DISCUSSION
The adults of *Choroedocus illustris* inhabits long grasses, dense bush and cultivated ground, migrate into cotton, sugarcane, rice, maize or vegetable crops for feeding purposes but return to grasses for shelter and egg-laying. It is a pest of forest plantations. Recently it has assumed a status of being a serious pest of bamboo in Aligarh. Hussainy (1951) reported it as a damaging sugar pest at Coimbatore (S. India). A confusion regarding univoltine life cycle has definitely been removed, as it is multivoltine in laboratory, might be single generation in nature due to environmental conditions incompletely recorded by Tinkham (1940). Sporadic changing ethology during outbreaks with special reference to nutritional ecology regarding crops under attack has been of great interest in Acridology.

The adults of *Acrida exaltata* inhabit grasslands but at times become serious pest of cotton in north India. They remain solitary but sometimes become gregarious and able to make swarmlets (Rizvi, 1985). Tinkham (1935b) and Hafez and Ibrahim (1958) have recorded its limited range of food plants. The present observations show that it has considerable large range of food plants.
Very little was known about these two species of great economic and agricultural importance and the present observations will complete the biological information about them to make an eco-ethological profile needed.

The details of the colour patterns have been examined in a very large number of hoppers so that the greater parts of the range and the form that the variation of coloration takes have been described. Three components of the colour patterns studied have been selected as being of greater importance principally because they are more easily measured. The treatment of the data has been as simple as possible but the results are considered to be promising because, within the range of material studied, the differences between the samples in respect of these three characters have shown a consistent association with differences of population histories. Similar observations were studied by Stower (1959) in the hoppers of desert locusts. The present work suggests that the association between hopper coloration and population may be close, although some authors (Gunn & Hunter – Jones, 1952), while studying Desert locusts, believe that precision in the biology might be illusionary. Pasquier (1952) emphasised that the colour, morphology and behaviour may not vary synchronously while studying phase differentiation and theory in Desert locusts. It was noted that the behaviour changes might occur much more rapidly than morphological changes. Rizvi (1985) suspected colour patterns
exhibited by *Choroedocus illustris* and *Acrida exaltata* and suggested that the characters are on the same pattern as in established locust species and termed it as 'Locust in making'. The author do not agree with Goodwin (1952) that the darkening of colors increases at low temperatures as compared to higher temperatures where colours are reduced. This is not true in these two occasionally gregarious acridids where darkening increased with increase in temperatures.

The act of copulation in these two species has been preceded by elaborate courtship which is of immense interest with reference to the time of copulation lasting about 311.00±45.46 minutes in *Choroedocus illustris* and 179.40±14.60 minutes in *Acrida exaltata*. The data is variable which can be attributed to the number of attempts successful and low temperature of the night. Similar observations have been recorded by Srivastava (1957) in *Atractomorpha crenulata*; Gregory (1961) in *Locusta migratoria migratorioides*; Hafez and Ibrahim (1958) in *Acrida pellucida* and Basit (1990) in *Gastrimargus africanus* and *Oedaleus abruptus*.

The mechanism involved in oviposition was found to be a typical acridian pattern such as digging, making false holes and showing selection preferences to soil texture. The average egg-laying process was 210.50±17.05
minutes while minimum was 130 minutes and maximum was 295 minutes in *Choroedocus illustris* and average egg-laying time for *Acrida exaltata* was 188.70±10.50 minutes while the minimum was 135 minutes and maximum was 256 minutes. The time of egg-laying was also variable during rainfall. Similar observations by Iqbal and Aziz (1974), Basit (1990) in *Eyprepocnemis alacris* and *Oedaleus abruptus*, respectively are in agreement with the present author.

The size of the egg-pod is mainly determined by the number of eggs per female. In *Choroedocus illustris* the average number of egg-pods per female was found to be 5.30±0.218 (Isolated condition) and 4.40±0.244 (Crowded condition) and the size of egg-pods laid earlier was longer than laid later. In *Acrida exaltata*, the average number of egg-pods per female was 4.90±0.481 (Isolated condition) and 3.50±0.453 (Crowded condition). The observations clearly reveal that the number of egg-pods and with their size can provide the total number of eggs expected by the species. Observations made by Majeed (1978) in *G. transversus* and by Basit (1990) in *Oedaleus abruptus* and *G. africanus* are on the same contention and agreement.

