

**ACRIDID FAUNA FOUND IN DIFFERENT
CROPPING SYSTEMS IN AKOLA VICINITY**

THESIS

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Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
for the Degree of

**MASTER OF SCIENCE
IN
AGRICULTURE
(AGRICULTURAL ENTOMOLOGY)**

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Enroiment Number - **DD-1315**

2011



DECLARATION OF STUDENT


I hereby declare that the experimental work and its interpretation of the Thesis entitled "**ACRIDID FAUNA FOUND IN DIFFERENT CROPPING SYSTEMS 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 has been duly acknowledged.

Place: Akola

Date: 26 / 05 / 2011

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CERTIFICATE

This is to certify that thesis entitled "**ACRIDID FAUNA FOUND IN DIFFERENT CROPPING SYSTEMS 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 **Shinde Satyajee Ramchandra** under my guidance and supervision.

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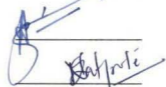

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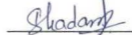


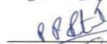
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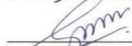
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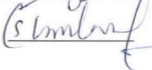
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D) List of Abbreviations

%	-	Per cent
viz.	-	Namely
@	-	At the rate
Ha	-	Hectare
± SE	-	Standard error of mean.
/	-	Per
°C	-	Degree Centigrade
Dr. PDKV	-	Dr. Panjabrao Deshmukh Krishi Vidyapeeth
PAGE	-	Polyacrylamide gel electrophoresis
TEMED	-	Tetra methyl ethylene diamine
DdH ₂ O	-	Double distilled water
e.g.	-	Exempli gratia (For example)
et. al.	-	Et alia (and others)
etc.	-	Et cetra
Fig.	-	Figure
g	-	Gram
mg	-	Milli gram
µg	-	Microgram
ng	-	Nano gram
hrs	-	Hours
i.e.	-	That is
cm	-	Centimeter
ml	-	Milliliter
mm	-	Millimeter
µ	-	Micron
µl	-	microliter
ppm	-	Parts per million
LC ₅₀	-	Lethal concentration to kill 50 percent population.

(E) THESIS ABSTRACT

- a) Title of the thesis : "ACRIDID FAUNA FOUND IN DIFFERENT CROPPING SYSTEMS IN AKOLA VICINITY"
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ABSTRACT

The present investigation entitled, "Acridid Fauna Found In Different Cropping Systems In Akola vicinity" was conducted at College of Agriculture, Akola during 2010 – 11. For the study insects were collected from

different cropping systems. The collected insects were killed, pinned, stretched and preserved. They were labeled and studied for morphological and taxonomical characters. Total 284 Orthopterans were collected from different cropping systems consisting of 193 caeliferans and 91 ensiferans. Indicating that the population of caeliferans were more than ensiferans.

The collected Orthopterans from Soybean, Sorghum, Maize, Pigeonpea, Green gram and Cotton cropping system 22, 82, 27, 23, 21, and 18 specimens were grouped under sub-order Caelifera. The above collected specimens also showed the characters of super family Acridoidea. All the collected specimens showing similar morphological characters were further grouped together and on Soybean three, Sorghum one, Maize two, Pigeonpea three, Green gram and Cotton one group of Family Acrididae were found on the basis of characters like short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consists of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarged. The study indicates that Acridid causing damage to Soybean also cause damage to Maize and Pigeonpea. Acridid causing damage to Maize also cause damage to Green gram and Acridid causing damage to Sorghum also cause damage to Pigeonpea.

CHAPTER I

INTRODUCTION

1.1 Background Information

Grasshoppers are polyphagous pests and prefer to feed on the leaves of sorghum, paddy, tur, maize, sunhemp, millets etc. (Yadav 2008). They consume considerable amount of foliage during their nymphal period and also in the adult stage. When they are especially abundant they cause economic damage to all the vegetation which comes in their way. They are terrestrial and found in grassland, trees, bushes and other vegetation on the surface or burrowing into the ground and occasionally in the caves. Several species are closely associated with water. Some species even have flattened hind tibia with rows of long setae that aid in swimming.

Grasshoppers belong to order Orthoptera (Saltatoria) derived from Latin words "Ortho" and "Ptera". Ortho means straight and Ptera means wings i.e. insect bearing straight wings. In this order grasshoppers, locusts, crickets, katydids and related forms are included. Orthoptera constitutes a large order and comprising of about 17,000 species, several species are of economic importance, (Tembhare 2005).

The Paddy grasshopper *Hieroglyphus banian* (Fabricius) and *Oxya fuscovittata* (Marshall), the Phadka *Hieroglyphus nigrorepletus* (I. Bolivar), the Cotton grasshopper *Cyrtacanthacris tatarica* (Linnaeus), the Deccan wingless grasshoppers, *Colemania sphenarioides* (I. Bolivar), the tobacco grasshoppers, *Atractomorpha crenulata* (Fabricius), the migratory locust *Locusta migratoria* (Linnaeus), the desert locust *Schistocera gregaria* (Forskal), and the Bombay locust *Patanga succinata*

(Johanson) are the major grasshopper pests found in India which have attracted and attracted considerable attention of Entomologists. 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 spp. are recognized as pests on 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, forewings are small, sclerotised, leathery forming tegmina, forewings thicker than hind wings, hind wings generally fan type. Ovipositor is well developed, cerci are short and unsegmented. The specialized sound producing (stridulatory) and sound receiving (auditory) organs are present. They are hemimetabolous. Eggs are elongated, ovoidal in shape and laid singly or in clusters inside or on the ground. The first instar nymphs are vermiforms and called as pronymph. Total number of instars vary from 4 – 15. In apterous forms metamorphosis is slight. They are terrestrial and found on grassland, trees, bushes and other vegetation. They are also found burrowing grounds and also occur in caves infrequently. The males produce sound in variety of ways. Generally they rub or stridulate one part of the body against another and produce sound. The sound is produced to attract members of opposite sex for mating. Most of them are plant feeders some of them are carnivorous, (Ambrose 2004).

1.2 Importance of study

It has been reported that *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 earheads of paddy and defoliate the plants. In wheat both nymphs and adults feed on the leaves and eat the wheat seedling. Besides 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). Like wise this study will be helpful to know the prevailing Acridids in different cropping systems in Akola.

Orthopterans are also found to have nutritive values, the adult insect contains crude proteins (CP) 654.2 g kg⁻¹, fat 83.0 g kg⁻¹ and chitin 87.3 g kg⁻¹ on dry matter basis. They also contain amino acids methionine, cystine and lysine found upto 17.0, 6.9 and 37.9 g kg⁻¹, respectively on dry matter basis.

In world the 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 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, Chocolate crispies, Cricket patties, Cricket hot pie, Pizza hopper, Cricket seaweed, Hot cricket avocado delight.

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

1.3 Objectives of study

1. Crop wise collection of Orthopteran (Acridids).
2. Grouping of Acridids on the basis of morphological and taxonomical characters.

