TAXONOMIC STUDY OF ORTHOPTERANS FOUND IN AKOLA VICINITY

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
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IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)

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DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation of the Thesis entitled **"TAXONOMIC STUDY OF ORTHOPTERANS FOUND IN AKOLA VICINITY"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Thokre.

Place : Akola **(Thokre Vijay Sheshrao)**

Date : 20/5/2010 **Enrolment No : CC / 743**

CERTIFICATE

This is to certify that thesis entitled **"TAXONOMIC STUDY OF ORTHOPTERANS FOUND IN AKOLA VICINITY"** submitted in partial fulfilment of the requirement for the degree of **"Master of Science in Agriculture (Agricultural Entomology)"** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **Thokre Vijay Sheshrao** under my guidance and supervision.

The subject of the thesis has been approved by the Student's Advisory Committee.

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Table of Contents

(A) List of Plates

Plate No.	Group	Title	After Page
1.		Collection, rearing, killing, pinning, labeling and storage of insect for study.	44
2.	OEG1	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllotalpidae.	58
3.	OEG2	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
4.	OEG3	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
5.	OEG4	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
6.	OEG5	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
7.	OEG6	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
8.	OEG7	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Grylloidea, Family Gryllidae.	59
9.	OET1	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Tettigonioidea, Family Tettigoniidae.	60
10.	OET2	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Tettigonioidea, Family Tettigoniidae.	60
11.	OET3	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Tettigonioidea, Family Tettigoniidae.	60

12.	OET4	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Tettigonioidea, Family Tettigoniidae.	60
13.	OET5	Group of insects showing characters of Order Orthoptera, Sub-order Ensifera, Super-family Tettigonioidea, Family Tettigoniidae.	60
14.	OCA1	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
15.	OCA2	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
16.	OCA3	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
17.	OCA4	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
18.	OCA5	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
19.	OCA6	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
20.	OCA7	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
21.	OCA8	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
22.	OCA9	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
23.	OCA10	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61

24.	OCA11	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
25.	OCA12	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
26.	OCA13	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
27.	OCA14	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
28.	OCA15	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
29.	OCA16	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
30.	OCA17	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae.	61
31.	OCA18	Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Pyrgomorphidae.	62

(B) List of Abbreviations

%	-	per cent
/	-	per
@	-	at the rate
^0C	-	Degree Centigrade
cm	-	Centimeter
e.g.	-	Exampli gratia (For example)
et al.	-	et alia (And others)
etc.	-	Etcetera
Fig.	-	Figure
g	-	gram
ha	-	Hectare
i.e.	-	id est (that is)
J.	-	Journal
kg	-	kilogram
m	-	meter
m^2	-	Square meter
No.	-	Number (s)
OCA	-	Orthoptera, Caelifera, Acridoidea
OEG	-	Orthoptera, Ensifera, Grylloidea
OET	-	Orthoptera, Ensifera, Tettigonioidea
Sr. No.	-	Serial number
Viz.,	-	Videlicet (Namely)
Unpub.	-	Unpublished

(C) THESIS ABSTRACT

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ABSTRACT

The present investigation entitled "Taxonomic Study of Orthopterans Found in Akola Vicinity" conducted at College of Agriculture, Akola and Head, Department of Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during 2009-2010. For the

study, insects were collected from field of jowar, maize, sugarcane, millets, sunhemp, arhar, etc. Also they were collected on light trap, with the help of hand, hand nets etc. methods. The collected insects were killed, pinned and stretched, after drying they were labeled and stored in collection boxes with due care.

The collected insects were studied for the morphological and taxonomical characters and the insect showing the characters of order Orthoptera were grouped together from total collected three thousand specimen 260 specimens were from order Orthoptera indicating that the population of Orthopteran in Akola vicinity is 8.6 per cent.

The collected insects were further grouped on morphological characters and were placed in sub-order, super-family, family on the taxonomical characters and it was found that the population of Orthopteran belonging to sub-order Caelifera was more78.85 per cent whereas Ensiferans were 21.15 per cent. Among the Orthopteran belonging to super-family Grylloidea, Tettigonioidea, Acridoidea, population of super-family Acridoidea was found to be more i.e. 78.84 per cent in Akola vicinity. The super-family groups were further studied for morphological and taxonomical characters and were placed in families Gryllotalpidae, Gryllidae, Tettigoniidae, Acrididae, Pyrgomorphidae among these families maximum population i.e. 78.07 per cent of Acrididae was observed indicating that in Akola vicinity population of Acrididae are more under order Orthoptera.

Chapter I

INTRODUCTION

1.1 Background Information

Grasshoppers belong to order Orthoptera (Saltatoria) derived from Latin word Ortho and Ptera. Ortho means straight and Ptera means wing i.e. insect bearing straight wings. In this order Grasshoppers, locusts, crickets, katydids and related forms are included. Orthoptera constitute a large order comprising about 17,000 species, several species are of economic importance. They are more abundant in tropic region, (Tembhare 2005).

Grasshoppers are polyphagous and prefer to feed on the leaves of paddy, jowar, maize, millets, sugarcane, grasses, sunhemp, arhar etc. (Yadav 2008). They consume considerable amounts of foliage during their nymphal development and also as adults. When they are especially abundant they cause economical damage to all the vegetation which comes in their ways.

The locusts are well known pestiferous insects which not only move long distance but also destroy all green vegetable matter on their way and cause a famine. They have induced human being to open one of the greatest internationally organized research programmes in biological science for their management. The paddy grasshopper *Hieroglyphus banian* (Fabricius) and *Oxya fuscovittata* (Marschall), the Phadka *Hieroglyphus nigrorepletus* (I. Bolivar), the cotton grasshopper *Cyrtacanthacris tatarica* (Linnaeus), the deccan wingless grasshopper *Colemania sphenarioides* (I. Bolivar), the tobacco grasshopper *Atractomorpha crenulata* (Fabricius), the migratory locust *Locusta migratoria* (Linnaeus), the desert locust *Schistocerca gregaria* (Forskal) and the Bombay locust *Patanga succinate* (Johanson) are the major grasshopper pest in India which have attracted considerable attention of entomologist. However, there are large numbers of other grasshoppers which have often been neglected but have sometimes occurred in large numbers and caused heavy damage. The example of these are the

mulberry grasshopper *Neorthacris acuticeps* (I. Bolivar), the surface grasshopper *Chrotogonus* spp., the coffee grasshopper *Aularches miliaris miliaris* (Linnaeus) and *Zeylanacris* spp. (reported as *Tarbaleus* sp.). The short-horned grasshoppers cause direct damage to crops by defoliation and also feed on flowers, stems, barks and growing points. As many as 100 species are recognized as pest of various crops in India (COPR, 1982).

Orthopterans are medium to large sized winged insects with well developed exoskeleton and mandibulate mouthparts, enlarged prothorax, enlarged hind legs facilitating jumping, alate, forewing are small, sclerotized, leathery forming tegmina, forewings thicker than hind wings, hind wing is generally fan type. Ovipositor is well developed, cerci are short and generally unsegmented. The specialized sound producing (stridulatory) and sound receiving (auditory) organs are present. They are hemimetabolous. Eggs are elongate or ovoidal in shape and laid singly or in clusters inside or on the ground. The first instar nymphs are vermiform called pronymph. Total number of nymphal instars varies form 4–15. In apterous forms metamorphosis is slight. They are terrestrial and found in grassland, trees, bushes and other vegetation. They are also found burrowing into the ground and occasionally in caves (cavernicolous). Several species are closely associated with water (hydrophilous). Some species even have flattened hind tibia with rows of long setae that aid in swimming. Most of them are plant feeders some of them are carnivorous (Ambrose 2004).

The males produce and perceive sound in a variety of ways. Generally they rub or stridulate one part of body against another and produce sound. The sound is produce to attract members of the opposite sex for pairing.

Order Orthoptera is further divided into two suborders on morphological characters i.e.

Sub-order Caelifera,

Sub-order Ensifera

Further they are grouped under super- families and families on the morphological and taxonomical characters. In the present study the characters shown by the collected specimens are studied and the specimens are placed accordingly in the sub-order, super-family and families.

1.2 Importance of study

This study will help to know the prevailing Orthopterans in Akola vicinity. Orthopterans may cause economic losses to the crop like jowar, maize, bajra etc. in days to come. Their feeding habit on sorghum plant is outward to inward direction on the leaves and the excreta are found in between the leaf sheath of sorghum plant, which gives the indication of grasshopper damage. *Hieroglyphus banian* Fb. the paddy grasshopper in which both the nymphs and adults are found feeding on the foliage of plants as well as on the developing ear heads of paddy and defoliate the plants. In tobacco the surface grasshoppers are seen feeding on the leaves and tender shoots of plants. In wheat both nymphs and adults feed on the leaves and eat the wheat seedling. Beside this some Orthopterans are beneficial *Hesperotettix viridis*. This is seen feeding on snakeweed, and also reported to feed on more than 30 other rangeland plants (Pfadt 1988)

Orthopterans are also found to have nutritive value, the adult insect contains crude protein (CP) 654.2 g kg^{-1}; fat 83.0 g $kg^{-1}$and chitin 87.3 g kg^{-1} on dry matter basis. The content of amino acids methionine, cystine and lysine concentrations in the grasshopper meal found to be 17.0, 6.9 and 37.9 g kg^{-1}, respectively on dry matter basis.

In world Orthopterans are on dining table in many countries like Thailand, Hongkong, Africa, Mexico, Korea, Japan and India. In India locusts are consumed from long back. Gope and Prasad (1983) reported that 20 species of insects are eaten by various tribes in Manipur. Srivastava, 2006 has reported 24 recipes prepared by using crickets. Some of them have been named as "Bombay curry, Punjab Broth, Chock late Crispies, Cricket Patties, Cricket Hot Pie, John the Baptist cricket bread, Pizza Hopper, Cricket and Mushroom, Cricket seaweed, Confetti salad, Jumping Jubilee (prepared over

flaming brandy), Hot cricket avocado delight".

By knowing the prevailing species of Orthopterans in Akola vicinity and by correctly identifying them we will be able to make the use of the Orthopterans as per our requirement.

1.3 Objectives of study

1. Collection and preservation of Orthopteran fauna from Akola vicinity.
2. Study of morphological and taxonomical characters of collected specimen for grouping them in sub-order, super family, families under order Orthoptera.

1.4 Scope and limitations

The present study will help to know the different families of grasshoppers which are prevailing in Akola region. The study will help to know the long horn grasshoppers and short horn grasshoppers prevailing in Akola by grouping them in suborders likewise the super-families and families of the grasshopper will be known for first time which are prevailing in Akola region from the present study. .This study in future can help to know about the presence of prevailing species of grasshopper. This can be co-related worldwide. This will be further helpful to know the status about prevailing species in the different part of the world. If the population of particular species is found prevailing in a particular area but at lower level then the probable reasons for keeping that species at lower strata can be evaluated. If any parasite and predator are prevailing in that area then it can be thought for augmentation through quartine, to check the prevailing population of grasshopper in this area or vice/vice. The present study will be more informative and act as ready reckoner to IPM workers and has vast scope, for which after grouping them to the family level, studies to identify them up to species level is also essential.

1.5 Hypothesis

It has been observed that when we have to implement the Integrated Pest Management concept the basic thing which is essential is the correct identification of the pest. This will help the IPM worker to adopt the correct strategies write from the use of pheromone lure to their development stages, pupation sites and feeding behavior etc. This study will help to know the weak link of the stages of insect and concentrate on it for management purpose. We know that this work has been carried out in the world but to get identify the specimen from outside world is a very costly. In India NPIB project has been launched for development of taxonomic study. These are the efforts made for NPIB project to make available the identifying characters to IPM worker. So that they can also very easily identify the family of grasshopper from photographs and identifying characters shown by them. The further study about identification up to species level will help the IPM worker to identifying the Orthopterans to the species level and this study will help them to take the correct control measures for managing them when they are acting as pest. Conserve them when they are beneficial and reproduce them when they are needed for food purpose.

CHAPTER II

REVIEW OF LITERATURE

"Taxonomic study of Orthopterans found in Akola vicinity" was felt essential to know the species of grasshopper prevailing in this area. Orthopterans are major pest of cereals, sugarcane and are dangerous, when there is outbreak i.e. gregarious phase (Locust). To undertake present study literature was searched out and briefed under headings and sub-headings.

2.1 Insect collection

Yang *et al.* (1994) used seventy two traps prepared from modified soft-drink bottle. Peanut butter was used as bait, from July to September, 1990 in a nursery of Paulownia fortunei and a 40-year plantation of Taiwan incense ceder (*Calocedrus formosana*) at Nantou, Taiwan. Total of 210 crickets, representing at least 6 genera and 9 species were collected with 1620 traps. Among the collected crickets, nymphs, female and male adult instars were 23% (49/210), 57% (119/210) and 20% (42/210), respectively.

Hernandez *et al.* (1998) a catalogue Orthopteroid insects from a nature reserve in Alicante, Spain. The insects were sampled monthly between September 1995 and October 1996 at 10 sites by sweeping and the use of pitfall traps.

Frank *et al.* (2002) reported that *Scapteriscus didactylus* and *Neocurtilla hexadactyla* are the two mole cricket species known from Grenada, Lesser Antilles. They cause damage to turf and vegetable seedlings during the month of June 1990. The year-round ultraviolet light trap samples collected yielded only one specimen of *S. didactylus* among 186 specimens of *N. hexadactyla*. The proportions of the two species captured in light traps bear no relationship to their relative importance to agriculture and horticulture. Almost all (175) the light-trapped *N. hexadactyla* were females, and they were trapped in September-April.

Sperber *et al.* (2003) used pitfall traps for sampling litter-inhabiting crickets, to avoid the escape from the trap aqueous detergent killing solution by formol-glycerin-alcohol solution were used. 105 cricket individuals (29 of which were adults) from nine species in three taxonomic groups: Phalangopsinae, Trigonidiinae and Brachytrupinae were captured.

Singh *et al.* (2007) collected nocturnal Orthoptera by means of light trap and the population fluctuations of twenty four species of Orthopterans were correlated with temperature and relative humidity. In all six families viz. Gryllidae, Gryllotalpidae, Tettigoniidae (belonging to Suborder Ensifera) and Acrididae, Tridactylidae and Tetrigidae (belonging to Suborder Caelifera) were collected. Gryllidae was found dominant followed by Tetrigidae as compared to other families.

2.2 Order Orthoptera

Linnaeus (1758) included 49 named species which are considered the Orthoptera *sensustricto*. Today the total stands under this order is 20,000 species, divided almost equally between the suborders Ensifera and Caelifera. Thus the Orthoptera is a small to medium-sized order, comprising approximately 2% of all described insect species.

Kirby (1914) describe the characters for order Orthoptera as moderate to large size insect undergoing an imperfect metamorphosis, having strong mandibles, front pair of wings tegmina and are mostly parchment-like texture, while hind wings membranous, short antennae and three jointed tarsi.

Shishodia *et al.* (1993) studied the Orthoptera of Andaman and Nicobar Islands. Though many workers have dealt with Orthoptera of the Indian subcontinent, none of them studied the fauna of these islands, except for a few species which have been referred occasionally. The study deals with 67 species of Orthoptera under 11 families and 47 genera, of which 20 species are recorded for the 1st time from these islands.

Chernyakhovskii (1994) studied eighty-one species of Orthoptera (47 Acridoidea, 29 Tettigonioidea and 5 Grylloidea) listed from

North Osetia on the basis of collections made in 1961-87. For 51 species, information was given on ecological groupings and abundance, while for the remainder simply their altitude affiliations were recorded. The groupings characterized and their degrees of similarity noted. Five species were recorded from the region for the 1st time.

Bonnet *et al.* (1995) provided notes on 52 species of Orthoptera (in 6 families of Acridoidea) from the Limousin region of France, based partly on material collected in 1991-93.

Ichim *et al.* (1996) collected 1758 Coleopteran and 711 Orthopteran from a seed crop of *B. inermis*. These comprised 22 species of Coleoptera and 4 species of Orthoptera. Carabidae was the most frequently found family, and the commonest species was *Harpalus tardus*. The commonest Orthoptera species was *Dociostaurus maroccanus*.

Thorens and Nadig (1997) presented information on the Orthopteran of Switzerland, containing general information, systematic, fauna, methodology, general distribution, phenology, altitude, habitats, distribution status and threats. Information and index on species (with distribution maps and graphs of altitude and phenology); and species that are introduced, non-established, potentially present were indicated.

Badih *et al.* (1997) studied on a community of Orthoptera in a littoral dune ecosystem associated with salt-water lagoons in the Punta Entinas-El Sabinar Nature Reserve (Almeria, Spain). Biweekly samples from October 1991 to November 1992 provided a census of total 19 species belonging to 4 super-families. Phenological analysis revealed the presence of 2 groups of species: seasonal species, appearing only during certain climatic seasons, and permanent species, being present nearly all year round.

Jago (1998) reported that Orthopteran pests attack was associations of two or more species, each of which oscillates in numbers independently. Monitoring studies rarely continue for periods long enough to understand what drives these changes. Exceptions are to be found in the mid-west of the U.S.A. (Anderson 1970, Hewitt, and Onsager, 1982), central Asian

and eastern Australia. Long-term changes in farming practice, e.g. replacement of millet by sorghum in the Sahel, may be indirect clues that Orthoptera pest damage is having an effect. Intercrops and poor weeding may favor greater attack by Acridids.

Onder *et al.* (1999[a]) described families Phamphagidae (5 species in 5 genera), Pyrgomorphidae (3 species in 1 genus), Catantopidae (10 species in 7 genera), and Acrididae (49 species in 21 genera), preserved in the Prof. Dr. Niyazi Lodos Museum in Izmir, Turkey. Information concerning specific name, describer and description date, locality and date of collection, place and plant from which the specimens were collected, and the number of species and determinants are given.

Olfert and Slinkard (1999) initiated study in response to concerns that grasshoppers were becoming an economic issue in lentil crops. The study characterized the type and extent of damage and determined the relationship between grasshopper numbers (*Melanoplus bivittatus*) in lentil (*Lens culinaris*) during flowering and yield loss. In commercial fields of Saskatoon, Canada, grasshopper damage was found on sepals, flowers and both immature and mature pods. Grasshoppers at relatively low population density levels had a major impact on yield of lentil. Populations of 2-3 m^2 damaged up to 23% of viable pods and 47% of flowers and immature pods. Field cage trials along with recent estimates of crop yields, crop price and control costs were used to estimate an economic threshold.