The present observations reveal that the isolated and crowded conditions affect the average fecundity of female of *Choroedocus illustris* and *Acrida exaltata*. Similar observations have been made by Norris (1950, 1952) in
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Locusta and in Schistocerca, Albrecht (1959) in Nomadacris and Basit (1990) in G. africanus and Oedaleus abruptus. The behaviour can be attributed to a polymorphic behavioural pattern and appear to be significant in such species which are said to be occasionally gregarious.

Average number of eggs per egg–pod was found to be 64.80±2.65 in Choroedocus illustris and 31.30±2.20 in Acrida exaltata under isolated condition. Khan (1974) recorded similar observations in Oedaleus abruptus while Basit (1990) recorded more eggs in an egg–pod in the same species. Majeed (1978) recorded a range of eggs per pod without mentioning reason. Variation in size of egg–pods obviously can be attributed to the number of eggs per pod and the variations were recorded in Choroedocus illustris and Acrida exaltata also. Norris (1950) and Ewer (1977) have recorded gradual decrease in size of the egg–pods, if laid many times by a single female in Schistocerca gregaria and Locusta migratoria respectively and these observations are in agreement with the present author in Choroedocus illustris and Acrida exaltata fundamentally.

The incubation period and hatching time in acridoids in general are recorded by Bernays (1971b) for Schistocerca are of great significance. The temperature, moisture and food have been reported to play an important role in
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successful hatching. Number of observations made by Basit (1990) and by the present author in acridoids shows similar phenomenon and going accordingly.

Attempts made by Ackonor (1988) regarding effects of soil moisture and temperature on hatchling and survival in *Locusta migratoria migratorioides* is of significance and Amatobi (1996) on egg development and nymphal emergence of *Kraussaria angulifera* in relation to rainfall has been supportive to the ecological behaviour shown by these two species, *Choroedocus illustris* and *Acrida exaltata* under study with the same ecological niches. This finding made by Gapparov and Latchinisky (2000) regarding consequence of ecosystem on acridid diversity and abundance also support fully the present findings.

Diapause does not occur at any stage of the life cycles of *Choroedocus illustris* and *Acrida exaltata*. It is possible to obtain 4–5 generations in a year in laboratory as well as in the field conditions. The egg diapause has been recorded in *Gastrimargus africanus* by Golding (1948) but species like *Oedaleus abruptus* and *Gastrimargus africanus* found with *Choroedocus illustris* and *Acrida exaltata* have not shown any diapause phenomenon (Basit, 1990) and the observations on diapause of *Locusta migratoria cinerascens* suggest that the photoperiod may cause diapause in non–diapausing species but
it has not been observed in present species under study. Similar observations were made by Basit (1990) in *Oedaleus abruptus* and *Gastrimargus africanus*. The present author could not find diapause at any stage of life cycle with a long dry season in Aligarh in case of these two species. This observation may suggest that the causes of diapause be initiated with multiple combinations of ecological gadgets.

The development of hoppers is of great interest and many acridologists have reported variations in the number of hopper instars from 4–6 in males and 5–7 in females. In *Choroedocus illustris* and *Acrida exaltata* there is slight variations in hopper instar numbers such as 5 in males and 7 in females and 6 in males and 8 in females, respectively under natural conditions but under laboratory conditions there is no such variation, only 5instars in both the sexes have been observed, but on an average and mostly in both cases the life cycle consists of nymphal instars.

