees in the pollination of plums in Murree hills. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 27.

Haq, K.A., Haq,M. and Khan, M.M. 1961g Studies on the effect of different packing materials on hive temperature and colony development in *Apis indica* F. bees. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 28.

Haq, K.A., Haq, M. and Khan, M.M.	1963	A survey of the bee-flora of Murree hills. Proc. Pak. Sci. Conf., 15 Sec. Agric. : 63-65.
Haq, K.A., Haq, M. and Siddique, M.	1961h	Studies on the influence of the application of different fertilizers on nectar secretion in 'sarson' and 'toria' crops. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 29-30.
Haq, M., Rafieul-Din, M. and Ghaffar, A.	1978	Effect of insect pollination on fruit bearing in kinnow mandarin (Citrus reticulata), and physical and chemical properties of the fruit. Jour. apic. Res., 17 (1):47-49.
Haydak, M.H.	1936	A feed for rearing laboratory insects. Jour. econ. Ent., 39: 1026.
Hussanein, M.H.	1953	Studies on the effect of pollinating insects especially the honeybee on seed yield of clover in Egypt. Soc. Fouad. Ler d' Ent. Bull., 37 : 337-344.
Jaksland, H.	1971	Innvintring pa vokstavler som bygges it under hostforinga. Bitidningen, 70 : 250-253.
Jehangir, K.	1985	Personal communication. Progressive Beekeeper, Khawaza khela, Swat, Pakistan.
Jordan, R.	1960	Die Bedeutung der Bauerneuerung fur die Erhaltung der Leistungsfahigheit der Bienenvolker, Bienenvater, 81 : 101-105.
Khan, K.M. and Bhutta, A.A.	1965	Pollen analysis of honey. Proc. Pak. Sci. Conf., 17 Sec. Biol.:23.
Khan, S.A., Siddique, M. and Shafique, R.M.	1978	Faunistic studies of oil-seed crops. Proc. First National Oil-seed Seminar. Pb. Agri. Res. Inst., Lyallpur: 142-146.
Koeniger, N. and Koeniger, G.	1985	Change of host by parasitic mites in Asia after a new honeybee species is introduced. Proc. 3rd Int. Conf. Apic. Trop. Climates, Nairobi : 160-162.

Koeniger, N., Koeniger, G. and Delfinado-Baker, M. 1983 Observations on mites of the Asian honeybee species (Apis cerana, Apis dorsata, Apis florea). Apidologie, 14 (3) : 197-204.

Koeniger, N. and Vorwohl, G. 1979 Competition for food among four sympatric species of Apini in Sri Lanka (Apis dorsata, Apis cerana, Apis florea and Trigona iridipennis). Jour. apic. Res., 18 (2) : 95-109.

Koeniger, N. and Wyjajagunasekera, H.N.P. 1976 Time of drone flight in the three Asiatic honeybee species (Apis cerana, Apis florea , Apis dorsata). Jour. apic. Res., 15 (2) : 67-71.

Kohli, N. 1958 Bee flora of North India. Indian Bee Jour., 20 (8) : 113-118, 20 (9) : 32-34, 20 (10) : 150-151 and 20 (12) : 192-193.

Koutensky, J. 1958 The result of pollination work of bees. Vcelarstvi, 11 (5) : 72-73.

Kshirsagar, K.K., Mahindre, D.B., Salvi, S. R. and Mittal, M.C. 1975 Occurrence of a viral disease in Indian hive bee Apis cerana indica F. : a preliminary report. Indian Bee Jour., 37 : 19-20.

Kureshy, K.U. 1978 A geography of Pakistan. Oxford Uni. Press, Karachi, 199 pp.

Latif, A. 1956 Role of Apis indica F. on the pollination of Egyption clover (Trifolium alexandrianum Linn.). Pakistan Jour. Sci. Res., 8 (1) : 48-50.

Latif, A., Haq A., Qayyum, A. and Abbas, M. 1958a Optimum number of Apis indica F. bee colonies required for pollination of an acre of 'toria' crop. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 32-33.

Latif, A., Haq, A., Qayyum, A. and Abbas, M. 1958b Precise role of Apis indica F. in the pollination of 'sarson' and 'toria' crops. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 29-30.