Coray and Thorens (2001) illustrated dichotomous key to the Swiss Orthoptera and presented facilitating the identification of 120 different species.

Khalid *et al.* (2002) surveyed grasshopper fauna in Azad Jammu and Kashmir, Pakistan, revealed the presence of *Dicranophyma uvarovi, Dicranophyma hingstoni, Paraconophyma politum, P. kashmiricum, Diabolocatantops innotabilis, Catantops humilis [Xanocatantops humilis],* and *Catantops unimaculata* sp. nov. The two allotypes of *Dicranophyma hingstoni*

and *P. kashmiricum* were reported for the first time. The new species and allotypes described in detail. A key to local genera and species is presented.

Lanjar *et al.* (2002) reported the occurrence and abundance of grasshopper species on rice crop, monitored on rice variety IRRI-6 at Rice Research Institute, Dokri during summer of 2001. The four species infesting rice crop recorded were, *Hieroglyphus banian* Fb. (Rice grasshopper), *Oxya nitidula* Willemse (Small green grasshopper), *Chrotogonus trachypterus trachypterus* Blanchard (surface grasshopper) and *Aiolopus tumulus* F. (Small grasshopper). *Chrotogonus trachypterus trachypterus* was recorded in maximum number (12.8 nymphs and 39.2 adults/observation) during July-October with mean temperature of 37.95^{0}C. *Aiolopus tumulus* and *Oxya nitidula* were observed with their maximum population of nymphs (37.6 and 51.0/observation) and adult (39.0 and 70.0/observation), respectively during September-October with mean temperature range of 34.02-37.95^{0}C. Species *H. banian* was observed maximum during August-October with (4.6 nymphs and adults 15.2/observation) under mean temperature range of 35.65-37.95^{0}C. Maximum nymphal activity of all grasshopper species was noticed during three weeks after transplanting of crop and adults were maximally active at crop maturity.

Kandibane *et al.* (2004) documented 25 species of Orthoptera from weeded and unweeded rice crop ecosystem of Tamil Nadu, India, during *kharif* and *rabi* of 2000 and *kharif* of 2001. Among them, 15 taxa of acridids, 1 taxon of pyrgomorphid, 5 taxa of tettigoniids and 4 taxa of gryllids were recorded. Grasshoppers and crickets showed the greatest diversity during the flowering stage of the crop in both years. In the unweeded plots, 18 species of weeds (including *Echinochloa crus-galli, Cyperus rotundus, C. difformis, C. iria* and *Convolvulus arvensis*) were recorded and they favoured the diversity and abundance of Orthoptera. Common species of grasshoppers were more abundant in the weeded plots.

Ambrose (2004) studied the identification characters for placing the insect in order Orthoptera as wings well developed, forewings horny, leathery or parchment like at least at the base, hind wings if present usually

membranous. Forewings modified as tegmina or hemelytra, containing veins. Mouth parts biting and chewing with well developed mandibles. Not social insects, hind wings folding fan-like, broader than fore wings. Antennae long with many filament-like segments, prothorax large and free from mesothorax, forewings usually long, rarely minute. Cerci present. Hind femora almost always much larger than fore femora and adapted for jumping, if not the forelegs adapted for burrowing, body more or less cylindrical, the wings held slopping against the sides of the body when at rest, specialized sound producing (stridulatory) and sound receiving (auditory) organs present, hemimetabolous development. Tergites usually larger than sternites (grasshoppers, locusts, crickets, katydids)

Tembhare (2005) reported that order Orthoptera are saltatorial exopterygotes with mandibulate mouthparts, large prothorax, hind legs modified for jumping, forewing modified into leathery tegmina, often with auditory and stridulatory organs, pair of short unsegmented cerci and female with ovipositor.

Kalacheva (2005) studied the disturbances in the stability of natural ecosystems caused by human activities, and changes in plant and insect species composition. The effect of land use on plant communities presenting fodder for insects, particularly Orthoptera, is outlined. Information is included on predominant insect communities of meadow and steppe zones, i.e. *Tettigonia viridissima*, *Poecilimon heroicus*, *Chorthippus dichrous* and *C. albomarginatus*. Predominant species of grasslands developing as the result of falling of tree hedges and ploughing of land after removing of forest shelterbelts, particularly *Poecilimon similis* and *Dociostaurus brevicollis*, is discussed. Occurrence of Orthoptera insect pests on wheat, oat, millet, Sudan grass, maize, sunflower, mustard, soybean, lucerne, sugarbeet, grape and melon crops is outlined. Orthoptera, particularly locusts, feed on the majority of cultivated plants. Orthoptera species feeding on a variety of plants, such as *Calliptamus italicus* and *Oedaleus decorus*, and those specializing on separate plants, i.e. *Phaneroptera nana* on grape and *D. brevicollis* mainly found on cereals, are considered. Data tabulated on life forms of Orthoptera

comprising 54 species belonging to 36 genera found in meadow-steppes, roadsides, forest shelterbelts, field crops, pastures, greenhouses, conservatories, orchards and fallow land communities.

Ragumoorthi *et al.* (2006) reported that order Orthoptera are medium to large sized insect, antenna filiform, mouthparts mandibulate, prothorax large, pronotum curved, ventrally covering pleural region. Hind legs saltatorial, forewings leathery, thickened known as tegmina capable bending without breaking, hind wings membranous with large anal area, cerci short and unsegmented, ovipositor well developed in female. Metamorphosis gradual, specialized stridulatory (sound producing) and auditory (hearing) organs are present.

Triplehorn and Johnson (2006) described order Orthoptera as winged or wingless. If winged forms, wings usually elongate, many veined and somewhat thickened called as tegmina, hind wing membranous, broad, fan type and many veined and at rest they usually folded beneath front wings, body elongate, cerci well developed with one to many segments, antennae shorter or relatively long sometimes longer than body and many segments, long ovipositor in some species and other short and more or less hidden, tarsi three to four segmented, mouthparts chewing type and metamorphosis simple.

Chandra *et al.* (2007) reported checklist of Orthoptera from Madhya Pradesh and Chhattisgarh. They reported that 139 species of Orthoptera belonging to 12 families were observed from these two states. Out of these, 94 species are reported from Madhya Pradesh and 84 species are from Chhattisgarh. Ten species i.e. *Mecopoda elongata* (Linnaeus), *Xiphidiopsis citrina* Redtenbacher, *Platygryllus lineaticeps* (Walker), *Xenogryllus* sp., *Pternoscirta cinctifemur* (Walker), *Tridactylus fasciatus* Guerin and *Xya opaca* (Walker) were recorded for first time from these states.

Castner (2008) reported characters for grouping the insect in order Orthoptera as wings present or absent, if present short or extend full length of body, forewings leathery, conceal membranous hind wings,

antennae thread like (filiform). Hind femora slightly to greatly enlarged, tarsi five segmented, chewing mouthparts with gradual metamorphosis.

2.3 Sub-order Ensifera

Ambrose (2004) described sub-order Ensifera as longer hair like antennae, three or four segmented tarsi and relatively long, sword shape or cylindrical ovipositor. The tympanal organ, if present located on upper ends of fore tibiae. The species that stridulate either rub edge of one forewing over file-like ridge on ventral side of other forewing.

Tembhare (2005) reported character of sub-order Ensifera as antennae very long, longer than body, tympanal organ on fore tibiae, stridulatory organs on tegmina, ovipositor elongate.

Ragumoorthi *et al.* (2006) reported characters of sub-order Ensifera as antenna long with more than 30 segments, tympanal organ found on fore tibiae, tactile response well developed, feed on dicot plants, nocturnal habit.

Castner (2008) reported characters for sub-order Ensifera as antennae long (usually as long as abdomen or longer), tympanal organ located on front tibiae when present, tarsi three or four segmented, hind femora usually moderately enlarged, females usually with obvious visible ovipositor.

2.4 Sub-order Caelifera

Kirby (1914) describe the character for sub- order Caelifera as antennae comparatively short, not more than twenty four joints, mandibles strong, first segment of abdomen bearing curious structure each side which known as organ of hearing.

Badih and Pascual (1998[a]) studied Caelifera of Rif and lower Moulouya basin (northern Morocco) during 1989 and 1993. Data concerning 70 species, including horizontal and vertical distributions, vegetation preferences and phenology, was presented.

Badih and Pascual (1998[b]) studied Caeliferan fauna of north Morocco during 1989-93. Total of 70 species were captured, comprising 37 genera and 5 families. Two species were recorded for 1st time from Morocco and 13 species for the 1st time in north Morocco, including *Pyrgomorpha cognata, Heteracris annulosus* [*H. annulosa*], *Acrotylus fischeri, Morphacris fasciata.*

Barranco and Pomares (2001) listed 24 species of Caelifera from Aragon, Spain, with notes on taxonomy and localities.

Ambrose (2004) reported the character for suborder Caelifera as more or less enlarged hind femora modified for jumping, shorter antennae, three or fewer segmented tarsi, cerci and ovipositor short. The tympanal, if present are located on sides of first abdominal segment. The species that stridulate either rub their hind femora over the tegmina or abdomen or snap the wings during flight.

Tembhare (2005) presented the characters for sub order Caelifera as antennae shorter than body and consisting less than 30 segments, tympanal organs always on first abdominal segment, stridulatory organs femora tegmen type in one or both sexes or absent. Ovipositor short and robust or absent.

Ragumoorthi *et al.* (2006) reported that the characters of sub order Caelifera as antenna short with less than 30 segments, tympanum organ found on lateral side of first abdominal segment, vision and hearing acute, mandibles specialized for consuming monocot foliage, diurnal habit.

Castner (2008) presented the characters of sub order Caelifera as antennae short usually less than half body length, tympanal organ located on the first abdominal segment, tarsi three segmented or less, hind femora usually enlarged for jumping, females without obvious visible ovipositor.

2.3.1 Super-family Grylloidea

Gorochov (1993) studied the material of super-family Grylloidea from Saudi Arabia and adjacent countries contain 44 species. Twelve species and 2 genera in the families Gryllidae (Gryllomorphinae, Gryllinae and Oecanthinae), Mogoplistidae and Myrmecophilidae (Myrmecophilinae) were described as new to science.

Herrera and Larumbe (1996) studied on the distribution of Grylloidea and Caelifera in Cantabria, Spain, from 1985 to 1988. A total of 142 individuals of Grylloidea (5 species of 5 genera) and 6542 individuals of Caelifera (44 species of 22 genera) were captured.

Onder *et al* (1999[b]) presented catalogue of the material of the Gryllidae family (21 species in 14 genera) and Gryllotalpidae family (1 species), preserved in the Prof. Dr. Niyazi Lodos Museum in Izmir, Turkey. Information concerning specific name, describer and description date, locality and date of collection, place and plant from which the specimens were collected, and the number of species and determinants are given.

Ingrisch *et al.* (2004) DORSA (German Orthoptera Collections) a specimen-based database with internet access to important Orthoptera collections held in German museums. It includes geographic information on a world-wide basis as well as media data like images of type specimens and sound recordings (Virtual Museum). During the 3 years project supported by the German Federal Ministry of Education and Science, more than 9000 specimens from 9 museum's collections were databased. Some 7421 type specimens in 2960 species (2229 species with primary types) were documented by more than 25,000 photographic images. Approximately one-tenth of the roughly 29,000 species group names in Orthoptera worldwide documented by type specimens in German collections. A public sound library for Orthoptera sounds was established comprising more than 4000 sound records linked to voucher specimens. All data made available via the SYSTAX database (http://www.biologie.uni-ulm.de/systax). For the moment the following data are already available online via the DORSA homepage

(http://www.dorsa.de): (1) a documentation of the Grylloidea types including 3000 images internet-linked on a species to species basis with the Orthoptera Species File (http://OSF2.orthoptera.org/basic/HomePage.asp) working in directions, (2) a Java-based map server with graphical user interface, (3) the sound library. A rapid assessment tool was developed for automated song recognition.

Tembhare (2005) reported in super-family Grylloidea only males forewings are tegmina have stridulatory apparatus, foretibia with tympanal organs, three segmented tarsi, ovipositor needle shaped bearing vestigial inner valves.

2.3.1.1 Family Gryllotalpidae

Canhedo and Corseuil (1996) species of Neocurtilla and Scapteriscus were studied in Rio Grande do Sul, Brazil. Two new species are described. *Scapteriscus acletus* is considered to be a junior synonym of *Scapteriscus borellii*. Sonographic studies, keys and illustrations are included.

Hill *et al.* (2002) proposed a hypothesis in relationships with subset of the mole cricket family (Gryllotalpidae), based on morphology and call type. Living and preserved specimens of six species were examined and a literature analysis conducted, as preliminary steps in a comparative study of this family, known world-wide in tropical and temperate regions. In the literature, 76 species in 5 extant genera are described, they included 34 species for analysis from four genera for which the most complete morphological data were available. All analyses were rooted by the out-group method, with *Gryllus texensis* Cade & Otte as the out group and the presence of mole-like digging forelimbs as the synapomorphic character diagnosing the in-group. Seven other characters in the analysis were restricted to discrete traits for a total of 8 characters in the analysis. Phylogenetic analyses of the complete data set yielded >15,000 trees to which we applied various consensus analyses by PAUP without high levels of resolution. The Adams method, however, revealed a resolved group of 14 in-group taxa from four genera, but mostly from the genus *Gryllotalpa,* that were subjected to re-

analysis with PAUP. Two equally parsimonious trees were roughly organized into clades by call type. The hypothesis supports previous work that has placed the genus *Scapteriscus* in a separate subfamily and other work that suggested the New Zealand endemic, *Triamescaptor aotea* Tindale, was more closely related to two Australian species of *Gryllotalpa* than to *Gryllotalpa* species as a whole. Additional field studies of songs of this family and addition of characters based on molecular data were important to resolve relationships suggested by this hypothesis.

Hoffart *et al.* (2002) represented the mole cricket family, Gryllotalpidae, in the continental United States by two native and three introduced species. The native species, *Gryllotalpa major* Saussure and *Neocurtilla hexadactyla* Perty, produce sexual advertisement calls of chirps, while the introduced species, *Scapteriscus borelli* Giglio-Tos and *S. vicinus* Scudder, produce calls of trills like most other species in the family. *Scapteriscus abbreviatus* Scudder does not have an advertisement call. Used a scanning Electron microscope was used to scan photograph forewings and describe the male and female condition of *Gryllotalpa major* for the first time. In addition they compared forewings of males of the four calling species to determine whether or not call type was linked to morphology of the stridulatory apparatus. The female *G. major* forewing was compared with those of females of the other calling species, including *S. vicinus*, which has previously been reported to produce low-amplitude sounds. Although there were generic differences in morphology of the stridulatory apparatus of value to taxonomists, there were no clear differences that can be used to segregate the mole cricket males into chirping and trilling species. The female *G. major* wing has a more highly developed stridulatory file than females of the other species from the continental United States.

Nickle (2003) revised mole cricket genus *Scapteriscus* to include 21 species, 9 of which are described herein as new: *S. costaricensis* sp. nov., *S. didactyloides* sp. nov., *S. ecuadorensis* sp. nov., *S. grossi* sp. nov., *S. macrocellus* sp. nov., *S. peruvianus* sp. nov., *S. quadripunctatus* sp. nov., *S. saileri* sp. nov., and *tibiodentalis*. Two species, *S. tenuis* sp. nov. and *S.*

didactyloides sp. nov., each having several geographical variants which may prove to be distinct species. Two species, *S. leptodactylus* and *S. siangensis*, described from India and Pakistan, were removed from *Scapteriscus* and placed in a new genus, described herein as *Indioscaptor*. *Scapteriscus* spp. defined using both traditional morphological characters and other methods of species recognition, including analyses of morphometrics and cuticular hydrocarbons.

Frank and Walker (2003) reported one species of mole cricket occurred in Jamaica, and it was *Scapteriscus abbreviatus*. It was not native to Jamaica, and it arrived there before 1926. This species occasionally damages crops, but has not heretofore in print, to the best of our knowledge, been reported to do so in Jamaica. In the West Indian islands of St. Croix and Cuba, *S. abbreviatus* was apparently misidentified as *S. didactylus* and here it has been report that the same misidentification was made in Jamaica in 1920s, which is uncorrected until now.

Zhantiev *et al.* (2003) the relationship between temporal and frequency parameters of males' calling songs and air temperature was studied in 3 Gryllotalpa species (*G. gryllotalpa, G. stepposa* and *G. unispina*). The increase in temperature resulted in the linear increase in the pulse rate and in the reduction of the duration of pulses and intervals between them. A negative relationship was observed between the density of teeth of pars stridens and the dominant frequency of calling song in the species of mole crickets. Five types of signals (calling, courtship, territorial, aggressive, and protest) are described in *G. stepposa* for the first time. The calling signals of the 3 species of mole crickets had definite temporal and frequency differences, but the variations were only slight, and the calling signals were stable enough to provide the reliable recognition of these sounds in natural conditions. Probable mechanisms of isolation in the genus *Gryllotalpa*.

Ambrose (2004) described the characters for family Gryllotalpidae brown black pubescent body, short antennae with many segments and forelegs modified into broad, spade like organs for digging. Ovipositor not visible externally and tegmina short.

According to Tembhare (2005) family Gryllotalpidae have forelegs modified for digging, tibia terminally flat and bear strong teeth and resemble fore paw of mole, eyes are reduced. Winged brachypterous or apterous, forewings short and hindwings are folded over abdomen, no stridulatory organs, ovipositor vestigial.

Ragumoorthi *et al.* (2006) reported that family Gryllotalpidae are brown coloured, eyes reduced, pronotum elongate ovate and rounded posteriorly. Forelegs fossorial, tibiae are expanded and digitate, hindwings extended beyond tegmina pair of processes, special stridulatory structures are absent, humming sound produced by rubbing forewings, pair of tympanum found under surface of tibiae, ovipositor vestigial.

Castner (2008) reported that family Gryllotalpidae have size greater than 20mm in length, front legs terminate in large, finger like claws, tarsi three segmented, antennae relatively short (less than half body length), ovipositor absent.

2.3.1.2 Family Gryllidae

Maes (1994) catalogue and presented of 25 species of Gryllidae and 2 species of Gryllotalpidae from Nicaragua. Details of geographical distribution, food plants and natural enemies are included.

