CHAPTER II

REVIEW OF LITERATURE

Acridids are polyphagous feeders living under varied conditions. The surface grass hoppers, including *Oxya nitidula*, mostly feed on *berseem*, sugarcane, maize and rice crops. Despite the fact that Acrididae has been the most worked group of insects, very little work appears to have been done on *Oxya* sp. Rao (1921) characterised *Oxya velox* to be a marshy insect feeding on grasses growing in such situations. These insects were active throughout the year, but had maximum population in the months of August to November. Observations similar to Rao were also reported by Nakayama (1929). The number of generations which the insects passed through in a year varied in different species, e.g., one in *Oxya chinensis* (Liu & Li, 1933), two in *Oxya vicina* (Sonan & Fukuda, 1926), three to five in *Oxya velox* (Muir & Swezey, 1927); whereas Kumashiro (1935) recorded only one generation in *Oxya vicina* and *Oxya velox*. Different species of *Oxya* overwintered in their egg stage and the eggs hatched in the following spring (Liu & Li, 1933; Katsumata and Nishikawa, 1935; Kumashiro, 1933; and Yokoo and Morita, 1939).

Rao (1921) further pointed out that *Oxya velox* exhibited a peculiar oviposition behaviour, i.e., in dry conditions it laid eggs in the soil, but in marshy places it laid them among paddy stems and grass clumps. Oviposition by the females of *Oxya* in soil was also recorded by Muir and Swezey (1927), Liu & Li (1933) and Yokoo & Morita (1939).
Rao (1921) also observed that a female laid 177 eggs in 12 egg pods and each egg-pod contained 10-29 eggs. The egg stage occupied 15-20 days, depending upon the season. The male nymphs passed through 6 molts whereas 50 per cent of the female nymphs had one additional molt. Sonan & Fukuda (1926) expressed that there were 6 molts in male nymphs and 6,7 or even 8 molts in female nymphs in 2 to 3 months. Egg duration of 6 weeks, nymphal duration of 6-10 week and a total life cycle of 20 to 28 weeks for *Oxya velox* was shown by Muir & Swenzey (1927). Liu & Li (1933) found that the overwintering eggs of *Oxya chinensis* hatched after 7 months and the nymphs molted five times in 100 days. They further stated that the pre-copulation and pre-oviposition periods occupied 15 to 41 and 10 to 41 days respectively. Katsumata and Nishikawa (1935) found that pre-copulation period occupied 9-26 days, while the duration of pre-oviposition, oviposition and post-oviposition periods was 8-27, 11-31 and 1-12 days respectively. They further stated that the nymphs of *Oxya* passed through 6 molts in 64 to 82 days. Kumashiro (1935), working on *Oxya vicina* and *Oxya velox*, demonstrated that the nymphs molted 6 to 7 times in 61 to 79 days and 5 to 7 times in 60 to 70 days respectively. Pre-oviposition period in *Oxya vicina* extended up to a month and a single female laid 1-8 egg-clusters, each containing 46 eggs, whereas a single female of *Oxya velox* laid 1-5 egg-clusters, each containing 38 eggs. He further concluded that the outbreak of this insect occurred
in the years of high temperature and low rainfall.

Majority of the acridids laid their eggs in the soil. The eggs of Northern spotted grasshopper (*Aularches punctatus* Drury), which were laid in September, hatched in the following April when kept in moist conditions but failed to hatch if kept in dry sand and hatched again on remoistening, (Katiyar,1955). Similar observations in short-horned grasshopper: (*Parahieraculus biliens* Bol.), were recorded by him in 1956. Both the species of grasshoppers congregated in masses on tree-tops to bask. Conclave(1956) recorded two generations in North-Eastern Locust(*Schistocerca pallens* Thumb.) in captivity, completing winter life cycle in 201 days and summer in 133 days. According to/poor food conditions, caused the second generation to be rare and abnormal in the field.

Jrvis(1916) and Pemberton(1943) observed *Oxya velox* and *Oxya chinensis* to be feeding on sugarcane. *Oxya* sp. feeding on rice was pointed out by Gator(1924),Uvarov(1926), Hadden(1928), Lever(1935, 1937), Hawai(1937), Silayan(1937), and Otanes and Sison(1941). Swesey(1951) showed that *Oxya velox* was becoming more wide-spread in some districts of the Hawaii Islands and fed on cane leaves, mostly along road sides where grass, specially nut-grass (*Cypres rotundus*), was growing on which the smaller grass-hoppers fed.