Latif, A., Haq, A., Qayyum, A. and Abbas, M.	1958c	Studies on different insect pollinators of 'toria' and 'sarson' crops growing within the reach of Apis indica F. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 31-32.
Latif, A. and Haq, M.	1955a	Preliminary trials on artificial insemination of queen-bees of Apis indica F. Proc. Pak. Sci. Conf., 7 Sec. Biol.: 64-65.
Latif, A. and Haq, M.	1955b	Two queen system in bee hives of Apis indica F. at Lyallpur. Proc. Pak. Sci. Conf., 7 Sec. Biol. : 63-64.
Latif, A., Haq, M. and Gill, M.T.	1960a	A comparative study of the mineral contents of various honeys. Proc. Pak. Sci. Conf., 12 Sec.Agric.:31.
Latif, A., Haq,M. and Khan, M.M.	1961a	Some studies on the migratory behaviour of Apis indica F. bee colonies from higher to lower hills and vice versa. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 37.
Latif, A., Haq,M. and Khan, M.M.	1961b	Some studies on the provision of supplementary food to Apis indica F. bees in hives. Proc. Pak. Sci. Conf., 13 Sec. Biol. : 28-29.
Latif, A. and Hussain, M.	1955a	Double queen colonies of Apis indica at Sialkot. Proc. Pak. Sci. Conf., 7 Sec. Biol. : 66-67.
Latif, A. and Hussain, M.	1955b	Researches on stimulants for queen bees. Proc. Pak. Sci. Conf., 7 Sec. Biol. : 62.

Latif, A. and Qayyum, H.A.	1956	Relationship between beekeeping and fruit growing. Punjab Fruit Jour., 15 : 1-2.
Latif, A., Qayyum, H.A. and Abbas, M.	1965	Insect pollinators of toria (Brassica campestris var. toria) and sarson (Brassica campestris var. dichotoma). Pakistan Jour. Agric. Sci., 2 (4) : 274-286.
Latif, A., Qayyum, H.A. and Gill, M.T.	1957a	Preliminary studies on the standardization of bees wax of Apis indica F. Proc. Pak. Sci. Conf., 9 Sec. Biol. : 38-39.
Latif, A.,Qayyum, H.A. and Gill, M.T.	1958d	Effect of heat treatment on the granulation of honey. Proc. Pak. Sci. Conf., 10 Sec.Agric.:28-29.
Latif, A., Qayyum, H.A. and Gill, M.T.	1958e	Some studies on the storage of honey. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 29.
Latif, A., Qayyum, H.A. and Haq, M.	1956a	Honeybees (Apis indica F.) as seed boosters in carrots (Dacus carota Linn.). Proc. Pak. Sci. Conf., 8 Sec. Biol. : 75.
Latif, A., Qayyum, H.A. and Haq, M.	1956b	Researches on the composition of Pakistan honey. Pak. Jour. Sci. Res., 8 (4) : 30-33.
Latif, A., Qayyum, H.A. and Haq, M.	1956c	Role of Apis indica F. in the pollination of Egyptian clover (Trifolium alexandrianum Linn.). Pakistan Jour. Sci. Res., 8 (1): 48-50.
Latif, A., Qayyum, H.A. and Haq, M.	1956d	Two queen system in relation to colony development. Proc. Pak. Sci. Conf., 8 Sec. Biol. : 77.
Latif, A., Qayyum, H.A. and Haq, M.	1957b	Some studies on "queen substance" in the colony of Apis indica F. bees. Proc. Pak. Sci. Conf., 9 Sec. Biol. : 36-37.
Latif, A., Qayyum, H.A. and Haq, M.	1957c	The effect of size and shape of pollen grains on bee visits.Proc. Pak. Sci. Conf., 9 Sec. Biol.:37.

Latif, A., Qayyum, H.A. and Haq, M.	1958f	Weight of a standard bee-colony and the number of bees in it. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 30.
Latif, A., Qayyum, H.A. and Haq, M.	1958g	A contribution to bee-flora of Pakistan. Pak. Jour. Sci. Res., 10 : 67-71.
Latif, A., Qayyum, H.A. and Haq, M.	1960b	Effect of multiple and two-queen system in the hill bee, *Apis indica* F., on the incidence of attack of large wax moth. Proc. Pak. Sci. Conf., 12 (3) Sec. Agric. : 31.
Latif, A., Qayyum, H.A. and Haq, M.	1960c	Effect of multiple- and two-queen system on swarming in the hill bee, *Apis indica* F. Proc. Pak. Sci. Conf., 12 Sec. Agric.:31-32.
Latif, A., Qayyum, H.A. and Haq, M.	1960d	Effect of two or more queens per colony on honey yield and bee strength. Bee World, 41 (8) : 201-209.
Latif, A., Qayyum, H.A. and Haq, M.	1960e	The role of *Apis indica* F. in the pollination of 'toria' and 'sarson' (*Brassica campestris* var. toria and dichotoma). Bee World, 41 (11-12) : 283-286.
Latif, A., Qayyum, H.A. and Hussain, M.	1956e	Dual behaviour in a two queen colony. Proc. Pak. Sci. Conf., 8 Sec. Biol. : 77-78.
Latif, A., Qayyum, H.A. and Hussain, M.	1956f	The importance of pollen supplement and substitutes in the development of colonies of *Apis indica* F. Proc. Pak. Sci. Conf., 8 Sec. Biol. : 74.
Latif, A., Qayyum, H.A. and Hussain, M.	1956g	The scope of mud wall hive for breeding *Apis indica* F. colonies in the plains. Proc. Pak. Sci. Conf., 8 Sec. Biol. : 76.
Latif, A., Qayyum, H.A. and Hussain, M.	1957d	Effect of feeding sugar to bees on the yield and quality of honey. Proc. Pak. Sci. Conf., 9 Sec. Biol. : 37-38.