Fontana and Massa (1999) described infestation of *Grylloderes brunneri*, which occurred during August-October 1999 in western Sicily, Italy. The insects were found in the vicinity of crop plants (especially melon, *Cucumis melo* var. inodorus, and tomato, *Lycopersicon esculentum*) and ruderal plants along roadsides, but also damaged young trees in a mixed deciduous plantation, particularly the bark. At the end of September, 100% of robinia (*Robinia pseudoacacia*) and bird cherry (*Sorbus aucuparia*) trees in the plantation were damaged; 50% of *Fraxinus ornus*, wild olive (*Olea europaea* var. *sylvestris*), *Quercus pubescens* and white mulberry (*Morus alba*) were attacked. The pests did not apparently attack conifers (*Pinus pinea, P. halepensis*), carob (*Ceratonia siliqua*) or azerole (*Crataegus azarolus*).

Cade and Otte (2000) described *Gryllus texensis* sp. nov., occurring from western Texas to western Florida. Previously, this was incorrectly referred as Gryllus integer.

Gorochov (2000) a new subgenus of the genus *Itara* with a new species from Kalimantan (*I. maxima* sp. nov.) were described.

Dambach (2004) reported that cricket [male] sing by rubbing their forewings (tegmina) rhythmically against each other. A file with regularly spaced teeth on the underside of the right tegmen is scraped against a ridge (plectrum) on the left tegmen. In *Gryllus campestris* both forewings and files are morphologically identical but, being an exclusive 'right-stroker', only the right file is subjected to mechanical stress. SEM-studies of files from older [male] have revealed conspicuous signs of wear and tear. The number of defects was significantly higher on the right tegmen than on the left in all the 20 pairs of files studied. Two typical defects are notches on the chisel-like edges of the hooked file teeth and cracks in the saddle-shaped interspaces. The form and location of these defects reveal the points of highest mechanical stress during stridulatory impact.

Ambrose (2004) studied the characters for family Gryllidae and observed that they have long cerci, long tapering antennae and long cylindrical ovipositor. Forewings positioned horizontally (rather than vertically) over body and exhibiting tendency for dorsoventrally flattened body. Male are usually good songsters and each species has characteristic song.

Tembhare (2005) reported characters for family Gryllidae as elongate antennae. Slender, cylindrical long, spear-shaped ovipositor, auditory organ on fore tibiae. Pair of long unsegmented cerci.

Sapna and Rohini (2005) reported that delimitation of species and identification of specimens to the species level continue to be difficult problems for practising entomologists, particularly those in tropical countries who often have no access to the holotype specimens or original literature of their local fauna. As a first step to the development of accurate Web-based species identification keys for Indian gryllids, we have examined the utility of

morphological and song characters in correctly delineating species boundaries among 4 sympatric species of tree crickets of the Genus *Oecanthus*. Using a numerical taxonomic approach, phenetic clusters and ordinations were constructed on the basis of morphological and song characters. Quantitative and qualitative morphological characters were analysed independently and the results compared. The efficacy of the clustering and ordination techniques in species delimitation was examined by both internal and external allocation of individual specimens. Both the delimitation of species and the allocation of new specimens were 95 to 100% accurate using song or qualitative morphological characters. Quantitative morphological characters could also accurately delimit species, provided a large number of characters were used, irrespective of the specific characters chosen. For quantitative morphological characters, ordination was found to be more accurate than cluster analysis, both for delimiting species and in the allocation of new specimens.

Ragumoorthi *et al.* (2006) reported family Gryllidae have antenna long, tarsus three segmented, ovipositor slender and needle like, forewings abruptly bent down to cover sides of body. Hind wings acuminate produced into pair of long processes which project beyond abdomen. Cerci long and unsegmented, auditory organs and stridulatory organs are similar to long horned grasshopper. Males stridulate during night and produce shrill chirping noise.

Castner (2008) reported that characters for family Gryllidae are small to medium sized (7-30mm), wings held flat over body, tarsi three segmented, tympanal organ located on front tibiae, ovipositor needle like.

2.3.2 Super-family Tettigonioidea

Tembhare (2005) described the character of super-family Tettigonioidea as long horned grasshoppers with stridulatory organs and tympanal organs, long well developed ovipositor and tarsi four segmented, winged and wingless forms.

2.3.2.1 Family Tettigoniidae

Rentz (1990) verify presented status of classification of family Tettigoniidae which was discussed and reclassification and an illustrated key to subfamilies was presented. Two new subfamilies Apteropedetinae from the Andes of South America containing one genus (*Apteropedetes*, gen. nov.) and one species; *Microtettigoniinae* from southern Australia, containing one genus (*Microtettigonia,* gen. nov.) and two species (*M. kangaroo*, sp. nov., and *M. tachys*, sp. nov.) was described. The geographical distribution and the relationship of the taxa were also discussed.

Jin and Xia (1994) the known species of Chinese Tettigoniidae which included in long-horned grasshoppers, katydids, camel crickets, cave crickets and leaf-rolling crickets, but do not include true crickets and mole crickets of the suborder Grylloptera. All known species were listed along with original references, synonyms, types, type depositories and known distributions in China. The geographical territory covered by this catalogue includes both mainland China and Taiwan, some parts of (outer) Mongolia, Ussurian region (border of Russia), Changbai Mt. (N. Korea), Ryuku Is. Of Japan, Himalaya (border of India and Nepal) and Tonkin (border of Vietnam).

Viscuso *et al.* (1998) examined spermatodesms collected from the male and female genital tracts of numerous Orthoptera Tettigonioidea revealed an overall morphological and ultrastructural organization that is generally similar in individuals of the same sex but considerably different between males and females of even the same species. In the male genital tracts each spermatodesm is composed of a limited number of spermatozoa whose nuclei and acrosomes are covered by a mucous cap. The spermatozoa inside each bundle are mainly arranged in parallel rows and are always distinctly separate. The number of spermatozoa per spermatodesm may vary within the same individual although it does not seem to exceed a maximum value that can only be determined exactly in Tettigoniidae species. The most characteristic feature of spermatozoa of all the species examined is a conspicuous elongation of the plasma membrane in the acrosomal region that is not present in the female genital tracts. In addition, spermatodesms

from females are composed of highly numerous tightly packed spermatozoa that are linked together via the acrosomal region. This characteristic of spermatodesms, never previously reported in other insect species, would involve their reorganization during transfer from the male to the female genital tracts and would seem to take place in the spermatophore. The probable role of spermatodesms in the reproductive physiology of Tettigonioidea might be related to the degree of maturity of the sex cells transferred to the female; the reorganization of the spermatozoa out of the male genital tracts seems to support this hypothesis.

Ayal *et al.* (1999) studied long-horned bushcrickets (Tettigoniidae) intensively in Israel for four decades. Forty-two species belonging to twenty-two genera have been recorded. The distribution of species associated with plant communities of the five phytogeographical provinces represented in Israel. The majority of the species are associated with the Mediterranean and Irano-Turanian flora, with a few species each associated with the Tragacant, Saharo-Sindian, and Ethiopian flora. A high proportion (about 50%) of endemism, associated with a high proportion of brachypterous species, was found in the first three groups but not in the last two groups. Despite a general association with specific plant communities, no distinct relation between species distribution and precipitation levels was found. However, within the Mediterranean and Irano-Turanian groups, there was a distinct segregation of species with similar morphology between bush-forest and shrub-grassland habitats.

Olmo (1999) described new species of the genus *Ctenodecticus* Bolivar, 1876, *Ct. thymi* sp. nov. from Iberian peninsula. The species was similar to *C. masferreri* Bolivar, 1894 and *C. granatensis* Pascual, 1978. The male cerci in *C. thymi* are longer than broad, similar to *C. granatensis* and different from *C. masferreri*, in which cerci width and length were similar. Regarding the females, the subgenital plate of the *C. thymi* had two fossae situated laterally near the margin, in an intermediate position with respect to the position of the other two species. This was the first case on the Iberian peninsula of a species showing intermediate morphological characters in a

genus where all species are very different, and suggests the existence of other undescribed species.

Kim and Kim (2001[a]) a taxonomic study of Korean Tettigoniinae (Orthoptera, Tettigoniidae) is presented. Thirteen species were recognized: *Eobiana engelhardti engelhardti, Metrioptera monticola* sp. nov., *M. ussuriana, M. bonneti, M. brachyptera, Paratlanticus ussuriensis, Anatlanticus koreanus, Atlanticus sinensis, Atlanticus brunneri, Gampsocleis sedakovi obscura, G. ussuriensis, Tettigonia ussuriana* and *T. dolichoptera dolichoptera. M. monticola* described as new and *T. ussuriana* was reported for the first time in Korea Republic.

Kim and Kim (2001[b]) presented taxonomic study of 4 subfamilies of Korean Tettigonidae (Bradyporinae, Mecopodinae, Meconematinae and Listroscelidinae). Some members of these subfamilies in Korea were also presented, which include 1 species of the subfamily Bradyporinae, one of Mecopodinae, 5 of Meconematinae and one of Listroscelidinae. Two of these species are reported for the first time in Korea. The geographical locations of these species and their distinct characteristics are presented.

Gorochov, (2001[a]) described new subgenus with two new species of genus *Xizicus* Gor. from Thailand.

Gorochov, (2001[b]) reported new subgenus *Exoteratura* with a single, new species from Sumatra.

Cplak *et al.* (2002) reviewed species of *Platycleis* from Turkey. Twenty-three species were recorded: *Platycleis affinis, P. albopunctata, P. escalerai, P. intermedia, P. incerta, P. persica, P. ankarensis, P. armeniaca, P. elegans, P. schereri, P. taurica, P. uvarovi, P. sepium, P. sporadarum, P. kurmana, Platycleis melendisensis* sp. nov., *P. sinuata, P. salmani* sp. nov., *P. weidneri, P. nigrosignata, P. tessellata holoptera, P. veyseli,* and *P. yalvaci.* Keys to subgenera and species, necessary figures, and distribution maps were provided. *Yalvaciana subgen.* nov. was established to include *Decorana yalvaci. P. salmani* and *P. melendisensis* were described. *Montana*

bifoveolata syn. nov. were placed in synonymy with *Platycleis schereri*. *Metrioptera brevipes* placed in synonymy with *P. sporadarum* in subgenus *Sporadiana*. *Platycleis* (*Squamiana*) *sinuate* transferred from subgenus *Platycleis*. Song oscillograms from *P. armeniaca* and *P. taurica* are presented. *Platycleis* (*Montana*) *armeniaca* a new record for Turkey.

Kim and Kim (2002) studied five *Conocephalus* spp. in Korea Republic, including *C. bambusanus, C. japonicus japonicus, C. maculatus, C. chinensis* and *C. gladiatus*. *C. bambusanus* which were recorded from Korea for the first time. The key to species, distributional data and comparative figures are given.

Mahasneh and Bader (2003) collected tettigonids weekly from February 2002 to the spring of 2003. Many specimens were collected from the different parts of Jordan. Specimens of Tettigoniidae collected previously from Jordan and preserved in the University of Jordan Insects Museum as well as other Jordanian collections were also studied. The specimens were found to belong to 25 species in eight genera and six subfamilies. Keys for the identification of subfamilies, tribes, genera, subgenera and species recorded in Jordan were constructed and provided with the necessary illustrations. For each species, the valid name, synonymy list, distribution in the world, collecting sites and dates in Jordan, description, color photographs of the entire specimen, were provided.

Ambrose (2004) described the character for family Tettigoniidae as greenish coloured and hair like antennae. Ovipositor bilaterally fattened blade-like, small portion of wing that held horizontally and dorsally over the body, wings slopes vertically when at rest.

Tembhare (2005) characterized family Tettigoniidae as auditory or tympanal organs present on fore tibia. In male cubito-anal regions of tegmina bear stridulatory organs and with overlapping and separating left tegmen from right, sound produce. Winged as well as wingless forms occur, commonly green in colour.

Rentz *et al.* (2005) discussed and reviewed the endemic Australian genus *Phricta redtenbacher* about its subfamilial status. Four species were known. The genus confined to eastern Australian coastal rainforests from the Daintree River area of northern Queensland to the Border and McPherson Ranges of northern New South Wales. This is a continuation of the Monograph of Australian Tettigoniidae.

Ragumoorthi *et al.* (2006) reported that characters for family Tettigoniidae as antenna long, slender as long as or longer than body, tarsi four segmented, ovipositor sword like, auditory organs found on foretibia. In each foretibia pair of tympanum present, outer tympanum larger than inner, sound production alary type.

Castner (2008) reported that characters for family Tettigoniidae as size variable (10-100mm), wings held vertically or roof-like over body, tarsi four segmented, tympanal organ located on front tibiae, ovipositor variable in shape but often flattened and blade-like.

2.3.3 Super-family Acridoidea

Kirby (1910) prepared synonymic catalogue on Orthoptera of the world. Latter on in 1914 prepared monographic treatment of Indian short-horned grasshopper and published it in the fauna of British India series which includes 220 species under 91 genera grouped in seven subfamilies.

Ander (1939) treated Acridoidea as super-family of the suborder Caelifera.

Uvarov (1966[a]) reported that the super-family Acridoidea contains ten families out of which only three families occur in the Indian subcontinent.

Cigliano (1991) studied the patterns of taxonomic congruence in 25 known species from Tristiridae, using cluster analysis, principal component and principal coordinate analysis, based on external morphology, female genitalia and phallic complex. The phenetic relationships based on the

external morphology were found highly congruent with those based on the female genitalia, but showed discrepancies when the phallic complex was analysed. Species from similar habitat clustered together when the analysis was based on the external morphology and different life forms were recognized. However, these groups were not set when the analysis was based on the phallic complex. Homoplasy is inferred to be represented in the phenetic analysis based on the external morphology, while homologous similarity due to a common ancestor is supposed to be represented when the analysis is based on the phallic complex.

Suhail *et al.*(1994[a]) collected twenty eight species of grasshopper fauna belonging to the families Tetrigidae, Eumastacidae, Pamphagidae and Pyrgomorphidae collected from various localities of Pakistan revealed that one family Eumastacidae and twelve species viz. *Criotettix maximus, Hyboella tibetana, Coptotettix annandalei, C. interruptus, C. testaceous, C. indicus, Paratettix semihirsutus, Euparatettix personatus, Ergatettix callosus, E. interruptus, E. crassipes, Gomphomastax antennata* have been recorded for the first time from Pakistan.

Parihar (1996) presented data on the species richness and habitat preferences of Acridoidea, Tenebrionidae and wood-boring Coleoptera occurring in the Thar Desert, India. Some of the species dealt with are known to be of economic importance.

Moizuddin (1998) recorded species of locust and grasshopper distributed in Lasbela, Balochistan, Pakistan. A total of 30 species belonging to 25 genera, 9 sub-families and 2 families of the superfamily Acridoidea were keyed.

Ma-EnBo *et al.* (2000) conducted chromosomal study on Acridoidea Cytotaxonomy of eight families in Acridoidea has been studied on the chromosomal number, the mechanism of sex determination, the shape and group of chromosomes, the feature of chromosomal C-banding and the total heterochromatin content (THC) value and so on. The results show that, among the eight families studied, the Pamphagidae is special, and is

distinguished from other families. The chromosomal number and group are similar to those in Pyrgomorphidae and Chrotogonidae, and they share the common heredity background. The Catantopidae and Oedipodidae can be grouped together according to the similar chromosomal number and other common characters, and the other two families Acrypteridae and Gomphoceridae have more similarity in the chromosomal markers and can be grouped together. Whereas family Acrididae, is placed intermediate between Pyrgomorphidae and Catantopidae.

Andersen *et al.* (2000) reported that grasshoppers are the diverse and functionally important group of insects, but assemblages of Australian grasshoppers are extremely poorly known. The study of the grasshoppers (Orthoptera: Acrididae, Eumastacidae, Pyrgomorphidae, Tridactylidae, Tetrigidae and Tettigoniidae) of Kakadu National Park in the seasonal tropics of the Northern Territory was the first comprehensive description of any regional grasshopper fauna in Australia. They list all known species, describe their biogeography, habitat associations and abundance, and proposed a functional group classification for Australian grasshoppers as a framework for future ecological and biogeographical studies. In all, 161 grasshopper species from 90 genera were known from Kakadu. The dominant family was Acrididae (64% of all genera, 63% of all species), within which the subfamily Catantopinae (44% of all grasshopper genera, 47% species) was particularly important, as typical for Australia. The Tettigoniidae was also relatively diverse, with 35 species from 16 genera. A large proportion of the fauna - 81 species (50%) and 15 genera (17%) - was undescribed. In total, 86% of Kakadu's species and 73% of genera are endemic to Australia. Many (42%) of the species are endemic to the northern half of the Northern Territory, and most of the others (36% of total species) have their Australian distributions restricted to the tropics. The major functional groups in terms of species are Grass-eating Acrididae and Pyrgomorphidae (33% total species), Broadleaf-eating Acrididae and Pyrgomorphidae (19%) and Open-ground Acrididae and Pyrgomorphidae (12%). There was a widespread macroecological tendency for locally abundant species to have wide

geographic ranges, but there was no consistent trend for locally abundant species in Kakadu to have widespread distributions.

Priya and Narendran (2003) prepared a dichotomous key for the easy identification of the genera of short horned grasshoppers of Kerala, India. A checklist of the genera of Acridoidea has been given.

Ambrose (2004) reported the characters for super family Acridoidea as tarsi three segmented, female abdomen with eight sterna, pretarsus with arolium. Well developed ovipositor.

Tembhare (2005) reported that characters for super family Acridoidea are as three segmented tarsi, pretarsus with arolium, female abdomen consisting eight sterna, well developed but short ovipositor.

Mandal (2007) listed the agriculturally important species of Acridoidea (Orthoptera) and prepared systematic account. Key to families of Acridoidea, Family Pyrgomorphidae. Key to the genera of family Pyrgomorphidae. Key to the species of Genus *Chrotognus* Serville, 1893 was prepared.

2.3.3.1 Family Acrididae

Kirby (1914) describe the character for family Acrididae like short antennae with three jointed tarsi, hind legs strongly developed, head usually short and broad, mandibles strong, tegmina comparatively long and narrow parchment-like and not folded. In Brunner Von Wattenwyl's "Revision of the Orthoptera", published at Geneva in 1893, he reported nine subfamilies of the present group of these the second and fourth (Pneumorine and Proscopine) are exclusively confined to South Africa and to Tropical America respectively; while the eight, the Pamphagia is not yet recorded from India, though it is probable that some representatives may occur in northern or north-western portions. The other subfamilies are all more or less fully presented.