**Behaviour:**

Karney(1921) termed *Oxya* sp. as a semi-aquatic grass-hopper and Rao(1921) characterized *Oxya velox* to be a marshy insect, whereas Joyce(1952) referred to *Oxya byla* as
a typical species of the wet area. The majority of the acridids oviposited in soil. However, some unusual ovipositional behaviour by the females was recorded by Rakshpal (1946 a) who observed Schistocerca gregaria to be ovipositing on soil surface or on the leaves of the trees and stated that the locusts began egg laying on the soil surface when they were unable to retain them. Similar observations were recorded by Srivastava (1956) in Hieroglyphus nigroplectus.

Plessis (1956) has noted that grazing improved the site for oviposition of the locusts and that stocking, at the rate of one sheep per one or two acres, made the fields favourable for oviposition. Schistocerca gregaria oviposited only in moist sand and females were capable of distinguishing sand moistened with water from that moistened with paraffin or saline water (Popeve, 1958). He has further stated that abnormal oviposition in locusts was associated with unfavourable environments and that the females, ready for laying eggs, could delay egg-laying only for 72 hours but not longer. Again he, with Stover and Greathead (1958), assessed that 91.4 per cent of the egg pods occurred in bare patches of the soil and 80 per cent of the egg pods were found on the west facing slopes of the soil.

Gunn et al. (1948) stated that locusts always roosted for the night on trees or bushes and descended from the trees to the ground after sunshine. Chapman (1954) observed that at constant temperature, hoppers of Locusta migratoria migratorioides were more active in light than in darkness and he (1959) mentioned that hoppers of Nomadacris
*septemfasciata* roosted over-night in tall grass, but they ascended to the top in the morning at the first light. The movement was initiated as the light intensity increased. The evening ascent, according to him, was related to a steep fall in temperature. He further mentioned that the morning descent was produced by a sharp rise in temperature; but, at other times of the day, it was caused by high wind, or disturbance or rain.

York (1951) mentioned that strip farming favoured grass-hoppers which moved out on the fallow land for warmth during the day and slipped back into the grain strips for protection or warmth at night. Dempster (1955) observed that *Chorthippus parallelus* (Zett.) nymphs tended to move from shorter to taller vegetation, and according to him that movement was from a hotter and drier habitat to a more favourable one. A temperature which fell below 10°C, induced *Chrotopogomus concavus* to hibernate by burying itself into the soil, while its eyes and antennae alone remained exposed. But if these insects failed to secure suitable shelter, they either clasped each other, irrespective of sex, or died in a severe cold (Katiyar, 1955). According to Ergene (1952) *Aorida turrita* changed its colour according to the colour of its back-ground, though the nymphs, when liberated on blue or dark blue back-ground, would not become blue but showed a change to grey.
Ecology:

The development in various species of Acrididae, in relation to temperature and relative humidity, has been studied by many investigators, but *Oxya* sp. does not seem to have received much attention in this respect. It is an established fact that both temperature and relative humidity play an important role in the development and activities of various locusts and grass hoppers. Boden-heimer (1929) mentioned that in locusts one-third developed eggs hatched successfully only in 80 to 100 per cent relative humidity, whereas those having completed their two-thirds development, hatched in 20% relative humidity. Parker (1933) stated that a higher percentage of the eggs of *Camnula pellucida* Scudder hatched in soil with medium moisture than under very dry or very wet conditions.