1.4 Scope and limitations

The present study will help to know the different kinds of grasshoppers which are prevailing in different cropping eco-zones of Akola vicinity. The study will help to know the short horned grasshoppers

prevailing in different crops in Akola by grouping them in suborders, super-families and families for the first time. If the population of particular species is found prevailing in particular area but at lower level then the probable reason for keeping that species at lower strata can be evaluated. If any parasite and predator is prevailing in the area then it can be thought for augmentation through quarantine, to check the prevailing population of grasshoppers in this area in particular cropping system. The present study will be more informative and act as ready reckoner to Students, Research workers, IPM workers and has vast scope for which after grouping them to the family level, studies to identify them upto species level is also essential.

1.5 Hypothesis

It has been observed that to implement the Integrated Pest Management concept the basic thing is exact identification of the pest. This will help IPM worker to adopt correct strategies' right from the use of pheromone lure to their development stages, pupation sites and feeding behavior etc. In the present study main focus is on collection of Orthopteran fauna which are prevailing in Akola in different cropping systems. Studying them for placing them in classification hierarchy. The outcome of the study will give the information about the Acrididae family prevailing in different cropping systems in Akola. The derived information in the study is presented in different plates on the characters shown by the collected specimens by running the keys of Order, Sub-order, Super-family, Family and wherever possible to the species level.

CHAPTER II

REVIEW OF LITERATURE

The present study aimed on, "Acridid fauna found in different cropping systems in Akola vicinity" was felt essential to know the grasshoppers prevailing in this area in different cropping systems. Orthopterans are major pest of cereals, sugarcane and are dangerous when there is outbreak. To know the present Orthopteran the literature was reviewed for collection and identification briefed under headings and sub-headings.

2.1 Insect collection

Yang et al. (1994) used seventy two traps prepared from modified soft drink bottle containing Peanut butter as bait in it, from July to September, 1990 in a nursery of *Paulownia fortunei* and a 40 year plantation of Taiwan Incense cedar (*Calocedrus formosana*) at Nantou, Taiwan. Total of 210 crickets, representing 6 genera and 9 species were collected in 1620 traps placed. 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) prepared 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 by the use of pitfall traps.

Frank et al. (2002) reported that *Scapteriscus didactylus* and *Neocurtilla hexadactyla* were two mole cricket species known from Grenada, Lesser Antilles. They cause damage to turf and vegetable seedlings during the month of June 1990. Year round ultraviolet light trap samples 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) 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 formal glycerin-alcohol were used. 105 cricket individuals (29 of which were adults) from nine species in 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 species which are considered the Orthoptera *sensu stricto*. 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) described the characters for order Orthoptera as moderate to large size insect, undergoing imperfect metamorphosis, having strong mandibles, front pair of wings tegmina and mostly parchment-like texture, while hind wings membranous, short antennae and three jointed tarsi

Shishodia et al. (1993) studied Orthopterans 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 52 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 the 1st time from this region.

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 *Docicstaurus 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, were 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 continue for periods long

enough to understand what drives these changes. Exceptions are to be found in the midwest of the U.S.A. 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 favour greater attack by Acridids.

Onder et al. (1999) described families Phamphagidae (5 species in 5 genera), Pyrgomophidae (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 Stinkard (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 culinabs*) 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.

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*, *Diaboloecatantops innotabilis*, *Catantops humilis* [*Xanocatantops humilis*], and *Catantops unimaculata* sp. nov. The two allotypes of *Dicranophyma hingstoni kashmiricum* were reported for the first time. The new species and Hotypes described in detail. A key to local genera and species was 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* in maximum number during July-October with mean temperature of 37.95°C. *Aiolopus tumulus* and *Oxya nitidula* were observed with their maximum population of nymphs and adult respectively during September-October with mean temperature range of 34.02 to 37.95°C. Species *H. banian* was observed maximum during August-October with under mean temperature range of 35.65 to 37.95°C. Maximum nymphal activity of all grasshopper species was noticed during three weeks after transplanting of crop and adults were 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 *khahf* and *rabi* of 2000 and *khahfot* 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*, *G ma* 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 part to biting and chewing with well developed mandibles. Non 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 sloping 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 Orthopterans were saltatorial exopterygotes with mandibulate mouthparts, large prothorax, hind legs modified for jumping, forewing modified into leathery tegmina, auditory and stridulatory organs present, 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*. 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 *Cslliptamus 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, observatories, 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 segmented 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 Chhattisgarh. Ten species i.e. *Mecopoda Elongata* (Linnaeus) *Iphidiopsis citrina* Redtenbacher, *Platygyllus lineaticeps* (Walker) *Enogryllus* sp., *Ptemoscirta cinctifemur* (Walker), *Tridactylus fasciatus* uerin 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 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 cognate*, *Heteracris annulosus* [*H. annulosa*], *Acrotylus fischeri*, *Morphachs 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 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 femur usually enlarged for jumping, females without obvious visible ovipositor.

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 *Chotettix maximus*, *Hyboella tibetana*, *Coptotettix annandalei*, *C. interruptus*, *C. testaceous*, *C. indicus*, *Paratettix semihirsutus*,

Euparatettix personatus, *Ergatettix callosus*, *E. interruptus*, *E. crassipes*, *Gomphomastax antennata* 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 Super- family 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. 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), Sroadleaf-eating Acrididae and Pyrgomorphidae (19%) and Open-ground Acrididae and Pyrgomorphidae (12%).

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 prepared by them.

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 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*,.

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 Pamphagia is not yet recorded from India, though it is probable that some representatives may occur in northern or north-western portions.

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 *Tylotrypidus 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 Indian 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 Grasshopper, *Trilophidia annulata* (Thunberg) (Insecta:Orthoptera: Acrididae), seriously damaging Bermuda grass in Rajasthan.

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

Haq and Aziz (1978) observed the *Acrotylus humberianus* Saussure on *Triticum aestivum* 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 Oak (*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.

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 to the subfamilies and genera of the family presented, based on international 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*, *Kirmaniania exilis*, *Ochrilidia geniculata*, *O. longiceps*, *O. turanica*, *O. gracilis gracilis*, *O. affinis* [*O. gracilis*], *Aulacobothrus luteipes*, *A. sven-hedini*, *Dociostaurus decisis*, *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 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 mensis*. 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), *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) reported 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 was 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 was based on material and data collected from Alexandra region. The taxon was 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 was also studied.

Pokivailov (2003) studied the Orthopterous fauna of Southwestern Tajikistan comprising of 139 species and subspecies of 9 species, 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 ' A characteristic feature of the fauna of Southwestern Tajikistan is it heterogeneity. The Tajik plains with their specific fauna including *Thrinchinae*, *Dehcorythini*, *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.

CHAPTER III

MATERIAL AND METHODS

The present study was aimed to know about, "Acridid fauna found in different cropping systems in Akola vicinity." Research was carried out in Entomology section, College Of Agriculture, Akola and Department of Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. During July 2010 to Jan 2011. For this study material required and methodologies followed for the study detailed below:

3.1 Material required

3.1.1 Materials

The material required for collecting grasshoppers were, insect collecting net, specimens tubes of various size, setting board, insect killing bottle, forceps, hand lens, entomological pins, drying chamber, small hair brush, camera for photographs, lenses for close up photographs, different colour century papers, insect preservation boxes etc.