Uvarov (1923) established the genus *Anacridium* which included three species and one subspecies. The genus *Patanga* was also established and he reported two species from India.

Uvarov (1927) observed *Tylotropidus varicornis* on sugarcane in Maharashtra.

Golding (1934) reported that *Trilophidia* is essentially a *geophilous* genus which lives in saturated grassland, grassland savanna, irrigated areas and area of sparse vegetation.

Rao and Bhatia (1939) reported that *Locusta danicus* well known as serious enemy of crop plants, when they come in swarms attacks almost any type of green vegetation. It has been also reported on common millet, rice, sorghum and sugarcane.

Drish (1954) revised the *Acrida* genus and recognized 23 species of which only three species occur in the India subcontinent.

Drish (1956) differentiated the subfamily on the basis of the absence of stridulatory pegs on the inner side of the hind femur and in most cases by the presence of a more or less well developed intercalary vein in the medial area of the tegmina. This is the largest subfamily including a vast number of genera and species.

Drish (1961) reported eleven subfamilies of short-horned grasshoppers out of them twelve recorded from India.

Uvarov (1966[b]) reported that Acrididae is the largest family in the Acridoidea and contains 19 subfamilies of which only 15 subfamilies occur in the Indian subcontinent.

Hollis (1971) observed *Oxya turanica* on rice, sugarcane distributed in Kashmir, Rajasthan, Karnataka, Maharashtra, and Andhra Pradesh.

Mason (1973) observed *Hieroglyphus banian* incidence in rice and maize crop in the state of Bihar, Gujarat, Karnataka and Tamil Nadu in India.

Banu and Kushwaha (1974) observed incidence of the grasshopper, *Trilophidia annulata* (Thunberg) (Insecta:Orthoptera: Acrididae), seriously damaging Bermuda grass in Rajasthan.

Tandon (1976) prepared a partial check list of ten subfamilies of the Indian Acrididae.

Haq and Aziz (1978) observed the *Acrotylus humbertianus* Saussure on *Triticum asestivum* Linn, *Hordeum vulgare* Linn, *Pennisetum typhoideum* Linn, *Sorghum vulgare* Pers, *Zea mays* Linn. in Indian subcontinent.

Ritchie (1981) in his revision of the genus *Oedaleus* recognized 20 species and three subspecies of which three species occur in Indian subcontinent.

Lo (1992) reported *Podapolipus transversus* sp. nov., an ectoparasite of *Atractomorpha ambigua* and *Podapolipoides acridae* sp. nov., attacking *Acrida chinensis* [*A. cinerea*] are described.

Mungai, (1992) the acridid genus *Chondracris* is revised for the first time in its entirety. On the evidence of the morphology of the phallic complex, the Afrotropical species formerly attributed to the genus are shown not to be congeneric with those occurring in Asia and the Far East. A new genus is erected to accommodate the 5 Afrotropical species. A new species is described from the Indian subcontinent.

Suhail *et al.* (1994[b]) studied thirteen species of Acridinae belonging to five genera were collected from various localities of Punjab province during a survey conducted in 1990-92. Of these, six species are recorded for the first time from Pakistan.

Outbreak of grasshopper, *Hieroglyphus nigrorepletus* was observed by Prabhu and Jawaredowda (1997) causing severe defoliation of sugarcane, sorghum and maize in the Bellary District of Karnataka, India, in Aug 1997.

Stewart (1997) observed the damage by *Locusta migratoria migratorioides* to wheat and maize crops in the Potgrietersrus District, Northern Province, in 1993. The economic losses due to them were in the range R331-1410 for wheat and R450 for maize.

Seema and Ameen (1997) *Poekilocerus pictus* is primarily a defoliator of aak (*Calotropis* spp.) but has also been reported defoliating other tree species, various ornamental plants and vegetables. During 1993-96 adults and nymphs were found defoliating young trees of *Acacia nilotica* (15%), *Acacia senegal* (10%), *Prosopis cineraria* (30%), *Prosopis juliflora* (7%) and *Tecomella undulata* (60%) in and around Jodhpur District, Rajasthan. Experimental host preference tests were carried out with 4 tree species (including 3 of those above), and showed that *T. undulata* was the preferred species of these (it was completely defoliated), followed by *P. cineraria* and *A. nilotica*. *Azadirachta indica* was not attacked at all.

Sharma and Gupta (1997) prepared illustrated taxonomic key for identification of grasshopper species. Identification key to the short-horned grasshoppers (Orthoptera: Acrididae) from sub-Shivalik plains of Jammu was also prepared.

Verma (1998) several new hosts of *Poekilocerus pictus* are reported from western Rajasthan, India. *Plumeria alba*, *Tabernaemontana* and *Chrysanthemum maximum* [*Leucanthemum maximum*] were preferred for feeding and *Moringa oleifera* for adult congregation.

Usmani *et al.* (1998) collected male and female adults of 11 genera of family Acrididae from the Fezzan region of Libya. General characteristics of the Acrididae, based on observations from dissections. A key to the subfamilies and genera of the family presented, based on conventional and genital characteristics. The presence or absence of ancorae

on the epiphallus, Jannone's organs and setae on the posterior margin of the female subgenital plate, the length of aedeagus sclerites and ovipositor valves and the morphology of diverticula of spermatheca were used to distinguish subfamilies. The length of ancorae on the epiphallus and of ovipositor valves in relation to the lateral apodeme, the width of the bridge, the mono-, bi-, or trilobate condition of lophi, the morphology and size of basal and apical valves of the aedeagus and the morphology of the apical valve, the male and female supra-anal plate and ceci, the male subgenital plate and the posterior margin of the female subgenital plate are used as generic characters.

Suhail *et al.* (1998) studied the morphology and habitat of *Aswatthamanus iranicus*, *Kirmania exilis*, *Ochrilidia geniculata*, *O. longiceps*, *O. turanica*, *O. gracilis gracilis*, *O. affinis* [*O. gracilis*], *Aulacobothrus luteipes*, *A. sven-hedini*, *Dociostaurus decisus*, *D. tartarus* and *Stauroderus scalaris* [*Chorthippus scalaris*] collected from various localities in Pakistan in a survey conducted during 1993-95. *D. tartarus* and *S. scalaris* were recorded for the first time in Pakistan.

Pierozzi and Lecoq (1998) displayed very conspicuous gregarious behaviour of both nymphal (bands) and adult (swarms) stages of *Rhammatocerus schistocercoides*. Classical measurements of morphological characteristics were carried out on adult collected from populations of different densities and localities in the Chapada dos Parecis, State of Mato Grosso, Brazil, during 1992-94 and in the llanos region in Colombia during 1996. A very high degree of morphological and chromatic homogeneity was observed in all populations. Results showed that *R. schistocercoides* did not display the phase phenomenon in spite of its conspicuous gregarious behaviour.

Khalid and Yousuf (1999) presented paper on a taxonomic study of the subfamily Oedipodinae which resulted in the identification of 11 species under 10 genera including the description of a new species, *Oedipoda neelumensis* . A key for the local genera was also provided.

Suhail *et al.* (2001) studied six acridid species in five genera in subfamily Cyrtacanthacridinae, viz., *Patanga succinata* (Johannson),

Schistocerca gregaria (Froskal), *Anacridium aegyptium aegyptium* (Linnaeus), *A. aegyptium rubrispinum* Bei-Beinko, *Chondracris rosea* De Gree and *Cyrtacanthacris tatarica* (Linnaeus), recorded from various localities of Pakistan. The main objective of this study was to explore the grasshopper (locust) species belonging to the subfamily Cyrtacanthacridinae (Family: Acrididae, Order: Orthoptera) from Pakistan.

Suhail *et al.* (2002) six species of the subfamily Oxyinae in the genus *Oxya* (*O. fuscovittata, O. hyla hyla, O. velox, O. japonica japonica, O. nitidula* and *O. chinensis*) were collected from various localities of Pakistan during a survey conducted in 1998-2001. *Oxya chinensis* was reported for first time from Pakistan.

Stidham and Stidham (2002) reported that *S. camerata*, a species known previously only from Mexico and Nicaragua, was also recorded in United States for first time. The presence of this species in southern-most Texas is confirmed by 5 specimens in museum collections and many individuals identified in the field by the authors.

Morris (2002) examine the distribution of new species of short-horned grasshopper, *Sigaus* species A, was first proposed by C. Jamieson. The identification is based on material and data collected from Alexandra region. The taxon is related to, but a separate species from, *S. childi*. Included in description of the morphological characteristics of *Sigaus* species A that separate it from *S. childi*, and a key suitable for field use to distinguish the grasshoppers present in Central Otago and Mackenzie Country. Evidence of hybridization between *S. childi* and the *S. australis* complex are also presented.

Pokivailov (2003) studied the Orthopterous fauna of Southwestern Tajikistan comprising of 139 species and subspecies of 9 families, 19 subfamilies and 77 genera. Most of the genera and species belong to the three families Tettigoniidae, Gryllidae and Acrididae. The Acrididae comprised of 39 genera (49%) and 83 species and subspecies (59%). A characteristic feature of the fauna of Southwestern Tajikistan is its

heterogeneity. The Tajik plains with their specific fauna including *Thrinchinae, Dericorythini, Diexiini, Tropidophilini* deeply penetrate into the southern part of the republic, where numerous endemics of the Hissaro-Darvaz mountains, e.g. *Tadzhikia, Clinomastax, Conophyma* and *Mizonocara.*

Smith *et al.* (2004) prepared dichotomous key to present and to help in identification of the adult stage of 71 grasshopper species known to occur in Florida, USA. Based on recent research, one subspecies, *Schistocerca alutacea rubiginosa,* has been elevated to species status *Schistocerca rubiginosa* in this key.

Song, H. J (2004) in North American Alutacea Group of genus *Schistocerca* revised based on phylogenetic analysis and morphological comparison. Phylogenetic analysis suggests that *Schistocerca alutacea sensu* Dirsh is paraphyletic because *S. alutacea albolineata sensu* Dirsh is sister to *S. obscura.* Here, he recognizes the monophyletic Alutacea Group consisting of six species: *S. alutacea, S. rubiginosa, S. lineata, S. shoshone, S. albolineata,* and *S. obscura.*

Ambrose (2004) place Orthopteran in family Acrididae on basis of characters like shorter antennae and ovipositor, wings usually well developed in adult and brightly coloured, pronotum not extended posterior over abdomen and are phytophagous.

Tembhare (2005) reported characters of family Acrididae as stridulatory organs on hind femora tegmen type. Auditory organ present on either side of first abdominal segment. Ovipositor short curved at tip.

Ragumoorthi *et al.* (2006) reported that character for family Acrididae as antenna short, tarsus three segmented, ovipositor short and horny. Tympanal organ located on first abdominal segment. Sound produced by femoro-alary mechanism, row of peg like projection found on innerside of each hind femur.

Castner (2008) reported that characters for family Acrididae are size variable (20-200mm), pronotum does not extend beyond the base of

wings, all tarsi three segmented, tympanal (when present) located on first abdominal segment. Hind femora usually greatly enlarged.

2.3.3.2 Family Pyrgomorphidae

Kirby (1914) studied the character for family Pyrgomorphidae as antennae like blue-black or greenish with yellow markings beyond basal third of their length and wings brick-red, abdomen yellow with transverse blue-black bands. Head and pronotum with slight median carina.

Kevan (1959) reported that *Chrotogonus trachypterus* occurs on the crop like cabbage, cauliflower, chickpea, jute, mustard in Indian states like Rajasthan, Gujarat, Delhi, Uttar Pradesh, Bihar, West Bengal, Assam, Maharashtra, Madhya Pradesh, Orissa and Andhra Pradesh.

Kevan and Akbar (1964) gave a historical account of how this group came to be known as Pyrgomorphidae and established 29 tribes and 17 subtribes comprising 127 genera, six subgenera and more than 400 species of these 35 genera and two subgenera were recorded from Southern Asia. They recorded the tribes Atractomorphini, Chlorizenini, Chrotogonini, Orthacridini, Poekilocerini, Pyrgomorphini, Tagastini, and Taphronotini occur in the Indian subcontinent.

Kevan (1966) transferred the genus *Meubelia* from Acrididae to the Pyrgomorphidae, the known species and their synonymy were discussed, and the types and genital structures figured. All material then known was listed. Almost simultaneously with the publication of the paper referred to, however, additional material came to light, which considerably increased our knowledge of the genus. Among the specimens involved were no fewer than four new species, all closely related to the type species, *M. gracilis* Willemse, but coming from different parts of the Philippines. Examples of two of these new species had been overlooked among the scanty material previously examined (Kevan, *op. cit.),* in one case because no adult was then known, and in the other, because of the great similarity to *M. gracilis.*

Hsiung and Kevan (1975) gave the distribution and differentiating characters of *Pyrgomorpha bispinosa bispinosa* (Walker).

Popov (1997) revised taxonomic status of species of families Pamphagidae and Pyrgomorphidae which occur in Saudi Arabia and the island of Socotra. Keys, redescriptions, illustrations, distribution maps and notes on biology and ecology are included.

Mirzayans (1998) published list of 46 species of Pamphagidae and 5 species of Pyrgomorphidae from Iran.

Ajaili and Usmani (2003) studied two genera of the family Pyrgomorphidae. Keys to subfamilies, genera and species belonging to this family in Fezzan region of Libya are provided based on conventional as well as genitalic characters. The significance of genitalic structures in the classification is also shown. Developed or indistinct condition of fastigial areolae; presence or absence of external apical spine of hind tibia; elongate or quadrate condition of mesosternal lobes; wide or narrow, long or short condition of lateral plates of epiphallus; presence, absence or indistinct condition of Jannone's organs on female subgenital plate; and elongate or short condition of apical diverticulum of spermatheca are used for separating subfamilies. Sulcated or flattened condition of frontal ridge; filiform or ensiform condition of antennae; distinct or indistinct condition of fastigial foveolae; ratio of length of metazona and prozona of pronotum; presence or absence of median or lateral carinae, number of transverse sulci crossing dorsum of pronotum; length of inner hind tibial spurs in relation to external spurs and basal-tarsal segment; broad or narrow condition of bridge of epiphallus; shape of posterior margin of female subgenital plate; toothed, tuberculate or smooth condition of ovipositor valves; and length of lateral apodeme in relation to the dorsal valves are suggested as useful generic characters. The specific characters body colour, sculpture, presence or absence and number of tubercles on pronotum, shape of egg-guide of female subgenital plate, shape of ovipositor valves and their apical tips, shape of male supra-anal plate and cerci, size of anterior and posterior lobes of lophi, and shape of apical valves of aedeagus are used.

2.3.3.3 Family Tetrigidae

Wagan and Kevan (1992) studied Tetrigidae from Indian region, lodged in the Lyman Entomological Museum of McGill University in Quebec. Two new species and 3 hitherto unknown morphs were described.

Ichikawa (1994) four new species and 2 new subspecies of Tetrigidae from the Ryukyu Islands (i.e., south of the Tokara group) are described belonging to the subfamilies Cladonotinae, Metrodorinae, Scelimeninae and Tetriginae. Redescriptions and some remarks are given for several known species. Keys to the genera and the species are given.

Ichikawa (1997) worked on subfamily Tetriginae. He worked out the keys to genera and species. A new species and a new subspecies were also described. Two doubtful records are also indicated.

Majeed *et al.* (2002) collected six species belonging to 5 genera (*Ergatettix, Euparatettix, Formosatettix, Hedotettix* and *Paratettix*) under the subfamily Tetriginae from various localities of Thal Area of the Punjab, Pakistan. These were *Hedotettix gracilis* (collected from grasses near the sugarcane fields and along the river bank), *H. attenuatus* (collected from grasses near sugarcane, sorghum and rice crops), *Formosatettix larvatus* (collected from grasses near stagnant water), *Paratettix nigrescens* (collected from grasses near rice, sorghum and sugarcane crops), *Euparatettix variabils* (collected from grasses near sugarcane, sorghum and rice crops as well as river and canal banks) and *E. crassipes* (collected near sugarcane fields). The genus *Formosatettix* (*F. larvatus*) is a new record from Pakistan, while *Hedotettix attenuatum* is a new record from Punjab.

Podgornaya (2003) examined structure of the male genitalia in the subfamily Tetriginae. Based on the external morphological characters and structure of male genitalia, the subfamily Cassitettinae was downgraded to the tribe Cassitettini of the subfamily Batrachideinae.

Kim and Kim (2004) revised the taxonomic study of Korean Tetrigidae (Orthoptera: Caelifera: Tetrigoidea). Twelve species were

recognized including two species (*Tetrix silvicultrix* Ichikawa and *T. minor* Ichikawa) recorded for the first time in Korea. Keys and photographs of habitus for species are provided.

2.3.4 Super-family Tridactyloidea

2.3.4.1 Family Cylindrachetidae

Gunther (1914) revised the family Cylindrachetidae Giglio-Tos. Supplementary redescriptions was given to all hitherto known two genera (*Cylindracheta* Kirby, 1906 and *Cylindroryctes* Tindale, 1928) and six species. The genus *Cylindraustralia* gen. n. and ten species of this taxon (*C. acuta* sp. n., *C. centricola* sp. n., *C. cookensis* sp. n., *C. divisa* sp. n., *C. granulata* sp. n., *C. karumbensis* sp. n., *C. parakochia* sp. n., *C. parvitarsata* sp. n., *C. setosa* sp. n., *C. tindalei* sp. n.) were described as new to science. A lectotype of Cylindroryctesspegazzinii (Giglio-Tos, 1914) was designated. Now 3 genera and 16 species belong to this family.

Chapter III

MATERIAL AND METHODS

The present study was aimed on "Taxonomic Study of Orthopteran found in Akola vicinity". The investigation was under taken in Entomology section, College of Agriculture under Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during July 2009 to Jan 2010. For this study the material required and methodologies followed for conducting the experiment are detailed below.

3.1 Material Required

3.1.1 Materials

The material required for collecting the Othopterans are, Insect collecting net, Light trap, Specimens tubes of various size, Setting board, Insect killing bottle, Forceps and hand lens, Separators and extractors, Insect storage box, Entomological pins, Insect killing and preserving media, Drying chamber, Small hair brush etc.

3.2 Method of insect collection

3.2.1 Insect collecting net

Collecting nets made up of wooden handle of convenient length, having circular iron ring attached at one end to which a collecting bag made up of ordinary mosquito netting cloth was attached. Such type of insect collecting net was used to collect the grasshopper by sweeping the nets.