According to Ahmed (1936) the incubation period in *Schistocerca gregaria* Forskal at a constant temperature ranging from 20°C to 37°C varied a great deal; on an average 58 days was recorded at the lowest level whereas 9.42 days at the highest temperature. He further observed that the viability percentage of the eggs was the highest between 35°C and 37°C and was markedly reduced at a temperature below 23°C. Hamilton (1936) recorded that the incubation period in *Schistocerca gregaria* at a suitable, relative humidity decreased with the rise in temperature. The incubation period in *Locusta, Schistocerca* and *Nomadacris* was 8, 12 and 14 days at a constant temperature of 110°F (43.3°C), 100°F (37.8°C) and 100°F (37.8°C) respectively.
The incubation period in *S. gregaria* was 18.11-12.12 and a little less than 32 days at 37°, 35°, 33° and 25°C (Husain *et al.*, 1940), whereas 18-20 days at 28°C and 12-13 days at 30°C were recorded by Bhatia (1958). The latter author further observed that splitting of pods increased mortality and, sometimes, the hatching was altogether prevented. Davidson (1938) observed that there was no embryonic development in *Chortoicetes terminifera* Walker in dry soil at 60°F (15.5°C), though the eggs remained viable for several months. Freppa (1938) stated that at the temperatures of 25°-28°C and 30°-34°C, 100% relative humidity accelerated the embryonic development of *Locusta migratoria capita* Sauss. The incubation period of 20 and 18-19 days, and 15 and 13 days at 27°C and 35°C was recorded by Kumashiro (1935) in the cases of *Oxya vicina* and *Oxya velox* respectively. Again he (1938) reported that the hibernating stages of *Oxya* sp. completed their development earlier when they were transferred to a higher constant or variable temperature than under natural conditions.

Locusta in all stages died if unfavourable conditions prevailed for some weeks; but their eggs survived in dry fields for 3 months and in cold for 5 months. A temperature of 57.5°F (14.2°C) was considered to be the threshold for development (Anonymous, 1941). And in case of 12 species of grass hoppers studied by Shotwell (1941), the minimum hatching temperature was 60°F (15.5°C).

Salt (1952) mentioned that the eggs of *Melanoplus*
bivittatus absorbed maximum moisture on the 8th and 9th
days, at 25°C, and, thereafter, this absorption decreased
because of the limited expansion of the cuticle. Their
original water contents were almost doubled. He further
observed that the moisture was lost up to 7 days and was
restricted only by the lipoid layer; and again, from the 8th
to the 14th day the desiccation rate was greatly increased.
But with the onset of diapause, the desiccation rate
decreased. Schulov (1952) stated that at the stage of the
late anatrepis in Schistocerca gregaria, the development
of the eggs was interrupted when contact moisture was
lacking; but the development was again resumed when the
eggs matured. Khan (1954) observed that the
eggs of the Gryllodes signillatus (Wlk.), when exposed to
dry air, shrivelled; but in saturated air these were attacked
by mould. According to Chin(1958) the rate of desiccation
of eggs per unit time was the greatest in the newly laid
eggs and least in the half developed eggs; and he
further stated that the water absorbed by the eggs, was
important for development and temporary loss of water led
to delay in hatching. He still further observed that
eggs near hatching were the most resistant to water loss
and newly laid eggs the least.

Parker(1930) observed that the nymphs of Melanoplus
mexicanus reared at alternating high and low temperatures
developed more rapidly than when kept under constant
temperatures. Schistocerca gregaria hoppers failed to develop
below 24°C and above 44°C (Husain and Ahmed, 1936) and *Melanophila differentialis* at or below 65°F(18.5°C) (Swenk and Bratt, 1941), and *Boccilocerus pictus* at 24°C (Fruthi, 1939). Hamilton (1936) observed that 26.7°C was the lowest constant temperature below which the complete development of *Nomadacris septemfasciata* Serv. could not take place. He further stated that in three species of African locusts the rate of development on suitable humidities increased with the rise in temperature.

According to Kennedy (1937) *Locusta migratoria migratorioides* R. & F. showed a preference for dry air in all parts of the humidity range, although dry air was by no means optimal for development, maturation or breeding. The development of *Nomadacris septemfasciata* became more rapid with increase in temperature, i.e. from 85°F to 90°F (29.4°C to 32.2°C) and decrease in humidity from 80 to 70% (Smee, 1937). Similarly Shotwell (1941) found that in grasshoppers the rate of development increased rapidly as the temperature was raised from 70°F (21.1°C) to 100°F (37.8°C).

Husain & Ahmed (1936) recorded that the duration of the hopper stage was from 62 to 64 days at 24°C in *Schistocerca*. Husain & Nathur (1944) observed that the developmental period in *Schistocerca gregaria* varied inversely with the temperature in both the sexes; and the body size was larger at lower temperature, i.e., 27°C, than at higher temperature of 40°C. Buck (1944) recorded this duration to be as 46.1 days at 89.9°F (32.2°C) and 51.2 days at 85°F (29.4°C).
Frappa (1938) recorded that the hopper stage of *Locusta migratoria migratorioides* in a saturated atmosphere lasted for 32-46 days at 27°C and 20 to 23 days at 33°C. This duration was 32-37 days at 30 to 35°C (Zolotarewsky, 1938). Pruthi (1939) recorded the rapid development of *Pogoclocreus pictus* (Pb.) at temperatures ranging between 32°C and 35°C, with mortality at 63%. Brett (1947) stated that *Melanoplus mexicanus mexicanus*, when reared on lettuce or maize, had its body size increased with the increase in its body temperature up to 100°F (37.5°C), that decreased with further rise in temperature.