Latif, A., Qayyum, H.A. and Khan, M.M.	1957e	Ovarian development and aggressive behaviour in Apis indica F. Proc. Pak. Sci. Conf., 9 Sec. Biol. :39.
Latif, A., Qayyum, H.A. and Khan, M.S.	1958h	Studies on the controlled mating of queen bees. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 28.
Latif, A., Qayyum, H.A. and Siddique, M.	1957f	Some studies on nectar secretion. Proc. Pak. Sci. Conf., 9 Sec: Biol. : 39-40.
Latif, A., Qayyum, H.A. and Siddique, M.	1958i	Further studies on nectar secretion in bee flora. Proc.Pak. Sci. Conf., 10 Sec. Agric.: 30-31.
Latif, A., Qayyum, H.A. and Siddique, M.	1958j	Studies on the preference of honeybees for solutions of various sugars found in nectar. Proc. Pak. Sci. Conf., 10 Sec. Agric. : 31.
Latif, A. and Yunus, C.M.	1950	The common or green bee-eater as an enemy of honeybees. Bee World, 31 : 91-92.
Lewis, W.J. and Jones, R.L.	1971	Substance that stimulates host-seeking by Microplitis croceipes (Hymenoptera: Braconidae), a parasite of Heliothis species. Ann. ent. Soc. America, 64 : 471-473.
Mackensen, O.	1951	Viability and sex determination in the honeybee (Apis mellifera L.). Genetics, 36 : 500-509.
Mackensen, O.	1955	Further studies on lethal series in the honeybee. Jour. Heredity, 46 : 72-74.
Makhdoomi, S.M.A. and Bajwa, M.H.	1978	Pests of oilseed crops and their control. Proc. First National Oilseed Seminar. Pb. Agri. Res. Inst. Lyallpur : 119-124.
Makhdoomi, S.M.A. and Chohan, M.S.	1980	Migratory schedule for successful bee farming. Jour. Agri. Res., 8 : 37-39.
Makhdoomi, S.M.A. and Khan, M.M.	1977	Effect on the yield of honeybee migrating Apis indica F. colonies from scarcity zone to ample bee flora localities. Proc. Sci. Conf., Sci. Soc. Pak. Multan, 18: 64-65.

Makhdoomi, S.M.A., Khan, M.M., Bhatti, A.H. and Nadeem, M.I.	1979	Effect of migration of hill bee <u>Apis indica</u> on honey yield. Proc. Sci. Conf., Sci. Soc. Pak. Islamabad, <u>19</u> : 4.
Makhdoomi, S.M.A., Khan, M.M. and Haq, I.	1975	Effect of migratory beekeeping practices on the development of brood and production of honey in <u>Apis indica</u>. Proc. Sci. Conf., Sci. Soc. Pak. Lyallpur, <u>16</u> : 57-58.
Makhdoomi, S.M.A., Khan, M.M. and Haq, I.	1976	Effect of migration of bees from sub-mountainous localities to Swat on the production of honey. Proc. Sci. Conf., Sci. Soc. Pak. Peshawar, <u>17</u> : 3-4.
Matsuura, M. and Sakagami, S.F.	1973	A bionomic sketch of the giant hornet, <u>Vespa mandarinia</u>, a serious pest for Japanese apiculture. Jour. Fac. Sci. Hokkaido Uni. Series 6, Zool., <u>19</u> : 125-162.
McGregor, S.E.	1976	Insect pollination of cultivated crop plants. Agriculture hand book No.496. Agri. Res. Services, USDA, Washington DC., 411 pp.
Meyerhoff, G.	1954	Investigation on the effect of bee visits on rape. Arch. f. Geflugelzucht und Kleintierkunde, <u>3</u> (3-4): 259-306.
Mohammad, A.	1935	Pollination studies in toria (<u>Brassica napus</u> L. var. dichotoma Prain) and sarson (<u>Brassica campestris</u> L. var. sarson Prain). Indian Jour. Agric. Sci., <u>5</u> : 125-154.
Morse, R.A.	1978	Honeybee pests, predators and diseases. Cornell Univ. Press, London, 430 pp.
Mortensen, E. and Bullard, E.T.	1968	Handbook of tropical and sub-tropical horticulture. U.S. Dept. State Agency for Int. Develop. Washington, D.C., 260 pp.
Mussen, E.C.	1987	Personal communication. Bee Biol. Faculty, Uni. California, Davis, California.
Mussen, E.C., Foote, L., Gary, N.E., Laidlaw, H.H., Thorp, R.W. and Watkins, L.H.	1987	Beekeeping in California. Coop. Ext. Uni. California, Div. Agric. & Nat. Resour. Publ. <u>21422</u>, 68 pp.
Narayanan, E.S., Sharma, P.L. and Phadke, K.G.	1960	Studies on the biometry of the Indian bees. Indian Bee Jour., <u>22</u> : 58-63.