3.2 Method of Insect Collection

The Acridids are diurnal in habit and hence the collection was done in the morning hours. The grasshoppers were searched inside the field and were collected by the methods given below. The population of Acridid was collected from Soybean, Maize, Pigeonpea, Green gram, Sorghum and cotton field. The photographs of damage to Soybean, Sorghum, Maize, Pigeonpea, Green gram are presented in Plate 1 to 3.

3.2.1 Insect Collecting Net

Insect collecting nets made up of wooden handle with a collecting bag made up of ordinary mosquito net cloth was used for collecting



Grasshoppers attack on Sorghum crop



GRASSHOPPERS ATTACK ON MAIZE PLOT



Plate 3 Damage caused by grasshoppers to Pigeonpea and Green-gram crop

grasshoppers. The grasshoppers were collected by sweeping the nets in the cropping system (within the rows of standing crops).

3.2.2 Hand picking

In this method grasshoppers were collected directly by hand and were put in the killing bottles. The immature stages which were collected in the field were kept in rearing cages cropwise in the laboratory and were reared to complete their development (Plate 4a).

3.3 Killing of collected specimens/ insects

Fully developed grasshoppers were killed immediately after capture. For killing them Potassium cyanide or ethyl acetate or chloroform were used (4b).

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 used. Two spoons of sodium cyanide was placed in the bottom of bottle and over it a layer of saw dust was placed and covered with a layer of plaster of paris upto 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 used for killing insects after couple of days. For killing of insects immediately, Ethyl acetate or Chloroform or Benzene was used in the field

3.4 Method of pinning the specimens

3.4.1 Pins

The specialized entomological pins which were slender, hard with pointed tip and small head made from pure nickel plated which were rust free were used. Commonly No. 16 and No. 20 pins were used for pinning the Orthopteran insects (Plate 4c).

3.4.2 Pinning of specimens

The correct pinning of grasshopper was essential for easy identification of their taxonomic characters for which Orthopterans were held between the thumb and forefinger in one hand and the pin was inserted into the insect with the help of other hand which was carried out as suggested by Richards and Davies (1997). Orthopterans were directly pinned as they were big. The pin was placed in such a way that all important diagnostic characters were viewed clearly, which was the little right side of the pronotum.

3.5 Labeling

Collections loose value, if they are not properly and accurately labeled. Labelling was done as soon as insects were dried to avoid loss of vital information. Labels were printed or hand written with micro tipped pen containing information like,

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

College of Agriculture, Akola Collection

Entomological pins were inserted beneath the insects by 1/3rd height from the base. The labels were placed in such a manner that the long axis of the label coincided with the long axis of the insect (Plate 4e).

3.6 Specimen care

3.6.1 Materials required

Grasshoppers were preserved by killing, pinning and drying. The materials required for preservation were, relaxing chamber, entomological pins,

setting board, paper folds, butter paper, needle, oven dry chambers, preserving chambers. preserving chemicals, naphthalene balls, fumigation media etc.

1. Relaxing chamber

The collected insects when became hard and could not be pin and stretch, such insects were placed in relaxing chamber i.e. dessicator in which relaxing fluid was placed. Insects were placed in relaxing chamber with due care that they should not come in contact of relaxing fluid and was made air tight for 24 hr. Then after 24 hr when insect become soft they were removed from relaxing chamber and then stretched and pin.

2. Setting board (Insect spreading board)

For setting the collected grasshoppers, for spreading the wings, stretching legs, antennae the setting boards and the thermocol sheets were also used. Cut grooves were made to the thermocol sheet to stretch the wings of grasshopper properly so that all the characters could be observed properly during study (4d).

3. Paper folds (Paper envelopes)

They were used for temporary preservation and storage of collected insects. These triangular envelopes were made from a sheet of butter paper. Butter papers were cut into rectangular size in the proportions 3;5. The information regarding collected specimen was written on projecting flap of butter paper with the help of marker pen.

4. Butter paper

Butter paper was also used for stretching the insect wings during pinning. They were also used for preserving the killed insect in the field during collection.



4a. Rearing of nymphal instar



4b. Killing of insect



4c. Pinning of insect



4d. Stretching of grasshopper



4e. Labelling of insect

5. Preservation of collected specimens

Fumigation media was prepared for which petrol 1lit, carbolic acid 2.5 gm and naphthalene balls 125 gm were added together and the solution was allowed to boil in amber colored bottle in hot sun for one day so that the solution can be formed. The cotton swab was dip in the solution and was placed in the collection box in the provided grooves and the fumigation of collected insect was carried out. This was under taken to preserve the specimen from saprophytes and fungus development on them.

3.6.2 Methods of preservation

3.6.2.1 Dry preservation/ Drying

After pinning and stretched collected specimens were dried in insect drying chambers so that the body characters and other morphological and taxonomical characters could be studied properly.

3.7 Storage

3.7.1 Insect store boxes

For displaying preserved insects wooden boxes of dimension 45x30x15cm were used. The boxes were air tight and moisture proof with a well hinged lid. A cell was provided inside to keep the fumigation. Cork sheets were glued to the bottom of the box to permit pinning. Storing of the specimen was made according to the common external taxonomical characters shown by the insect for placing them in Order, Sub-order, Super family and family.



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.....	
	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 from appendages.....	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 eye small and widely separated or absent; ocelli present or absent; body somewhat flattened dorsoventrally, 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 wingless 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 matathoracic 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 raptorial.....	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 sclerotised; exwrted; tarsi fivesegmented (Rock crawlers).....	Grylloblattodea
	Cerci short; no ovipositor; tarsi four segmented (Termites).....	Isoptera
19	Tarsomeres not exceeding five; body slender and stick like (walkin sticks).....	Phasmida
	Tarsomeres two to four; body not linear.....	20
20	Fore metatarsus swollen (Webspinners)	Embiidina
	Fore metatarsus not swollen.....	21
21	Tarsomeres apparently four-segmented ; cerci multi-articulate;	Isoptera

	antennae nine to thirty segmented (Termites).....	
	Tarsomeres two-segmented; cerci unarticulated; antennae nine segmented (Zorapterans).....	Zoraptera
22	Body depressed.....	23
	Body compressed (fleas).....	Siphonoptera
23	Mouthparts mandibulate.....	24
	Mouthparts haustella (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).....	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 (Suckinglice) ...	Anoplura
27	Forewings horny; leathery or parchment- like at least at base; hind wings; if present usually Forewings membranous.....	28
	Forewings membranous.....	37
28	Forewings modified as tegmina or hemelytra, containing veins.....	29
	Forewings modified as vein less, horny elytra , hind wings if	36

	present folded crosswise and lengthwise and hidden under the elytra.....	
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, at least one segment bearing a long thread like arista; forewings minute; cerci absent; minute species parasitic in wasps and bees (twisted wing parasite)	Strepsiptera
33	Hind femora not larger than fore femora; 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 prothorax.....	35
	Body oval much flattened; head usually concealed from above by the prothorax (Cockroaches).....	Blattaria
35	Prothorax much larger than mesothorax; forelegs usually heavily spined beneath and adapted for capturing and holding the prey; cerci usually with several segments (Praying mantids).....	Mantodea
36	Abdomen terminating in movable, heavily sclerotized forceps; antenna 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 wing present.....	55
38	Minute insects; wings long, narrow fringed with long hairs, almost veinless; tarsi unarticulated or biarticulated with	Thysanoptera

	swollen tips; mouthparts asymmetrical without biting mandibles, adapted for rasping and sucking plant tissues; no cerci (Thrips).....	
	Wings broader and often veined; rarely linear; the tarsi have more than two segments and the last tarsal segment is not swollen.....	39
39	Hind wings with the anal area folded in fan like plaits when at response, 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 (Caddish flies).....	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	Mecoptera