Pospelov (1926) observed that *Locusta migratoria migratorioides* did not attain full sexual maturity at temperatures fluctuating between 68 and 84°F. He further mentioned that the adults matured within about a month at 95-100°F, after the final moult. Similarly, the adults of *Locusta migratoria capito* Sauss. did not reach sexual maturity at a relative humidity below 60%, whereas nymphs preferred 70% relative humidity (Zolotarewsky, 1933). He further observed that under unfavourable conditions adults migrated, but the nymphs climbed to the top of their host plant if the relative humidity increased and descended, if it decreased, and then left the dry habitat. Maxwell Darling (1934) reported that *Schistocerca gregaria* existed as immature adults throughout the dry season and sexual maturation was induced by an increased atmospheric humidity.

Hamilton (1936) stated that the rate of sexual maturation increased as the temperature was raised from 80 to 100°F in *Locusta* and from 80 to 90°F in *Schistocerca*. 
He (1950) further observed that relative humidity over 70% was unfavourable for the longevity of the adults of *Schistocerca gregaria*. Husain, Ahmed and Mathur (1940) concluded that low humidity did not hinder the maturation of *Schistocerca gregaria*, and that at 100% relative humidity the adults lived for 16 days whereas at 40% these lived for 70 days. The hoppers and adults died if unfavourable conditions prevailed for some weeks. The weight of *S. gregaria*, reared at 40°, 37°, 32° and 27°C, was the highest in the case of individuals reared at the lowest of the above temperatures, (Husain and Mathur, 1943). According to Norris (1952), the rate of development in *S. gregaria* was unaffected by the difference in relative humidity ranging from 40-70% and 45-60% per cent. Again she (1957) stated that under caged conditions lowest obtainable humidities were most favourable for longevity. The high temperature caused rapid maturation of *Melanophila mexicana* mexicana (Washburn, 1953). Nakhala (1957) stated that the females of *Euprepocnemis prolana* Charp were found to be sexually mature on emergence and the males so, after 1-2 weeks, and favourable temperature for mating was found to be 28°-32°F.

Husain & Ahmed (1936) stated that at 36° and 40°C *Schistocerca gregaria* females laid only 3 egg clusters and at 30°C they laid 5 egg clusters. They further observed that male and female adults lived for 35, 55; 39.7, 36; 62.6, 64 and 85 days at 40°, 36°, 33° and 27°C respectively. Knipling and Sullivan (1958) reported that the various species of grass-hoppers were killed when exposed to 40° to 60°C in an
electric oven for 15 minutes.

Lethal influence of low temperature:

The lethal influence of low temperature has been studied by many workers. According to Ludwing (1928), the Japanese beetle (Papillio japonica) overwintered in second or third larval instar, in which they were capable of becoming dormant and survived moderately low temperature indefinitely. He further observed that both adults and first instar larvae lacked this capacity and the newly emerged first instar larvae could not survive 15 days at 10°C. Andewartha & Birch (1954) stated that insects of cold regions were cold hardy; but, on the other hand, species from tropical and sub-tropical climates, at all stages in their life cycle, and the species from temperate climates, at the stages of life cycles that were present in summer, lacked the capacity of becoming dormant when the temperature fell below that which favoured their active development. They further remarked that those forms were, as a rule, readily killed by exposure to moderate temperature, often well above 0°C. Robinson (1928) found that half the samples of adult beetles of Calandra oryzae died after an exposure of 8 days at 7.2°C and 4 days at 1.6°C and 2 days at -1.1°C.