Narayanan, E.S., Sharma, P.L. and Phadke, K.G. 1961 Studies on requirements of various crops for insect pollination-insect pollinators of berseem (Trifolium alexandrianum) with particular reference to honeybees and their role in seed setting. Indian Bee Jour., 23 (4-6) : 23-30.

Nixon, N. 1983 World maps of Varroa jacobsoni and Tropilaelaps clareae, with additional records for honeybee diseases and parasites previously mapped. Bee World, 64 (3) : 124-131.

Nyein, M.M. and Zmarlicki, C. 1982 Control of mites in European bees in Burma. American Bee Jour., 122 : 638-639.

Olsson, G. 1955 Wind pollination of cruciferous oil plants. Sverig. Utsadesforen. Tidskr., 65 (6) : 418-422.

Paschke, M. 1950 The building frame and its uses. Bee World, 31 : 81-82.

Pellett, F.C. 1978 American honey plants. Dadant and Sons, Hamilton, Illinois, 467 pp.

Peng, C. 1986 Personal communication, communicated by Dr. N. Koeniger, Inst. Binenkunde, Uni. Frankfurt, Oberursel, West Germany.

Pritsch, G. 1965 Increasing the yield of oil plants by using honeybees. Ved. Prace Vyzkum. Ustav. Vcelar CSAZV, 4 : 157-163.

Qayyum, A. and Shahid, M. 1975 Major sources of nectar and pollen yielding plants of honeybees (Apis indica F.) in N.W.F.P. Frontier. Jour. Agric. Res. 2 (1 & 2) : 80-87.

Qayyum, H. A. and Aslam, S.M. 1960a Effect of leaving surplus honey on the fecundity of the queen bee of Apis indica F. Proc. Pak. Sci. Conf., 12 Sec. Agric. : 33-34.

Qayyum, H.A. and Aslam, S.M. 1960b The effect of feeding pollen and pollen substitutes on the rate of oviposition in queen bee of Apis indica F. Proc. Pak. Sci. Conf., 12 Sec. Agric. : 34.

Qayyum, H.A. and Aslam, S.M. 1960c The effect of hormonal treatment on the fecundity of queen bee of Apis indica F. Proc. Pak. Sci. Conf., 12 Sec. Agric. : 35.

Qayyum, H.A. and Aslam, S.M. 1960d The influence of external temperature on the hive temperature and the colony development in Apis indica F. bees. Proc. Pak. Sci. Conf., 12 Sec. Agric. : 34-35.

Qayyum, H.A. and Aslam, S.M. 1960e The influence of feeding sugar to queen bee and colony as a whole on the egg-laying performance in Apis indica F. bee. Proc. Pak. Conf., 12 Sec. Agric. : 33.

Qayyum, H.A. and Aslam, S.M. 1960f The relationship between the age of the queen bee of Apis indica F. and her egg-laying performance. Proc. Pak. Sci. Conf., 12 Sec. Agric. : 34.

Rabbani, G. 1981 Personal communication-bio-data.

Radaeva, E.N. 1954 Bee pollination increases the yield of sunflower seeds (Helianthus annuus). Pehelovodstvo, 2: 33-38.

Rahman, K.A. 1940 Insect pollinators of toria (Brassica napus Linn. var. dichotoma Prain) and sarson (Brassica campestris Linn. var. sarson Prain) at Lyallpur. Indian Jour. Agric. Sci., 10 (3) : 422-447.

Rahman, K.A. 1944 Some authentic honey yields from Apis indica F. in the Punjab. Indian Bee Jour., 6 (5 & 6) : 1-4.

Rahman, K.A. 1945a Progress of beekeeping in the Punjab. Bee World, 26 : 42-44, 50-52.

Rahman, K.A. 1945b The Indian honeybee (Apis indica F.) (Hymenoptera) at Lyallpur. Proc. Roy. ent. Sec. London (A), 20 : 33-42 (R.A.E. (A) 34 : 297).

Rahman, K.A. and Singh, S. 1940 Beekeeping in India. Indian Farming, 1 (1) : 1-2.