	(Scorpionflies)	
	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 are 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, hornflies.....	Hymenoptera
49	Costal cell at least in forewing with many cross-veins (Lacewings).....	Neuroptera
	Costal cells without cross-veins (Scorpionflies).....	Mecoptera
50	Wings equal, rarely 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, fore metatarsus swollen, cerci conspicuous (Webspinners).....	Embiidina
	Social insects; tarsi apparently with four segments, fore metatarsus 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 halteres; antennae inconspicuous; cross veins abundant (Mayflies)	Ephemeroptera
	Hind wings reduced to hook like halteres; venation reduced to	Homoptera

	a forked vein, cross veins absent (minute delicate males of (scale insects).....	
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(Srivastava, 2006)

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

3.6.2 Placing the insect in Sub – Orders;

The characters shown by the specimen is detailed below

Caelifera

- Antennae are 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

- Antennae as long as body with more than 30 segments.
- Tympanum is found on fore tibia.

- Stimulatory organs are tegmino / alary type.
- Ovipositor is sword like, usually more or less elongate.
- Tactile response is well developed
- Mandibles not specialized for consuming dicot plants.
- Rely on crypsis.
- Nocturnal in habitat.
- Eggs are singly inserted into plant tissues or soil.

Above characters are 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 grouped into three super families. The key used for grouping the collected insect in super families and family are as below,

1. Antennae stout 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 lead on middle and hind legs (super-family; Tettigonoidea).....3
 Tarsi 3-segmented (superfamily: Grylloidea).....8
3. Second and third tarsal segments with large, mobile lateral lobes; wings when present, coiled spirally in response.....Schizodactylidae
 Tarsi and wings otherwise.....4
4. Body elongate, apterous, rod-like hind femora not thickened.....Phasmodidae
 Body more thickest, 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 females usually with stridulatory apparatus; fore tibiae almost always with tympanal organs; tibiae without mobile spines beneath.....Tettigonoidae
7. Forewings of male without stridulatory apparatus; 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 larger 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 second abdominal tergites.....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 study was aimed to know about the "Acridid fauna found in different cropping systems in Akola vicinity". Study was carried out in Entomology Section, College of Agriculture, Akola and in Department of Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the July 2010 to January 2011. During this period grasshoppers were collected from different cropping systems in Akola vicinity and could be collected from Soybean, Sorghum, Maize, Pigeonpea, Green gram and Cotton cropping system. The collected grasshoppers from each crop were grouped on the basis of morphological characters shown by them and were placed under Taxonomical hierarchy under Order, Sub-Order, Super-Family and Family. The study was focused on Orthopteran of Acrididae family those found during the present study are presented and discussed with available literature.

4.1 Acridids collected from different crops

4.1.1 Acridids collected from Soybean

4.1.1.1 Identification for order Orthoptera

During the present study different specimens of insect were collected from Soybean field. Only 48 specimens could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarge femora, mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organ present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

4.1.1.2 Identification for sub-order

a. Ensifera

The identified orthopterans were further grouped under sub-order, twenty six (26) (Table 1) specimens showing long antennae with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor sword like more or less elongated were grouped under Ensifera. As these groups were not related with Acridids they were not further studied.

b. Caelifera

Collected twenty two specimens (Table 1) had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment. Tarsi with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 22 specimens collected and placed under this sub-order are presented in Plate 5 to 7.

4.1.1.3 Identification for super-family under Sub-order Caelifera

Under Caelifera Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for character antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with

eight sterna. Twenty two specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.1.4 Identification for family Acrididae under super-family Acridoidea

The identified 22 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in three groups on the basis of similar morphological characters shown by them. In these three groups the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consist of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femora enlarge were observed and are presented in Plate 5 to Plate 7. Indicating that these three groups of Acrididae are prevailing on Soybean in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that these three group collected on Soybean crop belong to family Acrididae.

4.1.2 Acridids collected from Sorghum

4.1.2.1 Identification for order Orthoptera

During the present study different specimens were collected from Sorghum field. Only 98 specimens (Table 1. Graph 1) could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarge femora,

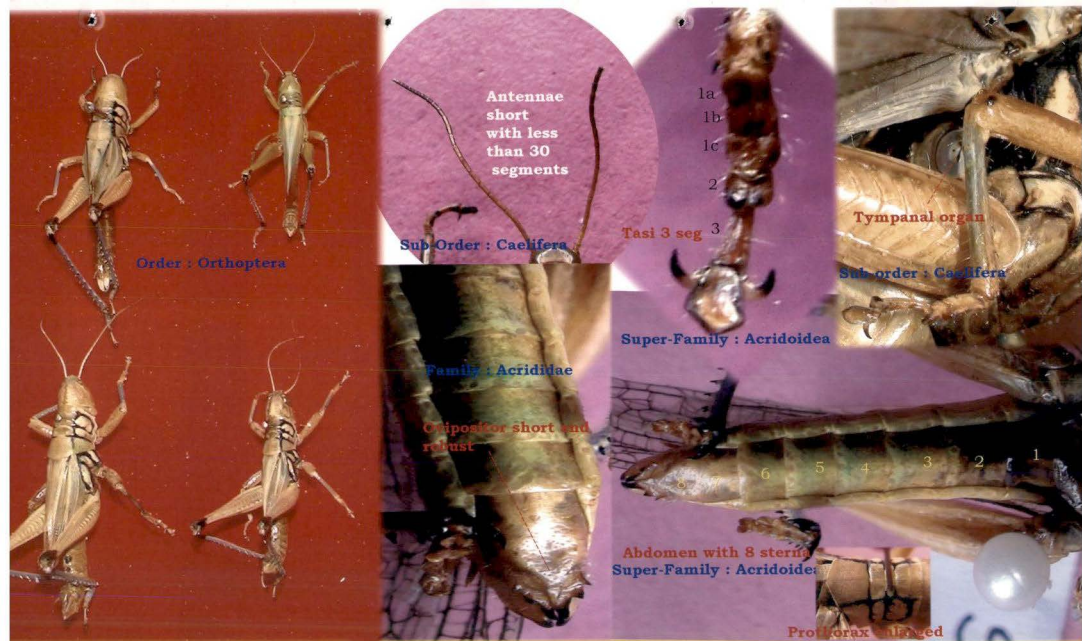


Plate 5 Identifying morphological characters of Order Orthoptera, Sub-order Caelifera, Super-family Acridoidea and Family Acrididae, collected from Soybean



Order : Orthoptera



Antennae less than 30 segments
(Short horned antennae)