Ecological studies:

Most of the work on field ecology of Acrididae done so far relates to the locusts and some migratory grasshoppers. Different workers have studied different
reservations or habitats for different locusts and grasshoppers and tried to find out possible reasons for their rapid multiplication. Rao (1953) suggested Mekran to be the possible place of the origin of *Schistocerca gregaria* outbreak and he suggested the need of an international organisation to nip this evil in the bud. Uvarov (1932) impressed upon the need to locate the reservations, where the locusts survive in sufficient numbers during the years of their minimum and were the source of further invasion, for ecological studies. Similarly the urgency of devising measures for preventing, predicting and controlling of their out-breaks were characterised as suitable objectives of the recent trend in grasshopper research by Cowan (1956), Gunn (1956), Key (1956) and Plessis (1956).

Pruthi (1940) postulated that any change in the environment of insects invariably led to a marked change in their numbers and this fact can be utilized in the control of insect pests. Mitchner (1953) characterised grasshoppers as the most destructive of all the insects and stated that the Rocky or mountain grasshopper (*Melanoplus mexicanus*) appeared in the form of an outbreak at irregular intervals of about 12 years or so. Smith (1954) advocated thorough investigation of the physical factors of an environment, particularly those of microhabitat, for achieving a better balance and mentioned that the living organisms and their non-living environment were inseparably inter-related and they interacted upon each other. On the other hand, Belanovskii (1936), while criticising the theory of sharp
variation in insect population, stated that the fluctuation of insect population showed a regular periodicity which affected the viability of their whole generation. He further stressed the point that external factors could not be held wholly responsible for their mass increase. According to Putnam and Shuklov (1956) variations in the micro-habitat affected the local concentration of *Melanoplus mexicanus* and *Cannula pellucida* in Western Canada, whereas large scale variations in topography and vegetation cover affected the distribution of the eggs.

Birch and Andrewartha (1944) noted that the eggs of *Austroicetee cruciata*, when exposed to 50°C for 24 hours and 60°C for 1 hour resulted in mortalities of 45 and 88% respectively. Under dry conditions they recorded 91% mortality of the eggs when the soil temperature reached 60°C in January. They recorded the highest soil-temperature of 57.7°C in the sun, whereas the shade temperature varied from 43.3 to 46.0°C; and they further argued that in nature temperature is not maintained long enough at an inimical point to kill a large proportion of the eggs. The indirect effect of drought through vegetation was recorded by Birch and Andrewartha (1941), who observed facts of an outbreak of *Austroicetee cruciata* that lasted during the years 1935-40. But in 1940 drought killed most of the vegetation, which further killed most of the insects before their reaching sexual maturity. Thus, according to them, grasshoppers
required more than one year to increase to plague number after being reduced to a very low ebb. Drought caused high mortality in Austroicetes terminifera when reared at constant temperatures of 26.6°, 32.2° and 37.8°C and a relative humidity of 10-100%. But a soil containing less than 4% moisture was fatal to their eggs (Anonymous, 1942). On the other hand, a saturated soil delayed the hatching of the eggs of locusts by 25 days as compared with those kept in a soil containing optimum moisture (Bodenhiemer, 1944).

The mortality of the eggs of Nomadacris septemfasciata, due to drought, was also recorded by Albracht (1956), who reported that all the first instalment of the eggs, laid on 19th November, and 50 per cent of the second instalment of the eggs, laid on 28th November, were destroyed by drought when there was no rain in November and December, 1953. He further observed that the eggs deposited within ten days of the resumption of rain, survived.

Parker (1935) reported that rain-fall below normal, during May-June for 2-4 years, and above normal temperature during July-September, led to the out-break of grasshoppers in North America. Zakhrov (1939) mentioned that an outbreak of Locusta migratoria migratoria, in the Volga regions, was followed by a sequence of 2-4 dry, hot years, which caused a higher fertility, the survival of the eggs and the transformation of swamps into meadows with vegetations suitable for breeding. According to him the spring floods killed the eggs of Locusta migratoria migratoria as once
flooded egg pods were covered with sand and were killed. Heavy rains, according to Corbett and Miller (1936), prevented the successful maturation of the swarming locusts in Malaya and swarms died without egg laying. The normal season, i.e., neither any month too moist nor successive months too dry, led to the outbreak of *Chortoicetes terminifera* (Kay, 1945). He again (1956) stated that at a favourable temperature the eggs of *Chortoicetes terminifera, Austroicetes cruciata* and *Gastrimargus musicus* showed a high mortality after about 3 months, if moisture was not adequate for hatching. Similarly the eggs of Variegated grasshopper (*Xenocerus variegatus*) shrivelled if transferred from a moist soil to a dry soil and the adults matured sexually only when the relative humidity rose to 80 per cent at 9 A.M. and 60 per cent at 3 P.M. (Godling, 1940).