Sweeping net are heavier having short handle, a large hoop and a muslin cloth bag. They are suitable for collecting leafhoppers, grasshoppers and other small insects. The net was swept over vegetation. The handle was turned by quick turn of the wrist to fold the cloth bag over the hoop in order to prevent the escape of trapped insects.

3.2.2 Hand picking

This method was also adopted for collecting grasshoppers, it is a tedious method. The grasshopper were collected by hand and put in the killing bottles, the immature stages were kept in rearing cages where they were reared and allowed to complete their development.

3.2.3 Light trap

Many types of insects are attracted to light and can be captured there by hand. The nocturnal Orthoptera were collected by means of light trap. Mostly the Gryllidae were found dominant in light trap collection.

3.2.4 Small boxes

These containers were used for storing specimens after their removal from killing bottles. They were made of cardboard, plastic or metal and partly filled with soft tissue or cloth to keep specimens and to avoid rolling. Cotton was not used because specimens get entangled in the fibers and it was impossible to extricate then without damage.

3.3 Killing of collected insects

Killing was done immediately after capture. Potassium cyanide, ethyl acetate, carbon tetra chloride and chloroform were commonly used for killing insects.

3.3.1 Preparation of killing bottles

Killing bottle was prepared in well ventilated room. For which wide mouth bottle, having 500 gm capacity with a tight iron screw cap were selected. Two spoons of potassium cyanide/ sodium cyanide was placed in the bottom of the bottle and covered with a layer of plaster of paris up to the height of 2-3 cm. Plaster of Paris was allowed to harden. A circular blotting paper was placed over the plaster of paris and the bottle was use for killing insect after couple of day.

For killing of insect immediately the following liquid killing agent were also used

1) Ethyl acetate 2) Chloroform

3) Ethyl alcohol 4) Ammonia water

5) Ether

3.4 Preservation

3.4.1 Materials required

Grasshoppers normally are preserved by killing, pinning, and drying. The materials required for preservation are paper folds, setting board, relaxing container, entomological pins, needle, butter paper, naphthalene balls, oven dry chamber, preservation chemicals, and fumigation media.

a. Paper folds (Paper envelopes)

They were used for temporary preservation and storage of large winged insects. These triangular envelopes were made from a sheet of note book or by using absorbent type of paper. Papers were cut into rectangles with their sides in the proportion of 3:5. The information regarding collection was written outer side of projecting flap.

b. Setting board (Spreading board)

It was useful for spreading the wings of dead insects. The setting board was made up of wooden board with central groove in which flat cork strips were glued on either side of the groove and bottom of groove to enable pinning. Thermocol sheets with centrally cut groove were also used as substitute for the setting board.

c. Relaxing container

Setting or mounting of insect was done within day after killing to avoid insect becoming stiff and brittle. Stiffness in dead insect was removed by placing them in relaxing container. High humidity inside the relaxing

container permits water reintroduction into specimens thus making them flexible. The relaxing container contains saturated sand with $1/4^{th}$ of its container. Few drops of carbolic acid or formaldehyde used to prevent mold growth.

The dried specimens were kept in small open box or in uncovered petri dish to avoid direct contact of specimen with moist sand. The lid is tightly closed and the specimens were allowed to remain for one or two days until they become flexible.

d. Pins

Common pins were undesirable for pinning insects. They were usually too thick and short. They usually rust or most commonly green substance called verdigris forms the pin comes into contact of insect body. The specialized entomological pins which were slender, hard with pointed tip and small head made from pure nickel or nickel plated which were rust free were used. Commonly No. 16 and No. 20 pins were used for pinning larger and smaller insects, respectively.

e. Butter paper

They were used for stretching the insect wings during pinning and stretching the insect also they were used for preserving the killed insect in the field during collection.

f. Fumigation media

Fumigation media was made from the Petrol, Carbolic acid and Naphthalene balls in the proportion of 1 l, 2.5 g and 125 g respectively.

3.4.2 Methods of preservation

3.4.2.1 Pinning

The correct pinning of grasshopper was essential for easy identification for their taxonomic characters. The dead specimens were pinned as suggested by Richards and Davies (1997) to the side of the rear part of

pronotum passing through the right side and near the rear edge. Leaving one-half inch of the pin above the specimen for safe handling of the specimen. Such pinned insects were dried. They remain as such on the pins without requiring any further treatment. During drying the outer exoskeleton remains intact while the inner soft tissues dry up. Insects were killed and pinned directly if they were fully developed. Pinning was done in such a way that all important diagnostic characters can be viewed clearly. Pinning was vertically through body. Depending upon the size of the insect, the entomological pins were selected. During pinning the Orthopterans were held between the thumb and forefinger in one hand and the pin is inserted into the insect with the help of other hand.

3.4.2.2 Dry preservation

The collected specimen after pinning and stretching were dried by keeping in insect drying chamber. The drying of insect specimen was under taken to study the body characters and other morphological and taxonomical characters.

3.4.2.3 Setting

Setting of insects was essential to study the wing characters. It also affords a better look to the preserved specimens. In grasshoppers, wings were stretched at least from one side to see the color and venation of the wings for easy identification. Setting boards and thermocol sheets were used for setting insects. The wings, antennae, and legs cannot be moved without breaking once the insect become hard. So they are kept in relaxing fluid for overnight and next day they were aligned. It is important to get the body parts aligned before drying. Setting work was completed before the insects become stiff and hard.

3.5 Labeling

Collections were of little value unless each insect was properly and accurately labeled. Labeling was done as soon as insect were dried to

Rearing of nymphal instar

Killing of insect

Pinning of insect

Streching of insect

Labelling of insect

Storage of insect pinned for study

Plate No 1. Collection, rearing, killing, pinning, labelling, and storage of insect for study

avoid the loss of vital information. Labels were printed or hand written with micro tipped pen containing information like.

Host:	Order:
Date of collection:	Sub-order:
Collected by :	Super-family:
	Family:

College of Agriculture, Akola collection

They were inserted beneath the insects at 1/3rd height from the base. The long axis of the label was coincide with the long axis of the insect.

3.5.1 Insect store boxes

Commonly wooden boxes of dimension 45 x 30 x 15 cm were used as insect store boxes for displaying preserved insects. The box were light in weight, air tight and moisture proof with a well fitting hinged lid. A cell was provided inside to keep repellents. Cork sheets were glued to the inside of the top and bottom of the box to permit pinning. Storing of specimen was made according to taxonomic grouping (i.e. Order, sub-order, super-family and families).

3.5.2 Repellents and preservatives:

Preserved specimens were commonly attacked by dermedstid beetles, red flour beetle and psocids. Naphthalene balls mounted on pins were pinned inside to repel museum insects. The head of pin was heated on flame and pressed against naphthalene ball. The pin melted the ball at the point of contact. The pin head entered the ball and the melted naphthalene solidified around the pin head. Such naphthalene balls with pin were placed in insect collection box to keep boxes free from museum insects.

3.6 Placing the insect in order Orthoptera

The insect showing hind femora almost always much larger than fore femora and adapted for jumping if not the fore legs adopted for burrowing, body more or less cylindrical, the wings held slopping against the sides of the body when at rest, tergites usually longer than sternites. (Grasshopper, locust, crickets, katydids).

All the insects showing above characters as described by Ambrose (2004), Tembhare (2005).

3.6.1 Key to orders

1. Wings vestigial or rudimentary or absent 2
   Wings well developed 27
2. Body more or less distinctly segmented into head, thorax and abdomen; segmented legs, capable of locomotion 3
   Body not distinctly segmented; legs not segmented, incapable of locomotion ..... Homoptera
3. Free living insects 4
   Parasitic on warm blooded animals 22
4. Mouth parts vestigial, retracted within the head; underside of the abdomen with styles or other appendages 5
   Mouth parts not vestigial and not retracted within the head 9
5. Abdomen ten or twelve segmented, without ventral sucker and springing apparatus 6
   Abdomen six or less segmented, with forked sucker at base below and usually with a springing apparatus near tip (Springtail) ..... Collembola
6. Antennae absent; head pear–shaped; prothorax short ; basal three segments of abdomen with styles (Proturans) ..... Protura
   Antennae thread like; prothorax not short; ventral styles occurring up to the seventh segment of abdomen 7
7. Body never scaly; mouth parts concealed within the head except for the palpi; abdomen not terminating as median process (two pronged Bristletails) ..... Diplura
   Body usually covered by scales; mouth parts not concealed within the head; abdomen terminating as cerci form appendage 8
8. Compound eyes larger, usually contiguous, ocelli present; body somewhat cylindrical with thorax arched; middle and hind coxae nearly always with styli; abdominal styli on segments 2 to 9 (Jumping bristletails) ..... Archeognatha

Compound eyes small and widely separated or absent, ocelli present or absent; body somewhat flattened dorsolaterally, thorax not arched; middle and hind coxae without styli; abdominal segments 1 to 6 usually without styli (Bristletails, Silverfish, Firebrats)..... Thysanura

9. Abdomen terminating in strong, movable forceps; prothorax free (Earwigs)..... Dermaptera
   Abdomen not ending in forceps; prothorax not free..... 10
10. Abdomen strongly constricted at base; prothorax fused with mesothorax (Ants and wing less wasps)..... Hymenoptera
    Abdomen not strongly constricted at base, broadly attached to the thorax 11
11. Head produce into a mandibulate beak (Scorpionflies)..... Mecoptera
    Head not produced into a mandibulate beak 12
12. Very small jumping species; prothorax inconspicuous; louse-like in appearance (Booklice)..... Psocoptera
    Larger species; prothorax larger 13
13. Hind femora enlarged; hind legs adopted for jumping; wing-pads of larvae, when present, in inverted position, the metathoracic overlapping the mesothoracic wing-pads (Grasshoppers)..... Orthoptera
    Hind legs not adapted for jumping; wing-pads, when present, in normal position 14
14. Prothorax must longer than mesothorax; fore legs raptorial (Mantids)..... Mantodea
    Prothorax normal, fore legs not raptional 15
15. Cerci present; antennae usually with more than fifteen segments 16
    Cerci absent; antennae usually with eleven segments (Beetles) ..... Coleoptera
16. Cerci with more than three segments 17
    Cerci one to three segmented 19
17. Body flattened and oval; head concealed under the oval prothorax (Cockroaches)..... Blattaria
    Body elongate; horizontal head not concealed under prothorax 18

18. Cerci long; ovipositor sclerotized, exserted; tarsi five segmented (Rock crawlers)..... Gryllobilattodea
Cerci short; no ovipositor; tarsi four segmented (Termites)..... Isoptera
19. Tarsomeres not exceeding five; body slender and stick like (Walking sticks)..... Phasmida
Tarsomeres two to four; body not linear 20
20. Foremetatarsus swollen (Webspinners)..... Embiidina
Foremetatarsus not swollen 21
21. Tarsomeres apparently four- segmented; cerci multi-articulate; antennae nine to thirty- segmented (Termites)..... Isoptera
Tarsomeres two- segmented; cerci uniarticulate; antennae nine-segmented (Zorapterans)..... Zoraptera
22. Body depressed..... 23
Body compressed (Fleas)..... Siphonaptera
23. Mouthparts mandibulate..... 24
Mouthparts haustellate (Wingless flies)..... Diptera
24. Mouthparts inferior; cerci long (Earwigs)..... Dermaptera
Mouthparts anterior or inferior; cerci short or absent..... 25
25. Rostrum segmented; tarsi not hooked; temporary parasites (Bed bugs, bat bugs)..... Heteroptera
Rostrum unsegmented; tarsi hooked for grasping hairs of host; permanent ectoparasites of mammals..... 26
26. Head broader than thorax; chewing mouthparts; antennae usually capitate or filiform, concealed beneath head; tarsi one or two segmented (Chewing lice)..... Mallophaga
Head narrower than thorax; piercing and sucking mouthparts, retracted into head when not feeding; antennae not as mentioned above; tarsi one segmented (Sucking lice)..... Anoplura
27. Forewings horny, leathery or parchment-like at least at base, hind wings, if present usually membranous..... 28
Forewings membranous..... 37
28. Forewings modified as tegmina or hemelytra, containing veins..... 29

Forewings modified as veinless, horny elytra, hind wings if present folded crosswise and lengthwise and hidden under the elytra.....36

29. Piercing and sucking mouthparts forming a segmented rostrum.....30
    Biting and chewing mouthparts with well developed mandibles.....31
30. Head usually horizontal with the rostrum arising from below and projecting downwards, the gula well developed; forewings usually overlapping one another and lying flat over the abdomen when at rest (True bugs).....Heteroptera
    Head usually vertical with the rostrum arising from the back and projecting backwards between the forelegs, gula absent or represented by a membrane; forewings not different from hind wings (Cicadas, some hoppers, aphids, some psyllids and whiteflies).....Homoptera
31. Social insects; hind wings not folded, similar to forewings; living in colonies (Termites).....Isoptera
    Not social insects, hind wings folding fan-like, broader than forewings.....32
32. Antennae long with many filament-like segments; prothorax large and free from mesothorax; forewings usually long, rarely minute; cerci present.....33
    Antennae short with few segments, as least one segment bearing a long thread-like arista; forewings minute; cerci absent; minute species parasitic in wasps and bees (twisted-wing parasites).....Strepsiptera
33. Hind femora not larger than forefemora; body more or less flattened; the wings superposed when at rest; tergites and sternites usually equal in size.....34
    Hind femora almost always much larger than forefemora and adapted for jumping, if not the forelegs adapted for burrowing; body more or less cylindrical; the wings held slopping against the sides of the body when at rest; tergites usually larger than sternites (Grasshoppers, locusts, crickets, katydids).....Orthoptera
34. Body elongate; head not concealed from above by the prothorax.....35

Body oval, much flattened; head usually concealed from above by the prothorax (Cockroaches)..... Blattaria

35. Prothorax much longer than mesothorax; forelegs usually heavily spined beneath and adapted for capturing and holding the prey; cerci usually with several segments (Praying mantids).....Mantodea
Prothorax short; forelegs not raptorial; cerci uniarticulate (Stick and leaf insects)..... Phasmida

36. Abdomen terminating in movable, heavily sclerotized forceps; antennae long and slender; forewings short, not covering the entire abdomen; hind wings nearly circular, delicate, radially folded from near the centre (Earwigs)..... Dermaptera
Abdomen not terminating in forceps; antennae variable; forewings usually completely covering the abdomen (Beetles)..... Coleoptera

37. Two pairs of wings present.....38
Only one pair of wings present.....55

38. Minute insects; wings long, narrow, fringed with long hairs, almost veinless; tarsi uniarticulate or biarticulate with swollen tips; mouthparts asymmetrical without biting mandibles, adapted for rasping and sucking plant tissues; no cerci (Thrips) .....Thysanoptera
Wings broader and often veined, rarely linear; the tarsi have more than two segments and the last tarsal segments is not swollen.....39

39. Hind wings with the anal area folded in fan-like plaits when at repose, larger than the forewings.....40
Hind wings not folded, not larger than the forewings, the anal area small and not separated.....42

40. Tarsi five-segmented; cerci inconspicuous.....41
Tarsi three-segmented; cerci segmented (Stoneflies).....Plecoptera

41. Costal area with few cross-veins; prothorax small; wing surface hairy (Caddisflies)..... Trichoptera
Costal area with many cross-veins; prothorax large; wing surface not hairy (Dobsonflies, fishflies, alderflies)..... Neuroptera

42. Antennae short, inconspicuous; wings net-veined with numerous cross-veins; larvae aquatic.....43

Antennae larger, distinct; if rarely small, cross-veins few; larvae almost always terrestrial.....44

43. Short lived sluggish fliers; hind wings much smaller than forewings; tarsi usually four or five segmented; abdomen ending in long thread-like caudal filament and cerci (Mayflies).....Ephemeroptera

Long lived active fliers hind wings resemble forewings; tarsi three segmented; no caudal filament (Dragonflies and damselflies).....Odonata

44. Head produced into a mandibulate beak; male genitalia usually greatly swollen and forming a reflexed bulb (Scorpionflies).....Mecoptera

Head not produced into a mandibulate beak; male genitalia not swollen.....45

45. Mouthparts mandibulate.....46

Mouthparts haustellate.....53

46. Tarsi five-segmented; rarely three or four-segmented; hind wings smaller than forewings.....47

Tarsi two, three or four-segmented; veins and cross-veins not numerous.....50

47. Prothorax small or moderately longer than head; if long, the forelegs are raptorial.....48

Prothorax long, cylindrical, much longer than head; forelegs normal (Snakeflies).....Neuroptera

48. Prothorax more or less free; wings similar, richly veined and cross-veined if with reduced venation, wings covered with a powdery bloom.....49

Prothorax fused with mesothorax; hind wings smaller than forewings, costal cells without cross veins (Ants, bees, wasps, sawflies, horntails).....Hymenoptera

49. Costal cell at least in forewing with many cross-veins (Lacewings).....Neuroptera

Costal cell without cross-veins (Scorpionflies).....Mecoptera

50. Wings equal, rarely the hind wing larger, held superimposed on top of abdomen when at rest, M fused with Rs for a short distance near the middle of wing; tarsi three, four or five-segmented.....51
Hind wings smaller than forewings, wings at rest folded back against the abdomen, R and M not fused; tarsi two or three segmented.....52

51. Usually solitary species; tarsi three-segmented, foremetatarsus swollen; cerci conspicuous (Webspinners).....Embiidina
Social insects; tarsi apparently with four segments, foremetatarsus not swollen; cerci usually minute (Termites).....Isoptera

52. Tarsi two or three-segmented; Rs and M branched; cerci absent (Booklice, barklice).....Psocoptera
Tarsi two-segmented; venation greatly reduced, Rs and M simple, wings shed at maturity; cerci present (Zorapterans).....Zoraptera

53. Antennae with few segments; mouthparts forming a segmented rostrum; wings not covered with scales, not outspread when at rest; prothorax large.....54
Antennae many segmented; mouthparts when present forming a long coiled proboscis; wings and body covered with scales forming definite coloured patterns (Butterflies, moths, skippers).....Lepidoptera

54. Rostrum arising from the back of head (Aphids, hoppers, others).....Homoptera
Rostrum arising from the front of head (True bugs).....Heteroptera

55. Mouth non-functional; abdomen with a pair of caudal filaments.....50
Mouthparts forming a proboscis, rarely vestigial; abdomen without caudal filaments (Flies).....Diptera

56. Hind wings not reduced to halters; antennae inconspicuous; cross-veins abundant (Mayflies).....Ephemeroptera
Hind wings reduced to hook-like halters, venation reduced to aforked vein, cross-veins absent (minute delicate males of scale insects).....Homoptera

Were grouped under order Orthoptera and were taken for further study.