Rahman, K.A. and Singh, S.	1941	Honeybee flora of Lyallpur. Indian Bee Jour., 4 : 32-35.
Rahman, K.A. and Singh, S.	1942	Honeybee in the service of fruit growers. Punjab Fruit Jour., 6 : 1328-1330.
Rahman, K.A. and Singh, S.	1943	Honeybee in service of fruit grower. Punjab Fruit Jour., 8 (28).
Rahman, K.A. and Singh, S.	1944	Bees and the war efforts. Indian Bee Jour., 8 (5,6).
Shahid, M. and Qayyum, A.	1977	Bee flora of the N.W.F.P. Pakistan Jour. Forestry, 27 (1) : 1-10.
Shamel, A.D.	1905	Relation of bees to fertilization of clovers. U.S. Dept. Agri. Year book for 1905 : 385-386.
Shaparew, V.	1980	Clustering of bees in summer. American Bee Jour., 120 : 377-378.
Singh, S.	1975	Beekeeping in India. Indian Council Agric. Res., New Delhi, 214 pp.
Singh, Y.	1979	Iridescent virus in the Indian honey bee *Apis cerana indica* F. American Bee Jour., 119 (5) : 398.
Subbiah, M.S. and Mahadevan, V.	1958	*Vespa cincta* Fabr.— a predator of hive bees and its control. Indian Jour. Vet.Sci., 27 (4) : 153-154 (R.A.E. (A) 48 : 45).
Suire, J.	1933	Note sur les *Apanteles* parasites de la fausse - teigne des ruches, *Galleria mellonella* L. Rev. Zool. agric., 32 : 45-51 (R.A.E. (A) 21 : 618).
Szabo, T.I.	1975	Comb building after the honeyflow. American Bee Jour., 115 : 306-307, 322.
Taber, S.	1977	Rearing honey bees when you need them. Proc. Intern. Cong. Apic. Apimondia, 26 : 327-334.
Thakar, C.V.	1962	Floral calendar of major and minor bee forage plants. Indian Bee Jour., 24 : 35-48.

Thompson, W.R. 1953 A catalogue of parasites and predators of insect pests. Sec. 2. Host parasite catalogue. Pt. 2. Hosts of Hymenoptera (Agaonidae to Braconidae): 143-176. Commonw. Inst. biol. Contr., Ottawa, Ont., Canada.

Verma, L.R. 1987 Current status of parasitic mites in relation to beekeeping with Apis cerana F. and Apis mellifera L. in India. Proc. FAO Workshop Poland, 6 pp.

Villumstad, E. 1970 Overvintring of varutvikling av bifolk pa tavler som ble bygget under hostforinga. Birokteren, 86 : 36-43.

Villumstad, E. 1980 Eine Methode zur Nosematose-prophylaxe aus Norwegen. Allg. Deut. Imkerztg, 14 : 38-40.

Vinson, S.B. 1968 Source of a substance in Heliothis virescens (Lepidoptera: Noctuidae) that elicits a searching response in its habitual parasite Cardiochiles nigriceps (Hymenoptera; Braconidae). Ann. ent. Soc. America, 61: 8-10.

Walters, M. 1981 The complete birds of the world. David and Charles, (Publishers) Ltd., London, 367 pp.

Wiese, H. 1980 Nova Apicultura. Por Alegre, Brasil : Editorial LEAL.

Wilkinson, D.S. 1934 On some Apanteles (Hym. Bracon.). Stylops, 3 (7) : 145-156 (R.A.E. (A) 22 : 487).

Woyke, J. 1971 Biology of reproduction as a basis for production of new varieties of honeybees. Ph.D. Thesis, Warsaw, Poland, 154 pp.

Woyke, J. 1976 Population genetic studies on sex alleles in the honeybee using the example of the Kangaroo Island bee sanctuary. Jour. apic. Res., 15 : 105-123.

Woyke, J.	1985a	Methods to combat the parasitic bee mite, Tropilaelaps clareae without the use of any medicine. Proc. 30th Inter. apic. Congr. Nagoya : 85-86.
Woyke, J.	1985b	Tropilaelaps clareae in Afghanistan, and control methods applicable in tropical Asia. Proc. 3rd Inter. Conf. Apic. Trop. Climates, Nairobi : 163-166.
Wulfrath, A. and Speck, H.J.	1957	Kritische Betrachtungen ueber den Wert alter Waben fuer den Bienenzuechter, Bienenvater, 78 : 183-185.
Zecha, H.	1964	Bauerneuerung im Dienste der Gesundhaltung und Leistungssteigerung unserer Bienevoelker. Bienenvater, 85 : 185-190, 267-272.

STUDIES ON HORNETS ATTACKING HONEYBEES IN PAKISTAN*

Nasreen Muzaffar and Rafiq Ahmad**

ABSTRACT: The hornets, *Vespa basalis* Smith, *V. orientalis* L., *V. tropica haematodes* Beq., *V. velutina pruthii* Vecht., and *Vespula germanica* (F.) preyed upon honeybees (*Apis* spp.) in Pakistan. Of these five hornet species, *V. velutina pruthii* and *V. basalis* were important and caused heavy losses by feeding on adults, brood and honey reserves of bees during the crucial floral dearth period extending from July to October. The European bee, *Apis mellifera* L. was comparatively more susceptible to hornet attack than the oriental bee, *A. cerana* F. Studies on control of these pests showed that a trap-capture technique using sugar solution bait in plastic containers (12 cm long, 5 cm dia) was a practical measure as large number of hornets were trapped and killed at a very low cost. The hornet, *V. velutina*, was predominantly attracted to these traps. A mite, *Pyemotes ventricosus* (Newp.) attacked *V. velutina* larvae and pupae, but it did not seem to be of considerable importance for biological control of this pest.