Sub-order: Caelifera



Super- family
Acridoidea

1
2
3
Tarsi 3 seg



1
2
3
Tarsi 3 segmented
Super family; Acridoidea



Hind femora enlarged for jumping

Family : Acrididae



Tympanal organ

Sub-order : Caelifera



Ovipositor short
and robust

Family : Acrididae



Abdomen with
8 sterna

Super family
Acridoidea

Plate 6 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Soybean



Order : Orthoptera



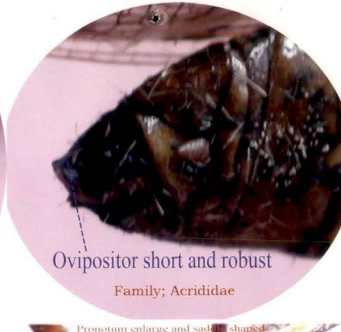
Tympanal organ

Sub-order: Caelifera



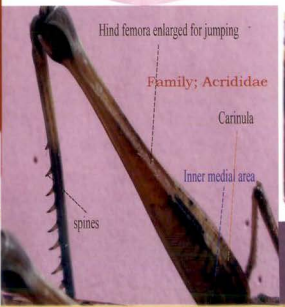
Tarsi 3 segmented

Super Family; Acridoidea



Ovipositor short and robust

Family; Acrididae



Hind femora enlarged for jumping

Family; Acrididae

Carinula

Inner medial area

spines



Pronotum enlarge and saddle shaped

Median carina

Lateral lobe



Sub-Order : Caelifera

Antennae short with less than 30 segments



Abdomen with 8 segments

Super-Family; Acridoidea

Plate 7 A Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Soybean

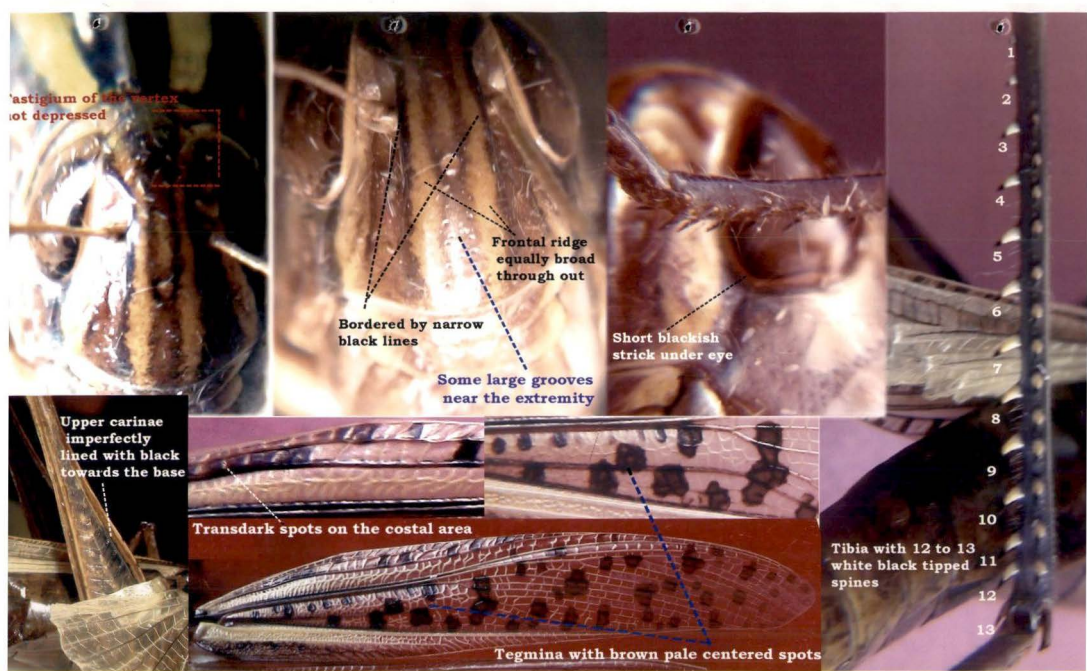


Plate 7 B Identifying morphological characters of Species *Heteracris elegans* collected from Soybean

mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organs present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

4.1.2.2 Identification for sub-order

a. Ensifera

The identified Orthopterans were further grouped under sub-order, Sixteen specimens showing long antennae with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor swards like more or less elongated were grouped under Ensifera. As this group was not related with Acridis, they were not further studied.

b. Caelifera

Collected eighty two specimens had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsi with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 82 specimens collected and placed under this sub-order are presented in Plate 8.

4.1.2.3 Identification for super-family under Sub-order Caelifera

Under Caelifera, Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for characters like antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the

first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna. Eighty two specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.2.4 Identification for family Acrididae under super-family Acridoidea

The identified 82 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in One group on the basis of similar morphological characters shown by them. In this one group the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consists of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarge were observed and are presented in Plate 8. Indicating that only one groups of Acrididae are prevailing on Sorghum in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that this one group collected on Sorghum crop belong to family Acrididae.

4.1.3 Acridids collected from Maize

4.1.3.1 Identification for order Orthoptera

During the present study from collected different specimens of insect from Maize field only 46 specimens could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae

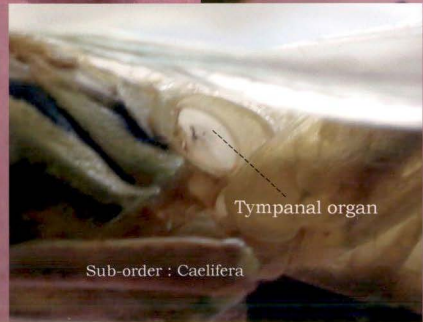
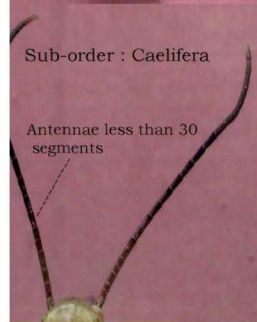
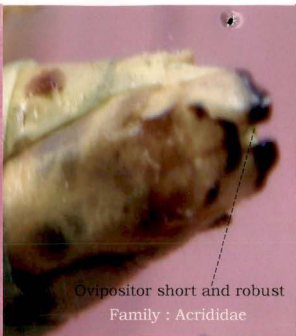


Plate 8 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Sorghum

filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarge femora, mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organs present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

4.1.3.2 Identification for sub-order

a. Ensifera

The identified orthopterans were further grouped under sub-order, nineteen specimens showing long antennae with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor swards like more or less elongated were grouped under Ensifera. As this group was not related with Acridid they were not further studied.

b. Caelifera

Collected twenty seven specimens (Table 1. Graph 1) had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsai with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 27 specimens collected and placed under this sub-order are presented in Plate 9 to Plate 10.