Uvarov (1957) reported that a majority of the insects of *Acrididae* were connected, in their distribution, with semi-arid and arid geographical regions and, in their ecology, with an open and dry habitat. However, conditions inside a dense, continuous stand of tall reeds created a hot house atmosphere, due to the lack of ventilation and the presence of water or wet soil which favoured the growth of nymphs and maturation of adults of *Locusta migratoria migratoria*. This peculiar eocclimate enabled several species of grasshoppers of unquestionable tropical affinities and origin (e.g. *Oxya* sp. and
Gelasorhimus) to survive in the midst of the desert climate of middle Asia. He further concluded that the drainage of the flooded plains would offer a permanent solution of the migratory locust problem. Yet, on the other hand, it is also a fact that a reclamation of reed swamps stimulated the population of Acrididae, as dried swamps created favourable conditions for them (Zakharov, 1930).

A low relative humidity and arid conditions of the habitat favoured the growth of locusts like Schistocerca gregaria (Maxwell Darling, 1936) and Locustaeus marocanus (Delcanizo, 1943), whereas grasshoppers preferred wet conditions (Godling, 1934) and (Rubtsov, 1938). Godling (1935) mentioned that the swarms of Locusta migratoria migratorioides were only present where mean relative humidity ranged between 40-85 per cent and breeding did not start after the dry season unless relative humidity rose up to 65%. The swarms of Locusta migratoria migratorioides were guided by the relative humidity in finding out a suitable habitat for themselves (Lean, 1936).

Population studies:

A population may be defined as the number of individuals of a particular species existing in a particular area. Uvarov (1956) stressed the need of a thorough study of the whole of the distribution area and to find out the reason how the insects there became a pest of an economic status. He further stated that swarms of locusts largely
flew in the day time, while the non-swarming populations flew at night, especially where nights were sufficiently warm. According to Midmann, 1937, the fluctuation in the population of insects was studied by two complementary methods, i.e., physiological experiments in the laboratory and investigations on population density in the fields. For investigating the density of population, different workers have adopted different methods of recording the population of different acridids. These methods are discussed as under:-

i. **Counting while walking:**

This method is particularly adopted in the populations having a low density. The insects, which were seen while walking at a standard pace (2.5 m.p.h.) and during a known period, were counted (Lean, 1936; Smith (1939) (Rao, 1942), Scheeper & Gunn (1958) and Scheeper, Eyssell & Gunn (1958). In addition to the above method, Smith (1939) suggested the distant method, i.e., counting the number of hoppers between two points or counting along parallel lines. Scheeper & Gunn (1958) stated that this method should be practised when the temperature ranged between 22° and 35°.

ii. **Quadrat method:**

This is the principal method employed for estimating the number of hoppers and adults in the field. Quadrats, made of stout wire and of different sizes, were placed in regular rows, spaced evenly, over the site and the population was recorded at definite intervals (Uvarov et al., 1951; Richard & Woloff, 1954; and Dempster, 1957).
Richard & Waloff, 1954, stated that counts were lower on cool and wet days.

iii. **Portable enclosure method:**

Enclosures of different sizes were used for estimating the population of locusts and grasshoppers and this method was considered to be the most reliable method (Rubtsof, 1935; Konakov and Omismova, 1936; Vinokurov, 1938; Prebble, 1943; Singh & Bhatia, 1952). However, Konakov, 1939, has justly called this method a laborious one.

iv. **Marking and recapture method:**

This sampling method has been widely used in studying the animal population. Richard & Waloff (1954) used this method for obtaining the mean length of the life of the population of British grasshoppers whereas Dempster (1957) adopted this method for assessing the population density of *Locusta migratoria* in the fields. According to him the population should occupy a defined area with no movement in or out.

v. **Sweeping with hand-net method:**

The sweeping with hand-net method has either been used for determining the density of population (Hoerner and Longford, 1925; Rubtsof, 1932; Joyce, 1952; Flock & Deal, 1959) or was adopted for recording the composition of the population of the insects (Wilber and Fritz, 1940; Dobzhansky and Parran, 1950; Richard and Waloff, 1954 and Dempster, 1957). Joyce (1952) stated that temperature, relative humidity and vegetation had a great influence on the efficacy of the method of the hand-net.