Key Words: Honeybees; Wasps; Pest Control; Traps; Pakistan.

INTRODUCTION

The hornets (*Vespa* spp.) attack the honeybees *Apis cerana* F., *A. florea* F., *A. dorsata* F. and *A. mellifera* L., in different parts of the world. Of these, the hornet, *Vespa orientalis* L., has been reported to be a serious pest of honeybees in India (Singh, 1975), Pakistan (Ahmad, 1981), Afghanistan (Guiglia, 1979), Egypt (Wafa and Sharkawi, 1972) and Israel (Ishay et al., 1967); *V. basalis* Smith in India (Singh, loc. cit.); *V. valutina* Vecht. (*V. auraria* Sm.) in Burma (Ghosh, 1924) and Pakistan (Ahmad, loc. cit.), India (Singh, Pakistan (Ahmad, loc. cit.), India (Singh, loc. cit.); *V. tropica* (L.) (*V. cincta* F.) in Pakistan (Ahmad, loc. cit.) and India (Subbiah and Mahadevan, 1958). *Vespula germanica* (F.), which is a European species (Cymorek, 1978; Roland et al., 1978; Gayubo, 1979; Kartsev, 1979) occurs in New Zealand (Thomas, 1960), Australia (Brown, 1979), South Africa, Chile, North-eastern U.S.A. (Edwards, 1976) and Pakistan (Ahmad, loc. cit.). Keeping in view the economic importance of these pests, the present studies were undertaken on their incidence, natural enemies and control.

* It is financed by PL-480 grant FG-Pa 333 (Pk-Sea-157N).

** National Agricultural Research Centre, Islamabad.

MATERIALS AND METHODS

The adult hornets were captured with an insect net and their numbers were calculated per man hour. Sugar solution baits were provided in plastic jars, 12, 16 and 26 cm long and 5, 7.5 and 10 cm wide at mouth. The trapped hornets were removed and counted after 24 h. The studies were conducted in different areas of Punjab and NWFP in 1983-84

For natural enemies, some 46 hornet nests were removed by covering them with cloth bags at night. The adult hornets were killed by pouring 4-5 ml anaesthetic ether in each bag placed in large airtight wooden box. The dead brood and adults were examined for parasites and predators.

RESULTS AND DISCUSSION

Incidence

During the present investigations, *Vespa velutina pruthii* Vecht. (Figure 1), *V. basalis*, *V. tropica haematodes* Beq., *V. orientalis* and *Vespula germanica* were found in descending order of abundance in apiaries at Hasan of October. The hornet *V. velutina pruthii* was the most destructive pest of *A. mellifera* at Islamabad and Haripur. The incidence of *V. orientalis* was low in the hills and foothills, but it was found in larger numbers than other *Vespa* spp. (ratio 15:2) in Daffar Forest (plains of Punjab).

At Islamabad, the hornets caused almost complete destruction of some weak colonies and brought about heavy bee mortality in 9 percent strong *A. mellifera* colonies in August, 1982, while up to 12 percent weak colonies succumbed to their attack in September. The bees were virtually unable to leave the hives for most of the day due to the activity of hornets. In some instances the hornet occupied the Langstroth hives and the colonies having normal or even clipped queens absconded resulting in heavy losses.

Comparative Bee Susceptibility

Some hornet *V. orientalis* and *V. tropica* adults were fought back and defended upon by the worker bees of *A. cerana*. Adults of *V. velutina pruthii* and *V. basalis* were more prompt and swift and were mostly seen waiting on wings in front of the hive. They overpowered the bees during their flight and carried them to their nests for feeding their young ones.

The western bee, *A. mellifera*, was more susceptible to hornet attack than the local bee *A. cerana*. The bees of the former species rarely repelled these wasps and it occurred only outside the hive as the guard bees clustered both inside and outside the entrance with some bees lying upward near the entrance wall. They continuously rocked their heads and antennae. But these bees could not effectively repel the hornets and finally fell prey to them. The bees of *A. cerana* defended themselves within the hive and also exhibited strong defence in groups of 15—70 individuals at the entrance. They rocked their bodies, opened their wings and swang in the direction of the hornet in an organized manner. Thus they occasionally defied the efforts of the hornets for capturing them.

Control Measures

The queens of the hornets *V. velutina*, *V. basalis* and *V. tropica* hibernated in sheltered situations in holes and crevices of walls and trees or in their nests in winter. The queens foraging in front of the hives were best killed in winter and early spring. A few aerial nests in open were destroyed due to frequent rains during monsoon in July and August (Figure 1d) resulting in death of large proportion of the developing brood owing to the break up of the combs, but the adults assembled at a nearby place and constructed the new nest. Thereafter the population in the nest was built up speedily. However, the nests in protected situations survived the monsoon hazards.