4.1.2.3 Identification for super-family under Sub-order Caelifera

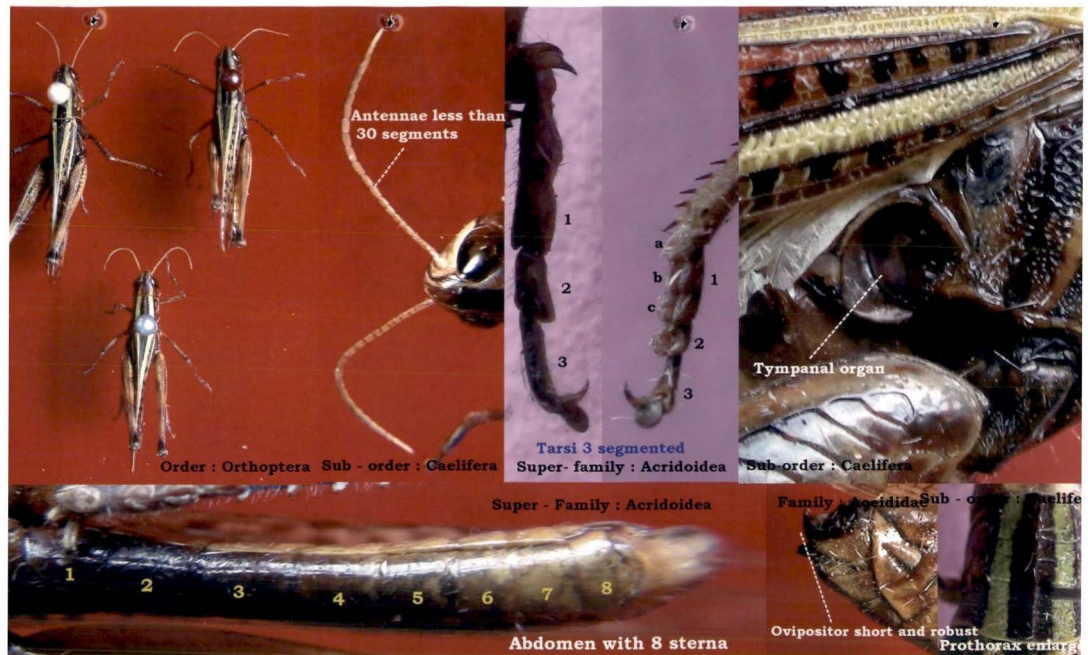
Under Caelifera Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for character antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna. Twenty seven specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.3.4 Identification for family Acrididae under super-family Acridoidea

The identified 27 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in two groups on the basis of similar morphological characters shown by them. In this two groups the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsai consist of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarge were observed and are presented in Plate 9 and Plate 10. Indicating that only two groups of Acrididae are prevailing on Maize in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that this two group collected on Maize crop belong to family Acrididae.



Antennae less than 30 segments

Tarsi 3 segmented
Super - family : Acridoidea

Tympanal organ

Sub - order : Caelifera

Super - Family : Acridoidea

Family : Acrididae Sub - order : Caelifera

Abdomen with 8 sterna

Ovipositor short and robust

Prothorax enlarged

Plate 9 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Maize

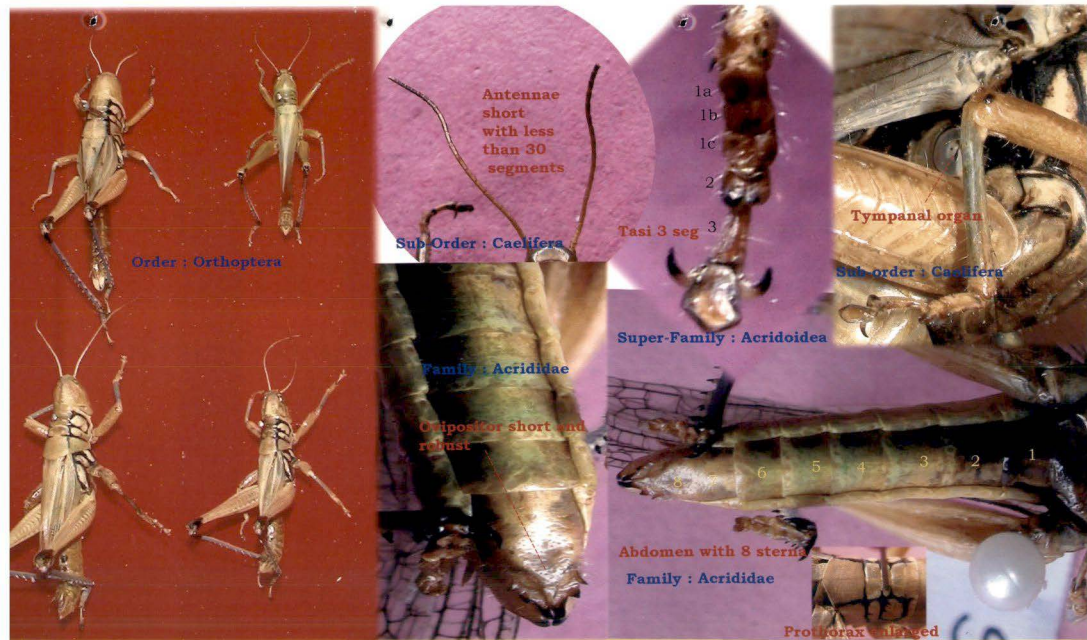


Plate 10 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Maize

4.1.4 Acridids collected from Pigeonpea

4.1.4.1 Identification for order Orthoptera

During the present study from collected different specimens of insect from pigeonpea field only 36 specimens could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarge femora, mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organs present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

4.1.4.2 Identification for sub-order

a. Ensifera

The identified orthopterans were further grouped under sub-order, thirteen specimens showing long antennae with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor swards like more or less elongated were grouped under Ensifera. As this group was not related with Acridid they were not further studied.

b. Caelifera

Collected twenty three specimens (Table 1. Graph 1) had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsai with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 23 specimens collected and placed under this sub-order are presented in Plate 11 to Plate 13.

4.1.4.3 Identification for super-family under Sub-order Caelifera

Under Caelifera Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for character antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna. Twenty three specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.4.4 Identification for family Acrididae under super-family Acridoidea

The identified 23 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in three groups on the basis of similar morphological characters shown by them. In these three groups the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consist of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarge were observed and are presented in Plate 11 and Plate 13. Indicating that only three groups of Acrididae are prevailing on pigeonpea crop in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that this three group collected on pigeonpea crop belong to family Acrididae.

4.1.5 Acridids collected from Green gram

4.1.5.1 Identification for order Orthoptera

During the present study from collected different specimens of insect from green gram field only 29 specimens could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarged femora, mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organs present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

4.1.5.2 Identification for sub-order

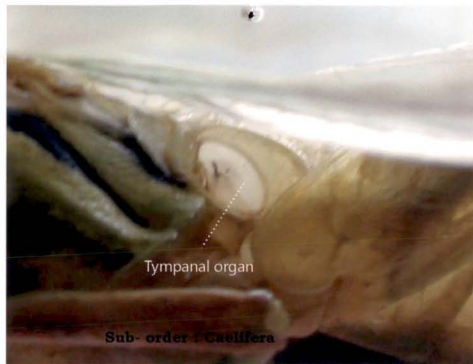
a. Ensifera

The identified Orthopterans were further grouped under sub-order, eight specimens showing long antennae with more than 30 segments or longer than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor swards like more or less elongated were grouped under Ensifera. As this group was not related with Acridids, they were not further studied.