Order is further divided into two suborders, Caelifera and Ensifera. The Caelifera were comprised of two super-families, Acridoidea (with five families) and Tridactyloidea (with two families) likewise the Ensifera were comprised of two super-families, Tettigonoidea (with six families) and the Grylloidea (with two families). The fifteen families, so recognized were separated by following key.

3.6.2 Placing the insect in Sub – Orders

Order orthoptera insect grouped under was further grouped in two sub orders Caelifera and Ensifera. On the basis of characters shown by the specimen as detail below

Caelifera

- Antenna is shorter than the body, less than 30 segments.
- Tympanum is found on the lateral side of the first abdominal segment.
- Stridulatory organs are femoroalary type.
- Ovipositor is short, robust, inner valves reduced.
- Vision and hearing acute.
- Mandibles are specialized for consuming monocot foliage.
- Rely on jumping to escape from predators.
- Diurnal in habitat.
- Eggs are laid in groups in soil inside shallow burrows.

Ensifera

- Antenna as long as body with more than 30 segments.
- Tympanum is found on the foretibia.
- Stridulatory organs are tegmino / alary type.
- Ovipositor is sward like, usually more or less elongate.
- Tactile response is well developed.

- Mandibles are specialized for consuming dicot plants.
- Rely on crypsis.
- Nocturnal in habitat.
- Eggs are singly inserted into plant tissue or soil.

Above characters described by Tembhare (2005), Ragumoorthi *et al.* (2006).

3.6.3 Placing the insect in Super families and families

The sub order Ensifera is further group into three super families. The key used for grouping the collected insect in super families and family are as follows,

1. Antennae about as long or longer than body, many-segmented (except in gryllotalpidae); tympanal organs, when present, on fore tibiae (suborder: Ensifera)..... 2
   Antennae shorter, with less than thirty segments; tympanal organs, when present; at base of abdomen (suborder: Caelifera).....9
2. Tarsi 4-segmented, at least on middle and hind legs (super-family: Tettigonoidea).....3
   Tarsi 3-segmented (super-family: Grylloidea).....8
3. 2nd and 3rd tarsal segments with large, mobile lateral lobes; wings when present, coiled spirally in repose.....Schizodactylidae
   Tarsi and wings otherwise.....4
4. Body elongate, apterous, rod-like hind femora not thickened.....Phasmodidae
   Body more thickset; hind femora enlarged.....5
5. Tarsi depressed.....6
   Tarsi compressed or cylindrical.....7
6. Forewings without stridulatory apparatus; fore tibiae without tympanal organs; middle and fore tibiae armed beneath with mobile spines.....Gryllacrididae
   Forewings of males usually with stridulatory apparatus; fore tibiae almost always with tympanal organs; tibiae without mobile spines beneath.....Tettigonoidae

7. Forewings of male without stridulatory apparatus or apterous; tibial tympanal organs usually absent.....Stenopelmatidae
   Forewings of male with stridulatory apparatus; tibial tympanal organs present.....Prophalangopsidae
8. Forelegs strongly fossorial, with tibiae expanded and digitate; ovipositor vestigial.....Gryllotalpidae
   Forelegs not markedly fossorial, tibiae simple; ovipositor elongate.....Gryllidae
9. Tarsi almost always 3-segmented, antennae usually longer (superfamily: Acridoidea).....10
   Hind tarsi 1 or 2-segmented; antennae short, with twelve or fewer segments (superfamily: Tridactyloidea).....14
10. Pronotum extended backwards to cover abdomen; empodium absent, antennae longer than fore femur.....Tetrigidae
    Pronotum normal or if rarely extended behind. Then empodium present or antennae shorter than fore femora.....11
11. Body elongate and rod-like, usually apterous, with long thin legs.....Proscopidae
    Not thus.....12
12. Hind legs not markedly different from two anterior pairs, femora not greatly enlarged; male with inflated abdomen and stridulatory ridges on 2nd abdominal targite.....Pneumoridae
    Hind legs markedly saltatorial with enlarged femora.....13
13. Prosternum unarmed; antennae shorter than fore femora; pronotum not compressed, usually flattened dorsally.....Eumastacidae
    Without this combination of characters.....Acrididae
14. Elongate, cylindrical, apterous forms; forelegs fossorial, hind tibiae not enlarged.....Cylindrochaetidae
    Small forms of more normal facies; forelegs normal, hind legs saltatorial with enlarged femora.....Tridactylidae

All the insects showing above characters as described by Prasad (1986), Ambrose (2004) and Tembhare (2005).

Chapter IV

RESULTS AND DISCUSSION

The present work on "Taxonomic study of Orthopterans found in Akola vicinity" was carried out during 2009-10 in Laboratory of Entomology section, College of Agriculture Akola and Head Department of Entomology, Post Graduate Institute Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Group of collected specimens were placed under Order, Sub-order, Super-family and Family of order Orthoptera on the basis of fixed identifying characters to place them in hierarchy are presented below, under respective headings and sub-headings and discussed with available literature.

4.1 Identification for order Orthoptera

During the present study three thousand specimens were collected and out of which 260 specimens showing the characters of order Orthoptera as detailed below were considered for study indicating that approximately Orthopteran contributes 8.6 per cent population in Akola vicinity.

The characters exhibited by the collected insects were such as medium to large size, with antenna thread-like filiform with 30 or more segmented, head position hypognathous type, prothorax large, hind leg having enlarged femora and modified for jumping or saltatorial, mouth parts chewing type with forewing leathery, thickened and known as tegmina, which are capable of bending without breaking. Hind wing membranous fan type with large anal area. Abdomen eleven segmented with cerci. Ovipositor well developed in female. Specialized stridulatory (sound producing) and auditory (hearing) organs were observed on wings, legs and abdomen were placed in order Orthoptera and are presented in Plate No. 2 to Plate No. 31.

Different authors Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006) described characters to place insect in order Orthoptera. The collected insects exhibited mostly similar characters and

hence were placed under order Orthoptera by running the key given by Ambrose (2004) for placing insect order wise and detailed in materials and methods.

4.2 Identification for Sub-orders

4.2.1 Ensifera

The insect specimens showing characters like long antenna with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three or four segmented. Ovipositor sword like more or less elongated and collected mostly during night hours were grouped under sub-order Ensifera and presented in Plate No. 2 to Plate No. 13. Total 55 specimens out of 260 were grouped under this sub-order indicating that in order Orthoptera the share of Ensiferans in Akola vicinity is 21.15 per cent.

Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006) had reported the above characters for placing the insect in sub-order Ensifera. After running the key for sub-order as described by Ragumoorthi *et al.* (2006). The specimens collected from Akola vicinity exhibiting above character were placed under sub-order Ensifera and are displayed in Plate No. 2 to Plate No. 13.

4.2.2 Caelifera

The insect specimen showing characters like antenna shorter than body length with less than 30 segments. Tympanal organ present on first abdominal segment, tarsi three or less than three segment and ovipositor short, robust or absent were grouped under this sub-order. Total 205 specimens out of 260 were grouped under this sub-order indicating that in order Orthoptera the share of Caelifera sub-order in Akola vicinity is 78.85 per cent. The insect collected and grouped under this sub-order were collected during day time exhibiting that Orthopterans belonging to this sub-order are diurnal in habit.

Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006) had reported the above characters for placing insect in sub-order Caelifera. After running the key given by Ragumoorthi *et al.* (2006) the present specimens collected from Akola vicinity and displayed in Plate No. 14 to Plate No. 31 were grouped under sub-order Caelifera.

4.3 Super-families and Families under Ensifera

4.3.1 Grylloidea

The insect specimen showing character like antenna with more than 30 segments. Only in males, forewings or tegmina have stridulatory apparatus, tympanal organ on fore tibia, tarsi three segmented. Ovipositor needle-shaped were grouped under super-family Grylloidea and are presented in Plate No. 2 to Plate No. 8. Total 33 specimens out of 260 were grouped under this super family indicating that 12.69 per cent Orthopterans belonging to super-family Grylloidea in Akola region are prevailing.

Ambrose (2004), Tembhare (2005) had also reported the above characters for placing the insect in super-family Grylloidea. After running the key for super-family as described by Tembhare (2005). The specimen collected from Akola vicinity exhibiting similar character were placed under super-family Grylloidea and are displayed in Plate No. 2 to Plate No. 8.

4.3.1.1 Gryllotalpidae

The specimen showing character like brown coloured insects. Pronotum elongate, ovate and rounded posteriorly. Forelegs modified for digging. Tibia terminally flat and bear strong teeth, finger like claws, forewings short and hind wings folded over abdomen. No stridulatory organs present, ovipositor vestigial. Humming sound produced by rubbing the forewings were grouped under family Gryllotalpidae and presented in Plate No. 2. Total 14 specimens out of 260 were grouped under this family.

Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing the insect in

family Gryllotalpidae. After running key for family as described by Castner (2008). The specimen collected from Akola vicinity exhibiting similar characters were placed under family Gryllotalpidae and displayed in Plate No. 2 indicating that the share of family Gryllotalpidae is 5.38 per cent in the population of order Orthoptera in Akola vicinity.

4.3.1.2 Gryllidae

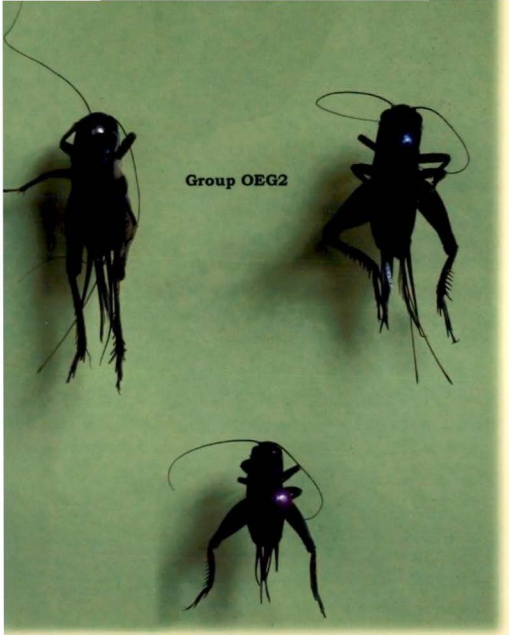
The insect specimen showing character like antenna long and elongate, tarsi three segmented, ovipositor slender and needle like with long and unsegmented cerci. Forewings abruptly bent down cover sides of body, males stridulate at night, produce shrill chirping noise were grouped under family Gryllidae and are presented in Plate No. 3 to Plate No. 8. Total 21 specimens out of 260 were grouped under this family.

Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing the insect in family Gryllidae. After running the key for super-family as described by Gen and Homathevi (2004). The present specimens collected from Akola vicinity are grouped under family Gryllidae and displayed in Plate No. 3 to Plate No. 8 indicating that the share of family Gryllidae in order Orthoptera is 8.07 per cent collected from Akola vicinity.

4.3.2 Tettigonioidea

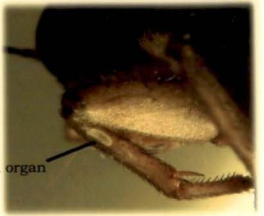
The insect specimen showing characters like antenna long, slender, longer than the body. Tarsi four segmented. Pair of tympanal organ on inner and outer side of fore tibia. Ovipositor well developed. Winged or wingless forms, stridulatory organ present were grouped under super-family Tettigonioidea and are presented in Plate No. 9 to Plate No. 13. Total 20 out of 260 were grouped under this super-family.

Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing the insect in super-family. After running the key for super-family as described by Castner (2008). The specimen collected from Akola vicinity exhibiting similar

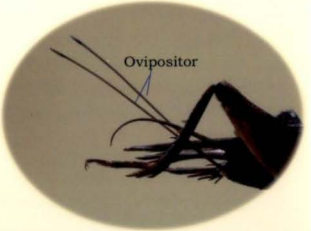


Long Antenna (Ensifera)

Three segmented tarsi
(Super-Family)



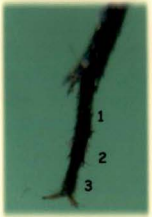
Tympanal organ on fore tibia
(Family)



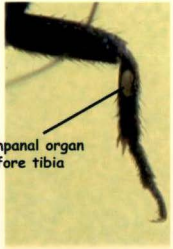
Needle like ovipositer between the two cerci
in female and in male ovipostor absent
(Family)

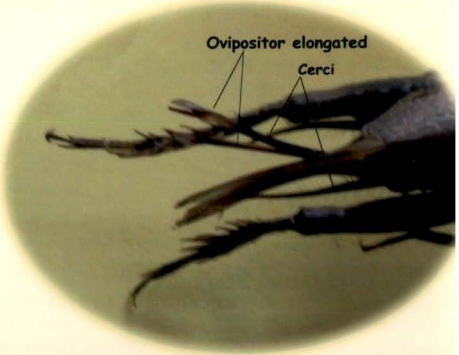
ate No. 3 OEG2 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera Super - family Grylloidea and Family Gryllidae

Antenna long and many segmented

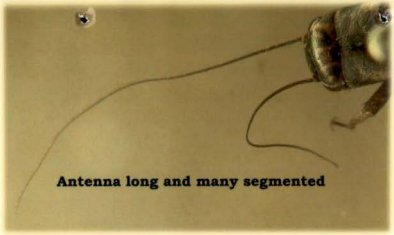


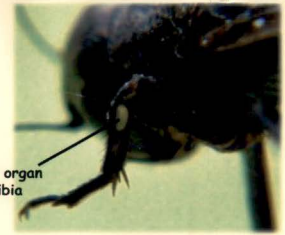
Tarsi three segmented

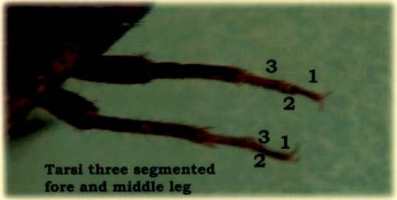




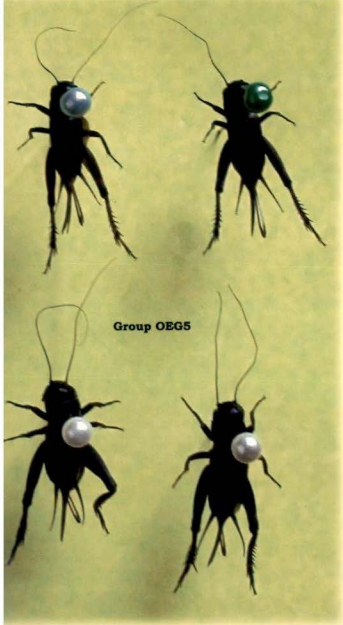
ate No. 4 OEG3 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera
Super - family Grylloidea and Family Gryllidae

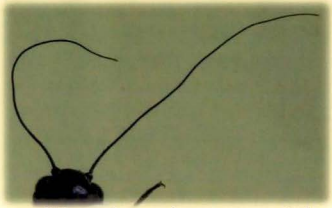




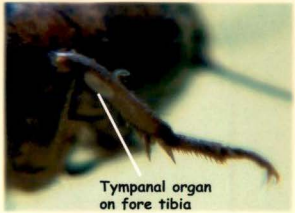


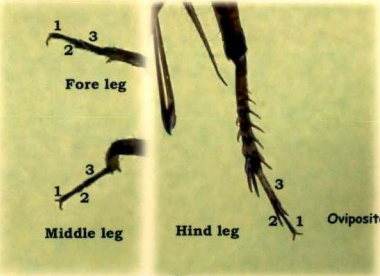
ate No. 5 OEG4 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Grylloidea and Family Gryllidae



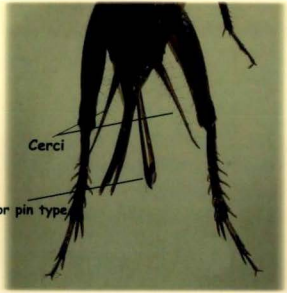


Antenna long and many segmented

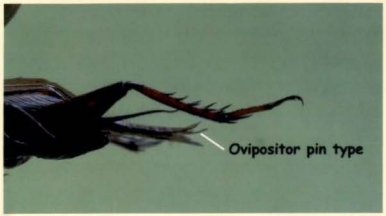


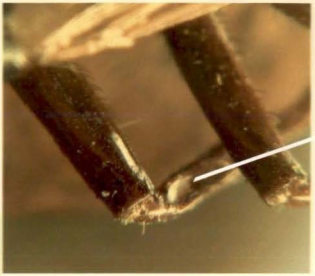


Tarsi 3 segmented

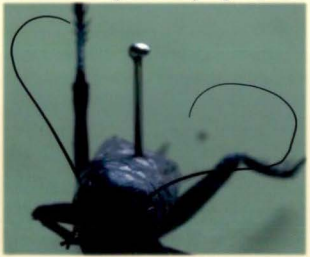


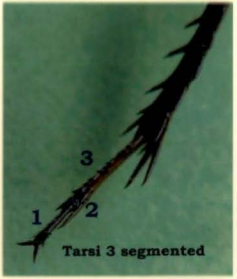
late No. 6 OEG5 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Grylloidea and Family Gryllidae



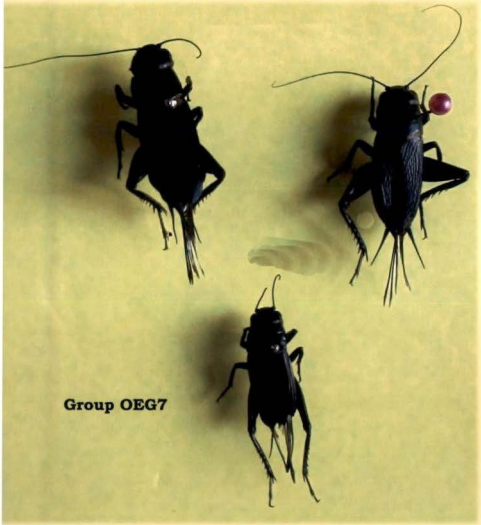


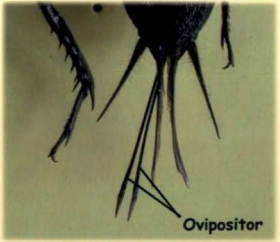
Antenna long and many segmented





ate No. 7 OEG6 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Grylloidea and Family Gryllidae





ate No. 8 OEG7 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Grylloidea and Family Gryllidae

characters were placed under super-family Tettigonioidea and are displayed in Plate No. 9 to Plate No. 13 indicating that the share of super-family Tettigonioidea in order Orthoptera in Akola vicinity is 7.69 per cent

4.3.2.1 Tettigoniidae

The insect specimen showing characters like antenna long, slender, longer than body. Tarsi four segmented, ovipositor sword like. Pair of tympanal organ present on inner and outer side of fore tibia. Forewings of males usually with stridulatory apparatus. Wings held vertically or roof-like over body were grouped under family Tettigoniidae and are presented in Plate No. 9 to Plate No. 13. Total 20 specimens out of 260 were grouped under this family.