The use of bee guards or fixing of a wire-gauze tube, 1.5 cm x 17 cm, as bee passage at entrance of the hive reduced the frequent entry of *V. basalis*, *V. orientalis*, and *V. velutina*, but did not lessen losses because bees were caught and killed by them during their flights.

Searching of hornet nests was difficult. The ability of some of the wasps to use general visual stimuli in search of bait has been demonstrated (Kartsev, 1979). Therefore, a few baits were tried. Sugar baits were used keeping in view the attraction of hornets to sweet secretions of sugarcane leaf-hopper, *Pyrilla aberrans* Kirby (Misra, 1917) and also to honeydew excreted by the aphids (Fernandez, 1978). A bait was prepared by pouring 50 percent sugar solution placed on a coarse cloth in a tray on the top cover of an empty hive. The sugar solution attracted *V. basalis* and *V. velutina* adults (ratio 1: 3). These were killed with fly flappers during their feeding.The number of adults killed varied from 11 to 17 per man hour between 7 and 11 h and 14 to 33 from 11 to 17 h in an apiary at Islamabad in August. The sugar solution bait also had some limitations because of its being food of bees.

(Saunders) in Pakistan. The Pakistan Cottons, 24(2): 139–176.

4. Cross, W.H.; McGovern, W.L., and Cross, E.A. 1975. Insect hosts of the parasitic mite called *Pyemotes ventricosus* (Newport). J. Georgia Entom. Sec. 10 (1): 1–8.
5. Cymorek, S. 1978. Uber Wespen als Holzverderber—Schaden, Ubrsachen, Bekampfung. Praktische Schadlingsbekampfer, 30 (5): 53–61.
6. Edwards, R. 1976. The world distribution pattern of the German wasp, *Paravespula germanica* (Hymenoptera : Vespidae). Entomologica Germanica, 3: 269–271.
7. Fernandez, G.S. 1978. Aprovechamiento de la melaza de *Tuberolachnus salignus* (Gmelin, 1790) por varios Vespidae Y crabroninae. Boletin de la Asociacion Espanola de Entomologia, 1: 188.
8. Gayubo, S.F. 1979. Contribucion al conocimiento de los vespidos de la sierrra de Bejar (Hym. Vespidae). Boletin de la, Asociacion Espanola de Entomologia, 3: 35–43.
9. Ghosh, C.G. 1924. Reports by the Entomologist, Mandalay, for years ended 30th June, 1922 and 1923. p. 1–14 and 1–19.
10. Guiglia, D. 1979. Contributo alla conoscenza dei vespidi dell' Afghanistan (Hymenoptera—Vespidae). Bollettino del Museo Civico di Storia Naturale di Venezia, 30: 7–11.
11. Ishay, J., Bytinski-Salz, H., and Shulov, A. 1967. Contributions to the bionomics of the oriental hornet (*Vespa orientalis* Fab.) in Israel. Israel J. Entomol. 2: 106.
12. Kartsev, V.M. 1979. Proof of the ability of the wasp *Paravespa germanica* (Hymenoptera, vespidae) to use general visual stimuli. Zoologicheskii Zhurnal, 58 (9): 1419–1420.
13. Misra, C.S. 1917. The Indian sugarcane leaf-hopper. *Pyrilla aberrans* Kirby. Memoirs Dept. Agric. Res. Inst. Pusa. 5(11): Entomol. Ser. p. 73–133.
14. Roland, C., Horel, A., and Montagner, H. 1978. The relationship between ecological factors, activity and rate of foraging success in societies of *Paravespula vulgaris (Vespula vulgaris* L.) *and Paravespula germanica (V. germanica* F.) (Hym., Vespidae). Lab. Psycho-Physiology, Nancy Univ., France p. 71–74.
15. Singh, S. 1975. Beekeeping in India. Indian Council Agric. Res. New Delhi, 214 p.
16. Subbiah, M.S., and Mahadevan, V. 1958. *Vespa cincta* Fabr. - a predator of hive bees and its control. Indian J. Vet. Sci. 27(4): 153–154.
17. Thomas, G.R. 1960. The European wasp (*Vespula germanica* Feb.) in New Zealand. Inform. Ser. Dep. Sci. Indus. Res. N.Z., 27, 74 p.
18. Wafa, A.K., and Sharkawi, S.G. 1972. Contribution to the biology of *Vespa orientalis* Feb. (Hymenoptera : Vespidae). Bulletin de la Societe Entomologique d' Egypt, 56: 219–226.