Order : Orthoptera



Tympanal organ

Sub- order : Caelifera



Abdomen with 8 sterna



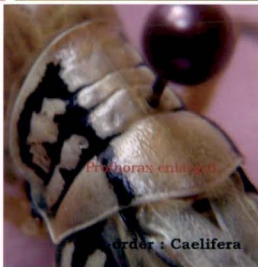
Antennae short with less than 30 segments

Sub- order : Caelifera



Tarsi 3 segmented

Super- family : Acridoidea



Prothorax enlarged

order : Caelifera



Ovipositor short and robust

Family : Acrididae

Super- family Acridoidea

Plate 11 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Pigeonpea



Order : Orthoptera



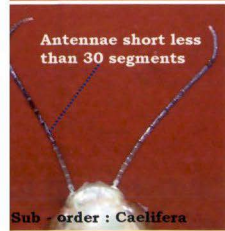
Tarsi 3 segmented

Super - family : Acridoidea



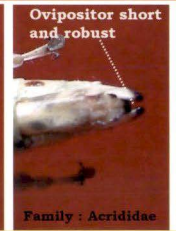
Abdomen with 8 sterna

Super - family Acridoidea



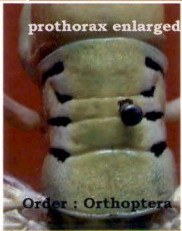
Antennae short less than 30 segments

Sub - order : Caelifera



Ovipositor short and robust

Family : Acrididae



prothorax enlarged

Order : Orthoptera



Tympanal organ

Sub - order : Caelifera

Plate 12 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae and collected from Pigeonpea

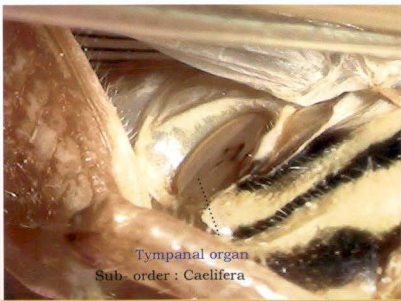
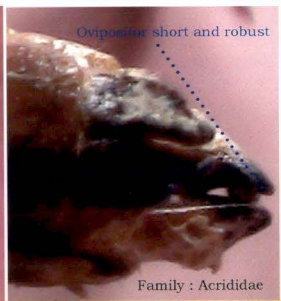
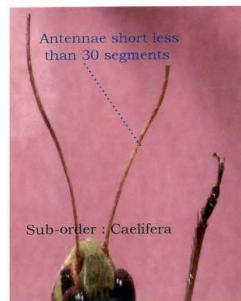
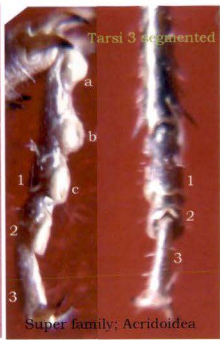


Plate 13 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae and collected from Pigeonpea

b. Caelifera

Collected twenty one (Table 1. Graph 1) specimens had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsi with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 21 specimens collected and placed under this sub-order are presented in Plate 14.

4.1.5.3 Identification for super-family under Sub-order Caelifera

Under Caelifera, Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for character antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna. Twenty one specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.5.4 Identification for family Acrididae under super-family Acridoidea

The identified 21 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in one group on the basis of similar morphological characters shown by them. In this one groups the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment,

tarsi of fore, middle and hind leg three segmented. First tarsai consist of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarge were observed and are presented in Plate 14. Indicating that only one group of Acrididae prevailing on green gram in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that this one group collected on green gram crop belongs to family Acrididae.

4.1.6 Acridids collected from Cotton

4.1.6.1 Identification for order Orthoptera

During the present study from collected different specimens of insect from Cotton field only 27 specimens could be grouped under order Orthoptera on the basis of their size which was medium to large, antennae filiform i.e. thread like with less than or more than 30 segment, head hypognathous in position with prothorax enlarged, hind leg with enlarge femora, mouth parts chewing type, forewing leathery, thickened i.e. tegmina type capable of bending and hind wing membranous fan type with large anal area. Abdomen having eleven segments with female having ovipositor. The stridulatory organs present.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for placing the insect under the taxonomical hierarchy Order – Orthoptera.

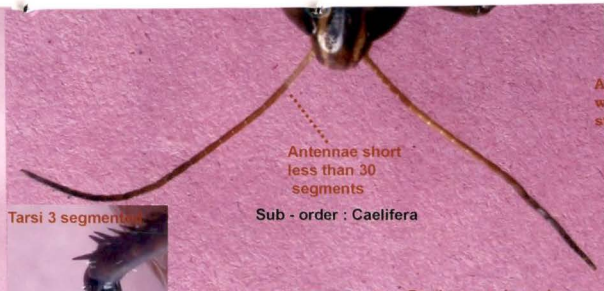
4.1.6.2 Identification for sub-order

a. Ensifera

The identified orthopterans were further grouped under sub-order, nine specimens showing long antennae with more than 30 segments or longer



Order : Orthoptera



Antennae short
less than 30
segments

Sub - order : Caelifera



Tarsi 3 segmental

Super - family : Acridoidea

Abdomen
with 8
sterna



Super - fam
Acridoidea



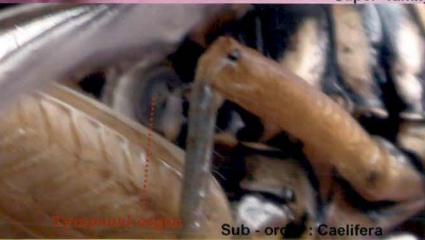
Ovipositor short
and robust

Family : Acrididae



Prothorax enlarged

Order : Orthoptera



Tympanal organ

Sub - ord : Caelifera

Plate 14 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Green-gram

than body, tympanal organ on fore tibia, tarsi three to four segmented. Ovipositor sword like more or less elongated were grouped under Ensifera. As this group was not related with Acridid they were not further studied.

b. Caelifera

Collected eighteen specimens (Table 1. Graph 1) had short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsi with three or less than three segments and ovipositor short and robust or absent. All these were placed in taxonomical hierarchy sub-order Caelifera.

Similar characters were considered by Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006) for grouping the Orthopterans in sub-order and same characters were observed in 18 specimens collected and placed under this sub-order are presented in Plate 15.

4.1.6.3 Identification for super-family under Sub-order Caelifera

Under Caelifera Tembhare (2005) has described two super family Acridoidea and Tridactyloidea. As the study is confined to super-family Acridoidea the collected specimens were studied for character antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna. eighteen specimens collected were grouped under this super-family which were further grouped for family characters.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) grouped the Caeliferan under super family Acridoidea on the basis of above characters which were also exhibited by the collected specimen under this study.

4.1.6.4 Identification for family Acrididae under super-family Acridoidea

The identified 18 specimens showing characters of family Acrididae under super-family Acridoidea were grouped in one group on the

basis of similar morphological characters shown by them. In this one group the morphological characters short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consist of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarge were observed and are presented in Plate 15. Indicating that only one group of Acrididae prevailing on Cotton in Akola vicinity.

Kirby (1914), Ambrose (2004), Tembhare (2005), Ragumoorthi et al. (2006), Castner (2008) had placed Acridid in family Acrididae. The present study coincides with the family key given by Gen and Homathevi (2004) and gives support to the present finding that this one group collected on Cotton crop belong to family Acrididae.