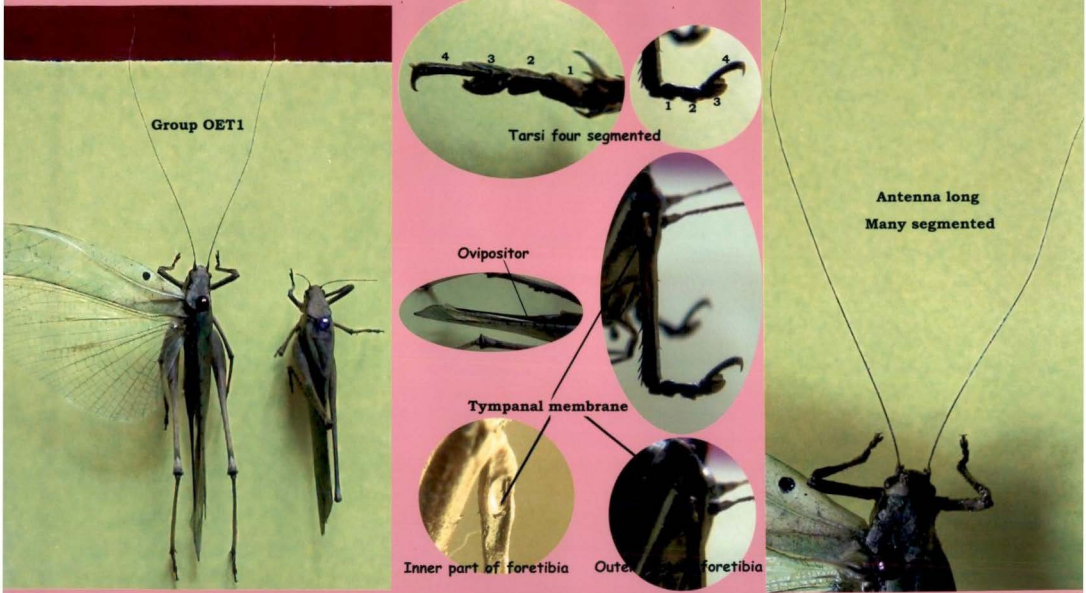
Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing the insect in family Tettigoniidae. After running the key for family as described by Castner (2008). The specimen collected from Akola vicinity exhibiting similar characters were placed under family Tettigoniidae and are displayed in Plate No. 9 to Plate No. 13 indicating that the share of family Tettigoniidae in Akola vicinity in order Orthoptera is 7.69 per cent.

4.4 Super-families and Families under Caelifera

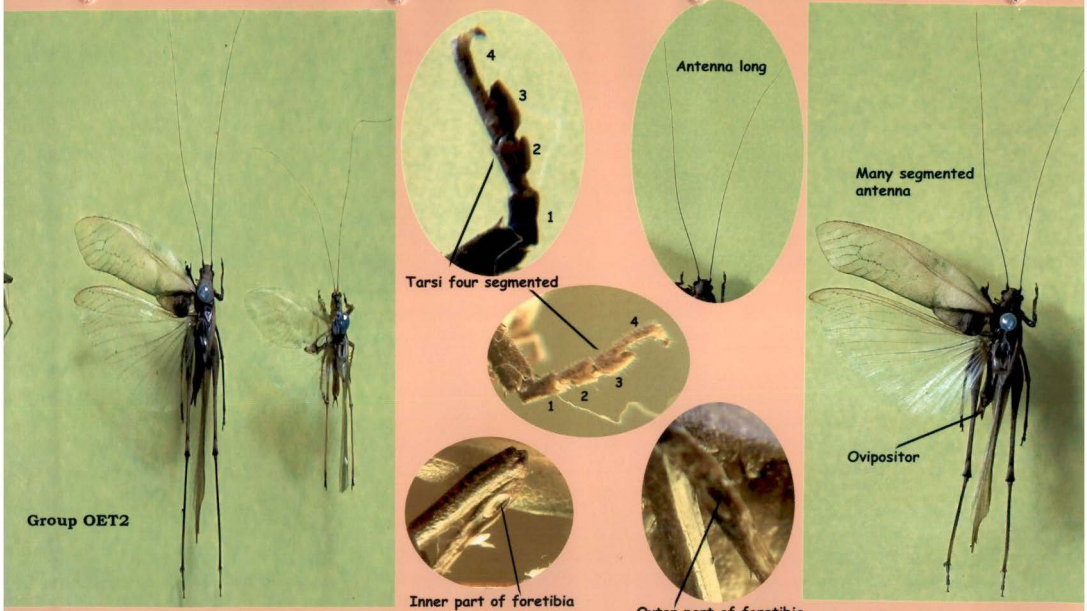
4.4.1 Acridoidea

The insect specimen showing characters like antenna short than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen of female with eight sterna was grouped under super-family Acridoidea and is presented in Plate No. 14 to Plate No. 31. Total 205 specimens out of 260 were grouped under this super-family.

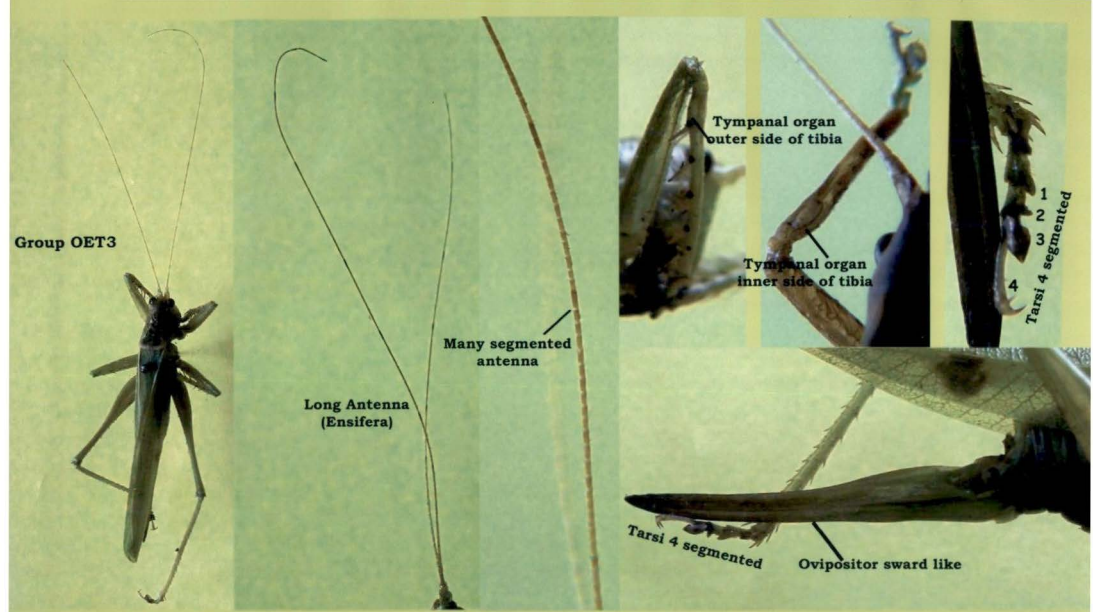
Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing



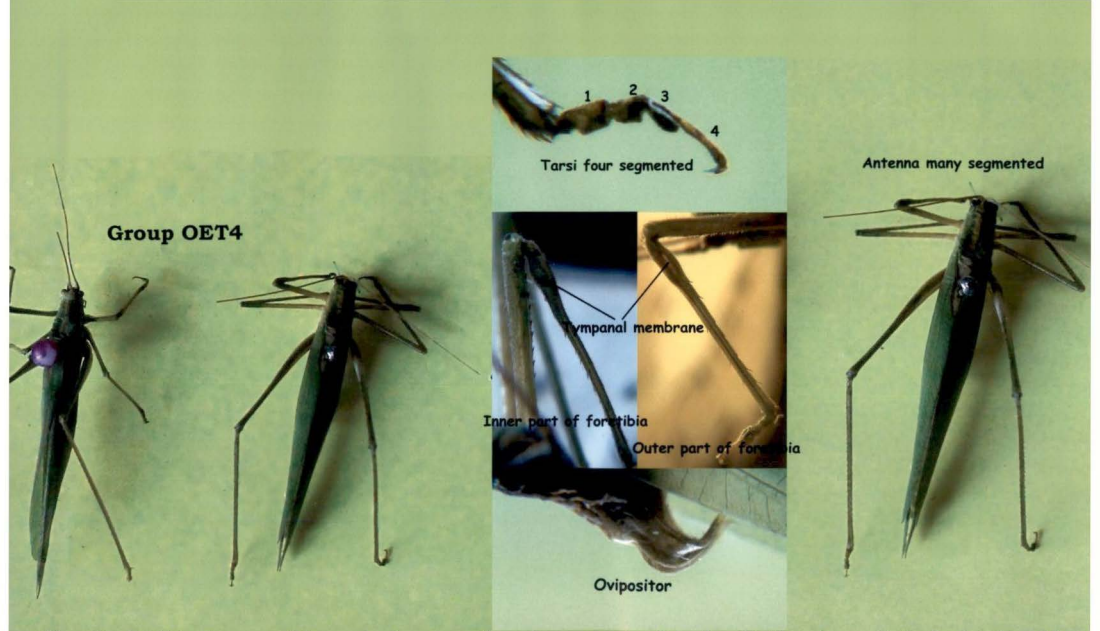
late No. 9 OET1 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Tettigonioidea and Family Tettigoniidae



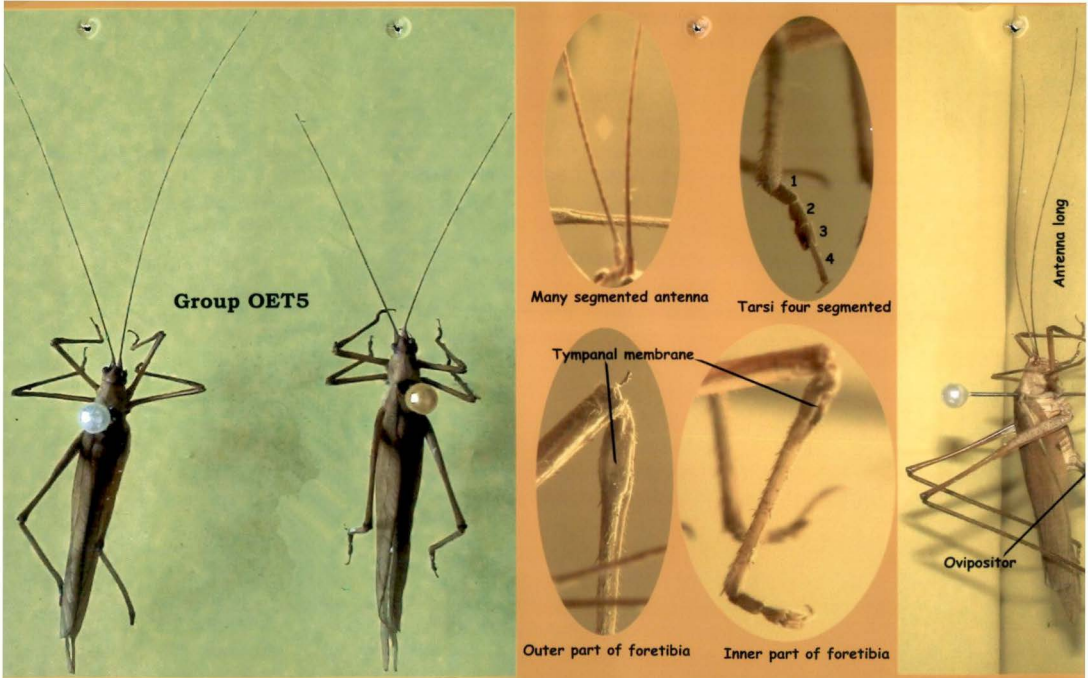
ate No. 10 OET2 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera Super - family Tettigonioidea and Family Tettigoniidae



ate No. 11 OET3 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera, Super - family Tettigonioidea and Family Tettigoniidae



ate No. 12 OET4 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera Super - family Tettigonioidea and Family Tettigoniidae



ate No. 13 OET5 Group of insect showing the characters of Order Orthoptera, Sub-Order Ensifera
Super - family Tettigonioidea and Family Tettigoniidae

the insect in super-family Acridoidea. After running key for super-family as described by Prasad (1986). The specimen collected from Akola vicinity exhibiting similar characters were placed under super-family Acridoidea and are displayed in Plate No. 14 to Plate No. 31 indicating that the share of super-family Acridoidea was highest i.e. 78.84 per cent in Akola vicinity indicating that Acridoidea are prevailing in more numbers in Akola.

4.4.1.1 Acrididae

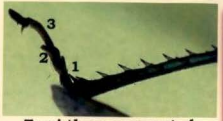
The insect showing characters like antenna short than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment. All tarsi three segmented. Pronotum does not extend beyond base of wings. Ovipositor short and horny, row of peg like projection found on inner side of hind femur. Hind femora usually greatly enlarged were grouped under family Acrididae and are presented in Plate No. 14 to Plate No. 30. Total 203 specimens out of 260 were grouped under this family.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi *et al.* (2006), Castner (2008) had reported the above characters for placing the insect in family Acrididae. After running key for family as described by Gen and Homathevi (2004), the specimen collected from Akola vicinity exhibiting similar characters were placed under family Acrididae and are displayed in Plate No. 14 to Plate No. 30 indicating that the share of family Acrididae is 78.07 per cent which is highest in Akola vicinity.

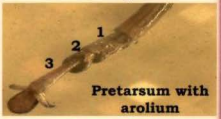
4.4.1.2 Pyrgomorphidae

The insect showing characters like antenna short than body length with less than 30 segments, blue-black or greenish with yellow markings and wings brick-red, abdomen yellow with transverse blue-black bands. Head and pronotum with slight median carina. Fastigium of vertex with median longitudinal sulcus rather bright aposematic coloration was grouped under family Pyrgomorphidae and is presented in Plate No. 31. Total 2 specimens out of 260 were grouped under this family.

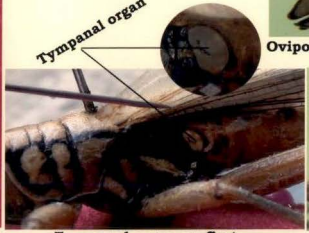
Antenna is short



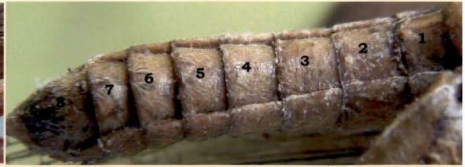
Tarsi three segmented



Ovipositor short and robust

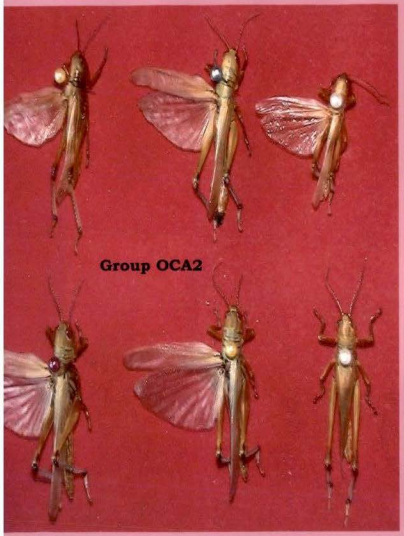


Tympanal organ on first abdominal segment



Abdomen with eight sterna

ate No.14 OCA1 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.



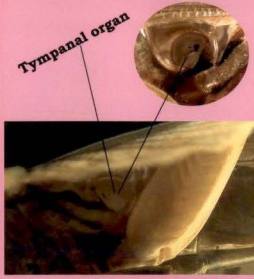
Group OCA2

Antenna is short

Pretarsum with arolium

Tarsi three segmented

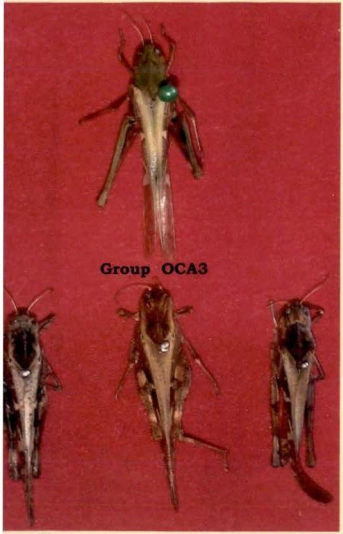
Abdomen with eight sterna



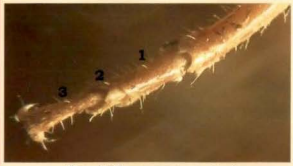
Tympanal organ on first abdominal segment

Ovipositor short and robust

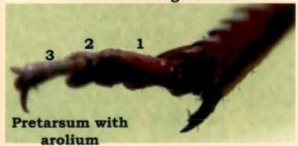
ıte No. 15 OCA2 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.




Antenna is short



Tarsi three segmented

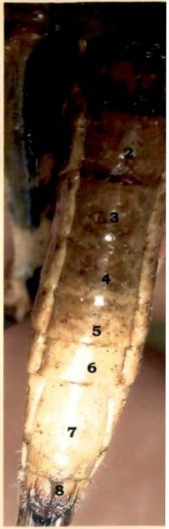


Pretarsum with arolium


Tympanal organ on first abdominal segment

Tympanal organ

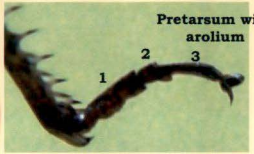

Ovipositor short and robust



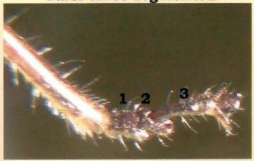
Abdomen with eight sterna

ıte No. 16 OCA3 Group of insects showing the characters of Order Orthoptera, Sub-order Caeliferа Super-family Acridoidea and Family Acrididae.