Appendix I

Professor L. R. Verma
M.Sc. Ph. D. (Guelph, Canada)
Scientific Adviser (Apiculture)
Govt. of Himachal Pradesh

Chairman & Dean

Department of Bio-Sciences
H. P. University
SHIMLA 171 005 INDIA
Phones : 3613 Res : 4887

Dated August 8,1988

Dr. Rafiq Ahmad,
Pakistan Agricultural Research
Council,
National Agricultural Research Centre,
P.O. National Institute of Health,
Islamabad, Pakistan.

Dear Dr. Ahmad,

I am pleased to inform you that your following papers submitted to IBRA has been accepted for presentation in the up coming IVth International Conference on Apiculture in Tropical Climates to be held in Cairo Egypt from 6-10,November 1988.

i) Distribution and Competition of Apis spp. in Pakistan by Nasreen Muzaffar and Rafiq Ahmad.

ii) Insect and plant resources of honey dew honey in Pakistan by Nasreen Muzaffar and Rafiq Ahmad.

I hope both you will kindly attend our session on "Asian bees" to present these research papers.

With regards and best wishes.

Yours sincerely,

(L.R. Verma)
Organizer & Chairperson,
on Asian bees session.

RSP/RA/881988.

Appendix III

APIMONDIA

FEDERATION INTERNATIONALE DES ASSOCIATIONS D'APICULTURE

INTERNATIONAL FEDERATION OF BEEKEEPERS' ASSOCIATIONS

INTERNATIONALER VERBAND DER BIENENZÜCHTER - VEREINIGUN

3700

Rome, 25 GIU. 1987

ige:
rso Vitt. Emanuele 101
186 Roma, Italia
l. 65121
lex 612533
lefax 6548578
nca Naz. Agricoltura N. 488/L
.p. N. 57499006
de Fiscal 80082150584

ésident Honoraire:
HARNAJ
l. Ficusului 42, Sect. 1
544 Bucuresti, Romania

ésident:
BORNECK
e du Creux
340 Montbarrey, France
l. 84815007

ce-Présidents:
BILASH
bnoe, Ryazan
viet Union.

TONSLEY
lte Gates 46 Queen St.
ddington, Nr. Kettering
rthamptons., England

crétaire Général:
CANNAMELA
rso Vitt. Emanuele 101
86 Roma, Italia

Mr. Nasreen Muzaffar
Pakistan Agricultural Research Council
National Agricultural Research Centre
Honey Research Programme
P.O. National Institute of Health
Islamabad , Pakistan

Dear Sir(s),

XXXIst International Beekeeping Congress

We have much pleasure in informing you that your paper has been accepted for presentation at the XXXIst International Beekeeping Congress of Apimondia, to be held in Warsaw, Poland, 19th - 25th August, 1987.

Yours very truly,

Silvestro Cannamela
General Secretary

Title(s): "Studies on two chemotherapeutic agents for the control on hornet predators of honeybees".

Appendix IV

APIMONDIA

FÉDÉRATION INTERNATIONALE
DES ASSOCIATIONS D'APICULTURE

INTERNATIONAL FEDERATION
OF BEEKEEPERS' ASSOCIATIONS

INTERNATIONALER VERBAND
DER BIENENZUECHTER - VEREINIGUNGEN

4524

Rome, 24 GIU. 1987

- Mr. Nasreen Muzaffar

Honeybee Research Programme
Pakistan Agricultural Research Council
National Agricultural Research Centre
P.O. National Institute of Health
Islamabad, Pakistan

Dear Sir(s),

XXXIst International Beekeeping Congress

We have much pleasure in informing you that your paper has been accepted for presentation at the XXXIst International Beekeeping Congress of Apimondia, to be held in Warsaw, Poland, 19th - 25th August, 1987.

Yours very truly,

Silvestro Cannamela
General Secretary

Title(s): "Studies on bird predators of honeybees and their control by a scaring device".

Appendix V

A P I M O N D I A

FEDERATION INTERNATIONALE
DES ASSOCIATIONS D'APICULTURE

INTERNATIONAL FEDERATION
OF BEEKEEPERS' ASSOCIATIONS

INTERNATIONALER VERBAND
DER BIENENZÜCHTER - VEREINIGUNGEN

3/89 ....

Rome, 25 MAR. 1987

e:
o Vitt. Emanuele 101
3 Rome, Italia
68121
612533
ax 6546578

a Naz. Agricoltura N. 468/L
N. 57498006
Fiscal 80082150584

– Mr. Nasreen Muzaffar

Pakistan Agricultural Research Council
National Agricultural Research Centre
P.O. National Institute of Health
Islamabad - Pakistan

COPIA
copy

Dear Sir(s),

XXXIst International Beekeeping Congress

We have much pleasure in informing you that your paper has been accepted for presentation at the XXXIst International Beekeeping Congress of Apimondia, to be held in Warsaw, Poland, 19th - 25th August, 1987.

Yours very truly,

Silvestro Cannamela
General Secretary

Title(s): "Studies on insect pest and pollinator management of rape (Brassica Campestris) crop in Pakistan".