4.2 Orthopterans collected from different cropping systems

The Orthopterans collected from different cropping systems are detailed in Table 1 and Graph1

Table 1. Collections of Orthopteran from different cropping systems

Crops	Total Orthopterans collected	Sub-orders	
		Caelifera	Ensifera
Soybean	48	22	26
Sorghum	98	82	16
Maize	46	27	19
Pigeonpea	36	23	13
Green gram	29	21	08
Cotton	27	18	09
	284	193	91



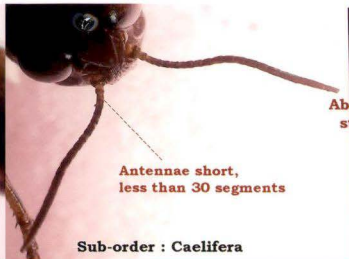
Order : Orthoptera



1 2 3

Tarsi 3 segmented

Super family : Acridoidea



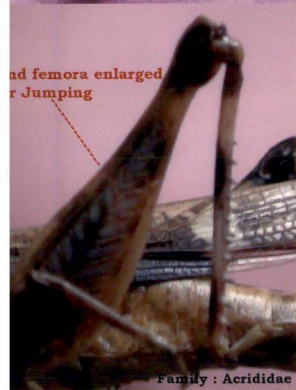
Antennae short,
less than 30 segments

Sub-order : Caelifera



Abdomen with 8
sterna

1
2
3
4
5
6
7



and femora enlarged
for jumping

Family : Acrididae



Tympanal organ

Sub-order : Caelifera



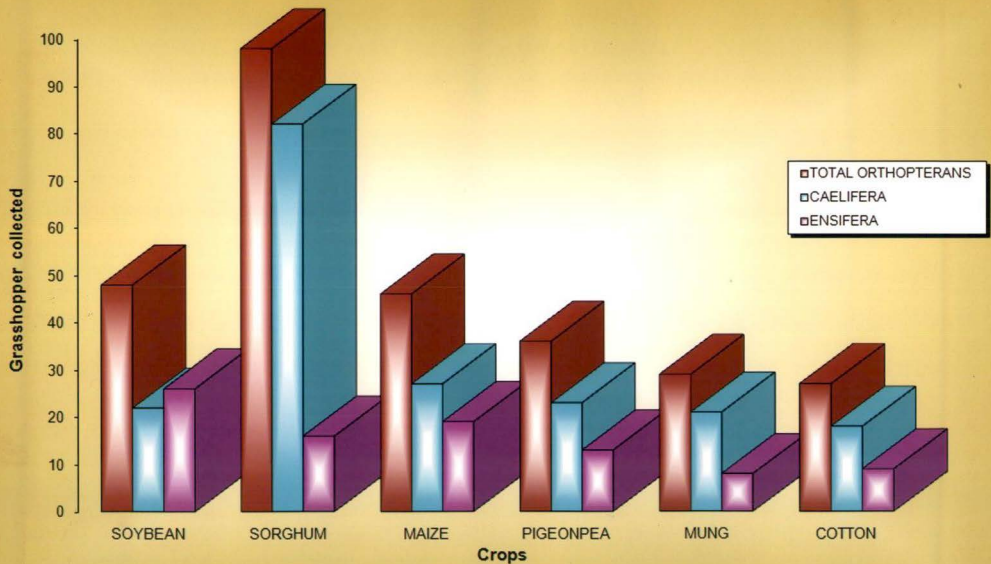
Ovipositor short and robust

Family : Acrididae



Super-family
Acridoidea

Plate 15 Identifying morphological characters of Order Orthoptera, Sub-Order Caelifera, Super-Family Acridoidea and Family Acrididae collected from Cotton



Graph 1. Collections of orthopteran from different cropping systems

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study was aimed to know about the "Acridid fauna found in different cropping systems in Akola vicinity". Study was carried out in Entomology Section, College of Agriculture, Akola and in Department of Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during July 2010 to January 2011. Grasshoppers were collected during this period from different cropping systems in Akola vicinity and could be collected from Soybean, Sorghum, Maize, Pigeonpea, Green gram and Cotton cropping system. The collected grasshoppers from each crop were grouped on the basis of morphological characters shown by them and were placed under Taxonomical hierarchy under Order, Sub-Order, Super-Family and Family. The study was focused on Orthopteran of Acrididae family those found during the present study are summarised below.

Grasshopper belongs to order Orthoptera and also includes locusts, crickets, katydids and related forms. Grasshoppers are polyphagous and prefer to feed on leaves of sorghum, pigeonpea, soybean, maize, Rice, millets, arhar etc. Locusts are well known pestiferous insects which not only move long distance but also destroy all green vegetable matter on their way and cause famine. For this study insects were collected from different cropping systems and were killed in killing bottle. After death of insect they were pinned, stretched and stored in the collection box. After wards insects showing similar morphological and taxonomical characters were grouped together. The groups showing the characters of order Orthoptera was further study and were placed in the sub-order, super-family and family.

Total 284 Orthopterans were collected from different cropping systems consisting of 193 caeliferans and 91 ensiferans. Indicating that the population of caeliferans were more than ensiferans. From the collected Orthopterans from Soybean, Sorghum, Maize, Pigeonpea, Green gram and Cotton cropping system 22, 82, 27, 23, 21, and 18 specimens were grouped

under sub-order Caelifera due to characters like; short antennae, less than the body length i.e. less than 30 segment. Tympanal organ on first abdominal segment, tarsi with three or less than three segments and ovipositor short and robust or absent.

The above collected specimens also showed the characters of super family Acridoidea like antennae shorter than body length with less than 30 segments, tympanal organ on lateral side of the first abdominal segment. Fore, middle and hind tarsi 3 segmented, pretarsum with arolium. Ovipositor short and well developed. Abdomen with eight sterna.

All the collected specimens showing similar morphological characters were further grouped together and on Soybean three, Sorghum one, Maize two, Pigeonpea three, Green gram and Cotton one group of Family Acrididae were found on the basis of characters like short antennae, shorter than body length with less than 30 segments, tympanal organ on lateral side of first abdominal segment, tarsi of fore, middle and hind leg three segmented. First tarsi consists of three pads, Pronotum not extending beyond the wings. Ovipositor not extended beyond the wings. Ovipositor short, row of pegs like projection on inner side of hind femur, hind femur enlarged.

Conclusion

The collection and identification data gives information that,

The Orthopterans which were collected from Soybean field were also found to feed on Maize and Pigeonpea. As there is increase in cultivating area under Soybean + Pigeonpea cropping system. There is likely to have increase in the population of these Acridids on Soybean and Pigeonpea cropping system and hence alertness is essential with informing locality.

The Orthopterans which were also collected from Soybean field were also found on Maize and Green gram indicating that the same Acridids were attacking on these crops and the species characters studied indicate that it belongs to species *Heteracris elegans*

Orthopterans collected from Sorghum were also found to feed on pigeonpea. Most of the farmers in multiple cropping system are taking one row of Sorghum in between the two rows of pigeonpea as both the hosts are feed by the Acridids. There is possibility of increase in the population of these Acridids and cause problem to the cultivated crop.

CHAPTER VI

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