Antenna is short

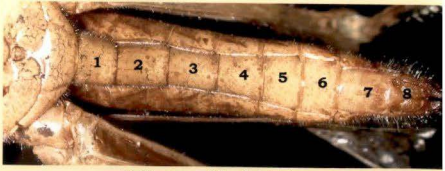


Tarsi three segmented



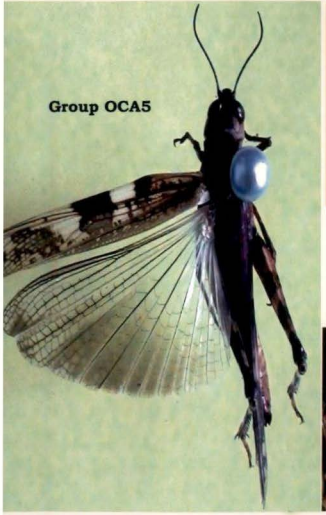
Tympanal organ on first abdominal segment

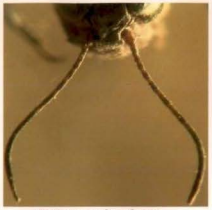
Ovipositor short and robust



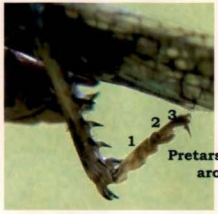
Abdomen with eight sterna

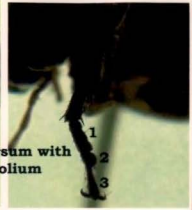
te No. 17 OCA4 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.





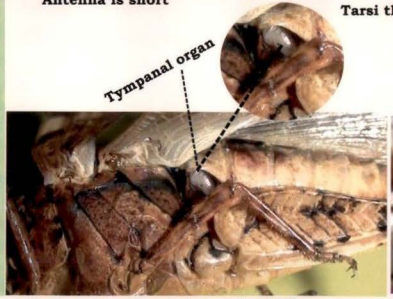
Antenna is short





Tarsi three segmented

Abdomen with eight sterna

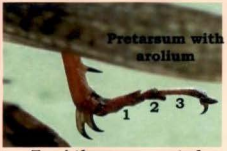


Tympanal organ on first abdominal segment

Ovipositor short and robust

ıte No. 18 OCA5 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer Super-family Acridoidea and Family Acrididae.


Antenna is short



Tarsi three segmented


Ovipositor short and robust


Tympanal organ on first abdominal segment

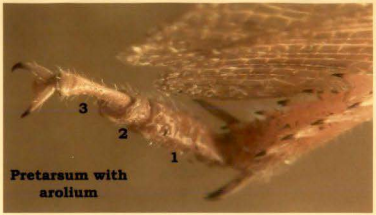

Hind wing fan type

Abdomen wi
eight stern

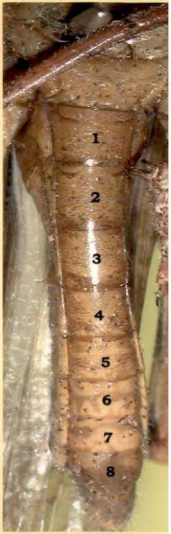
ate No. 19 OCA6 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer
Super-family Acridoidea and Family Acrididae.

up 7 OCA

Antenna is short



Tarsi three segmented



Abdomen with eight sterna

Ovipositor short and robust

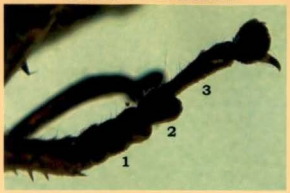
Tympanal organ on first abdominal segment

te No. 20 OCA7 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.

Group OCA8

Antenna is short

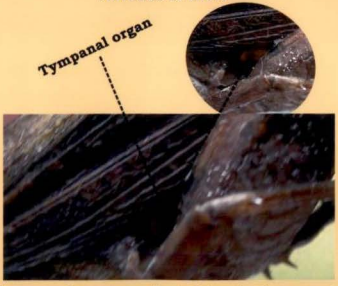
Pretarsum with arolium



Tarsi three segmented

Abdomen with eight sterı

Tympanal organ



Tympanal organ on first abdominal segment

Ovipositor short and robust

ıte No. 21 OCA8 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.

Group OCA9

Antenna is short

Tarsi three segmented

Pretarsum with arolium

Abdomen with eight sterna

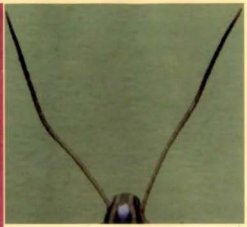
Ovipositor short and robust

Tympanal organ

Tympanal organ on first abdominal segment

te No. 22 OCA9 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.

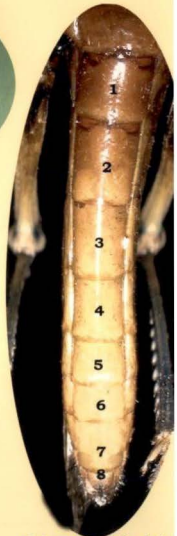
Group OCA11



Antenna is short

Pretarsum with arolium

Tarsi three segmented



Abdomen with eight sterna

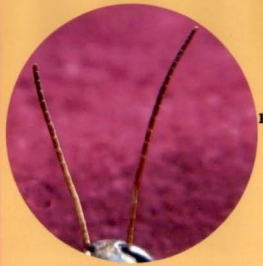
Tympanal organ

Tympanal organ on first abdominal segment

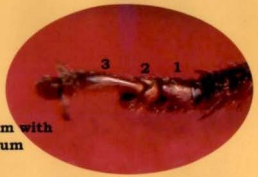
Ovipositor short and robust

te No. 24 OCA11 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer
Super-family Acridoidea and Family Acrididae.

Group OCA12



Antenna is short



Pretarsum with arolium

Tarsi three segmented

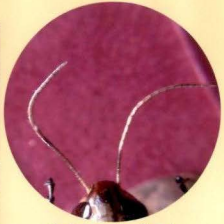
Tympanal organ

Tympanal organ on first abdominal segment

Ovipositor short and robust

Abdomen with eight sterna

e No. 25 OCA12 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifera Super-family Acridoidea and Family Acrididae.


Antenna is short

Tarsi three segmented

Pretarsum with arolium

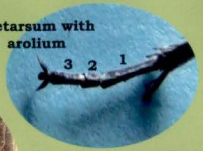

Tympanal organ on first abdominal segment


Ovipositor short and robust

Abdomen with eight sterna

te No. 26 OCA13 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer
Super-family Acridoidea and Family Acrididae.


Antenna is short



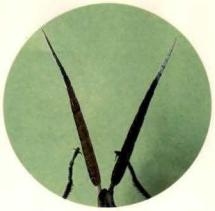
Tarsi three segmented

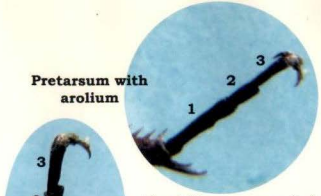

Ovipositor short and robust

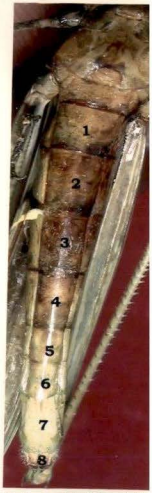

Tympanal organ on first abdominal segment

Abdomen with eight sterna

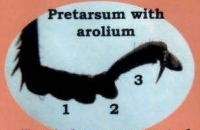
te No.27 OCA14 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer
Super-family Acridoidea and Family Acrididae.

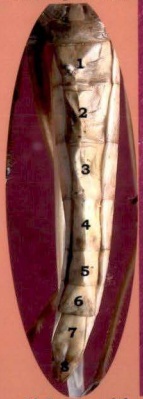


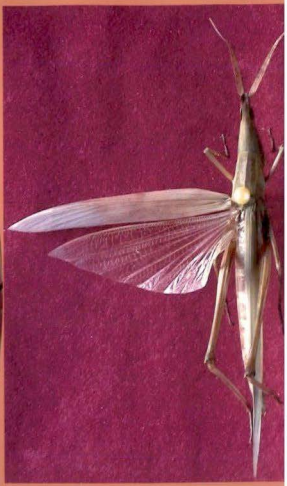




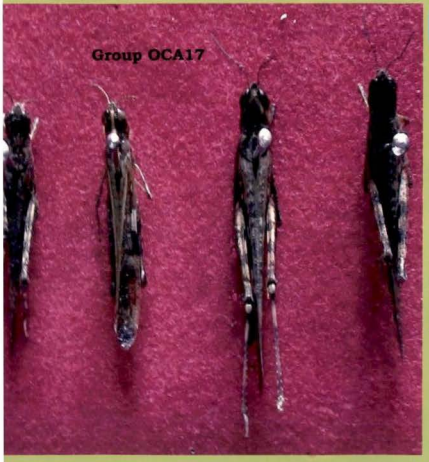
te No. 28 OCA15 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer
Super-family Acridoidea and Family Acrididae.

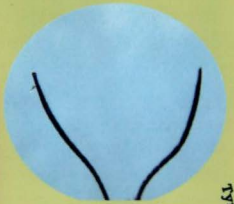






e No. 29 OCA16 Group of insects showing the characters of Order Orthoptera, Sub-order Caelife Super-family Acridoidea and Family Acrididae.





Tarsi three segmented

Tympanal organ

Tympanal organ on first abdominal segment

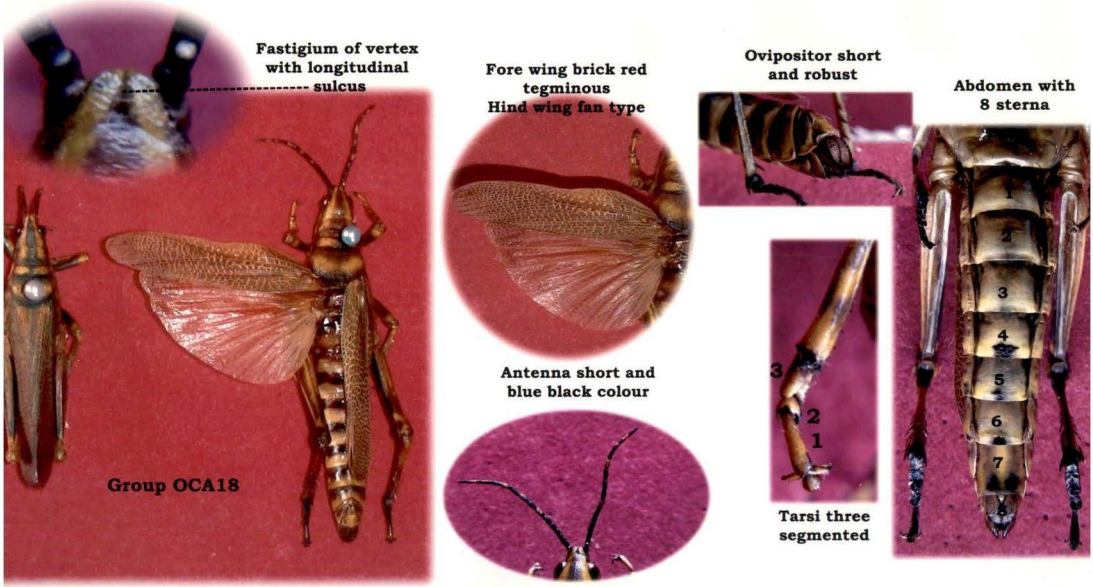
Pretarsum with arolium

Ovipositor short and robust

Abdomen with eight sterna

e No. 30 OCA17 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer Super-family Acridoidea and Family Acrididae.

Kirby (1914), Tembhare (2005) had reported the above characters for placing the insect in family Pyrgomorphidae. After running key for family as described by Gen and Homathevi (2004), the specimen collected from Akola vicinity exhibiting similar characters were placed under family Pyrgomorphidae and are displayed in Plate No. 31 indicating that the share of family Pyrgomorphidae is 0.77 per cent in Akola vicinity.



te No. 31 OCA18 Group of insects showing the characters of Order Orthoptera, Sub-order Caelifer Super-family Acridoidea and Family Pyrgomorphidae.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present investigation entitled "Taxonomic Study of Orthopterans Found in Akola Vicinity" conducted at College of Agriculture, Akola and Head Department of Entomology, Post Graduate Institute Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during 2009-2010. For the study of morphological and taxonomical characters of collected Orthopteran specimen were studied for grouping them in sub-order, super-family and families under order Orthoptera.

Grasshopper belongs to order Orthoptera and also includes locusts, crickets, katydids and related forms. Grasshoppers are polyphagous and prefer to feed on the leaves of paddy, jowar, maize, millets, sugarcane, grasses, sunhemp, arhar etc. Locusts well known pestiferous insects which not only move long distance but also destroy all green vegetable matter on their way and cause a famine. For this study insects were collected from field and light trap by different methods and were killed in killing bottle. After death of insect they were pin stretch and stored in the collection box. After wards insects showing similar morphological and taxonomical character were grouped together. The groups showing the characters of order Orthoptera was taken for further study and were placed in the sub-order, super-family and family as detailed below.

5.1 Order Orthoptera

Present study three thousand specimens were grouped together and on the basis of characters shown by the collected insect related to order Orthoptera from the collected 260 specimens were found to show the characters of order Orthoptera. They were placed in order Orthoptera and studied further for sub-order characters. The present study gives indication that Orthopteran contributes 8.6 per cent population in Akola vicinity.

5.2 Sub-order Ensifera

The collected Orthopterans showing the character of sub-order Ensifera were grouped together and such 55 specimens out of 260 were grouped under this sub-order indicating that in order Orthoptera the share of Ensiferans in Akola vicinity is 21.15 per cent.

5.2.1 Super-family Grylloidea

From the collected sub-order Ensiferans the specimens were further studied for character of super-family Grylloidea and total 33 specimens out of total 260 Orthopteran collected were placed under this super-family. Indicating that 12.69 per cent Orthopterans belonging to super-family Grylloidea in Akola region.

5.2.1.1 Family Gryllotalpidae

The grouped specimens in super-family Grylloidea were further studied for characters of family and according by 14 specimens out of 260 were placed under this family. Indicating that the share of family Gryllotalpidae in order Orthoptera is 5.38 per cent in Akola vicinity and further on the basis of the external morphological and taxonomical characters they were grouped and are presented in Plate No. 2.

5.2.1.2 Family Gryllidae

The grouped specimens in super-family Grylloidea were further studied for family character and according by 21 specimens out of 260 Orthopteran collected were grouped under this family. Indicating that Gryllidae are 8.07 per cent in Akola vicinity. On the basis of external morphological and taxonomical characters shown by the specimen they were grouped and are presented in Plate No. 3 to Plate No. 8.

5.2.2 Super-family Tettigonioidea

From the collected sub-order Ensiferans the specimens were further studied for character of super-family Tettigonioidea. 20 out of 260 were

grouped under this super-family. Indicating that share of super-family Tettigonioidea in order Orthoptera is 7.69 per cent in Akola vicinity.

5.2.2.1 Family Tettigoniidae

The grouped specimens in super-family Tettigonioidea were further studied for characters of family and according by specimen exhibiting similar characters to family Tettigoniidae. Were found to be 20 out of 260 Orthopterans collected. Indicating that the Tettigoniidae share is 7.69 per cent population. Further on the basis of morphological and taxonomical characters they were grouped together and are presented in Plate No. 9 to Plate No. 13.

5.3 Sub-order Caelifera

The collected Orthopterans showing the character of sub-order Caelifera were grouped together and such 205 specimens showing character of sub-order out of 260 were is indicating that the share of Caeliferans in Akola vicinity is 78.85 per cent.

5.3.1 Super-family Acridoidea

From the collected sub-order Caelifera the specimen were further studied for character of super-family Acridoidea and total 205 specimens out of 260 total Orthopteran collected indicating that 78.84 per cent Orthopterans belong to super-family Acridoidea in Akola vicinity.

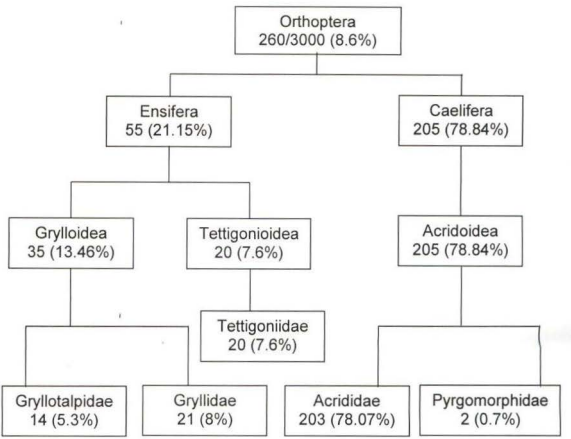
5.3.1.1 Family Acrididae

The grouped specimens in super-family Acridoidea were further studied for family characters and according by 203 specimens out of 260 Orthopteran collected were grouped under this family indicating that Acrididae are 78.07 per cent in Akola vicinity. On the basis of external morphological and taxonomical characters shown by the specimen they were grouped together and are presented in Plate No. 14 to Plate No. 30.

5.3.1.2 Family Pyrgomorphidae

The grouped specimens in super-family Acridoidea were further studied for family characters and according by 2 specimens out of 260 were grouped under family Pyrgomorphidae indicating that Pyrgomorphidae are 0.77 per cent in Akola vicinity. On the basis of external morphological and taxonomical characters shown by the specimen they were grouped together and are presented in Plate No. 31.

Orthopterans in Akola vicinity



5.4 Conclusion

The study indicated that the prevailing population of Orthopterans in Akola vicinity is 8.6 per cent.

On the basis of morphological and taxonomical character studied for sub-order it was found that the Caeliferan population was more than Ensiferan in Akola vicinity.

On the basis of morphological and taxonomical character studied for super-family it was found that Orthopteran belong to super-family Grylloidea, Tettigonioidea, Acridoidea are prevailing in Akola vicinity and population of super-family Acridoidea is more in Akola vicinity.

On the basis of morphological and taxonomical character studied for family it was found that Orthopteran belong to family Gryllotalpidae, Gryllidae, Tettigoniidae, Acrididae and Pyrgomorphidae are prevailing in Akola vicinity and among them the population of Acrididae family Orthopterans are more and i.e. 78.07 per cent in Akola vicinity.

Chapter VI

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