Basit (1990) has reported similar biological profile of nymphal instars in *G. africanus* and *O. abruptus*, the species found in the same pattern of niches with the species under study. The number of hopper instars and their variations between species has been attributed to the food of grasshopper but present author does not agree to it as the present two species have not shown any
Impact of quality and quantity of food on nymphal instars but do effect the nymphal duration in *Choroedocus illustris* and *Acrida exaltata*. Recently Rizvi *et al.* (2003) have reported nymphal duration under crowded and isolated conditions in *Acrida exaltata*. Earlier similar behaviour was reported by Rizvi *et al.*, (1975) in *Hieroglyphus nigrorepletus*. It means that many factors may affect nymphal duration and instar numbers instead of food alone.

Roonwal's (1952b) statement that most species pass through 5–instars are available for tropical species. All contentions regarding nymphal instars cannot be accepted till 2002 but in 2003, the field and laboratory experience of 20 years (Rizvi, 1985) suggests that the number of nymphal instars in acridoids may be attributed to the combination of abiotic and biotic environments as well as pressure by the biological control agents from time to time. The present author agrees with Basit (1990) reporting that the trends towards reduction in number of instars in acridids may be attached to the size of the species.

A variation in colour and its pattern has also been recorded from instar to instar up to an adult stage. Observations made by Hunter–Jones and Ward (1959), Rowell (1970), Richard & Waloff (1954), Basit (1990) in *Gastrimargus africanus*, in various British grasshoppers and *Oedaleus abruptus* respectively are of immense value in acridid ethology. Rowell (1970)
suggested that the environment determines the coloration in *Gastrimargus africanus*. Rizvi (1985) had created a concept of chromoecology as a visual gadget in phase polymorphism in acridoids. The present author has confirmed the concept through experiments on *Choroedocus illustris* and *Acrida exaltata* and other’s findings Badruddin *et al.*, (2003) and Khan *et al.*, (2003) have also supported the Rizvi’s concept and such chromatic changes are presented as bioindicators of the environmental and biological (crowding) changes. Some useful observations made by Guerruci and Viosin (1988) on the influence of environmental factors on the colour morphs, by Sobolev (1990) on the cryptic behaviour of locusts, by Garlinge *et al.*, (1991) on sex–related morphs frequencies in *Acrida conica*, by Islam *et al.*, (1994) on parental effects on the colouration, by Suresh and Muralirangan (1995) a colour morphs of *Acrida exaltata* in the agroecosystem of Tamil Nadu, by Briddle *et al.*, (2001) speciation in grasshoppers with colour pattern and by Schmidt and Albutz (2002) on sex–linked coloration in desert locust have contributed in establishing a new aspect of acridid ethology based on chromatic changes under certain influences and simultaneously may be used as bioindicators accordingly.

Dyar’s law (1890) has been successfully applied to hopper instars of *Choroedocus illustris* and *Acrida exaltata* as applied by Basit (1990) in *G.*
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*africanus* and *O. abruptus*. However no other reference on Dyar’s law in acridoids is available. Majeed (1978) has applied the law in *G. transversus* but the number of observations are not convincing.

The eggs of *Choroedocus illustris* and *Acrida exaltata* are laid in moist soil and hatching was influenced by temperature and humidity gradients. Incubation period was reduced with the lowering of temperature and humidity and vice-versa. Viability of eggs, successful percentage of hatching and survivability was found directly proportional to the optimum temperature, relative humidity gradient accordingly.

Grewal and Atwal (1968) in *Chrotogonus trachypterus*, Iqbal and Aziz (1973) in *Spathosternum prasiniferum*, Basit (1990) in *G. africanus* and *Phlaeoba infumata* have reported similar observations accordingly with reference to environmental factors. A convincing contention made by Montealegre *et al.*, (1998) is in agreement with the present author.

Temperature and relative humidity have been found affecting the hopper duration and developmental index as recorded by the present author in *Choroedocus illustris* and *Acrida exaltata*. Basit (1990) has concluded with the same contention and results while working on *O. abruptus* and *G. africanus*. 
Similar attribute has been observed by Pradhan and Peswani (1961) in Hieroglyphus nigrorepletus, Parihar (1971) in Poekilocerus pictus, Iqbal & Aziz (1973) in Spathostenum prasiniferum. Basit (1990) has reported that 37°C was also favourable for the development of hoppers of G. africanus and O. abruptus and the present author find similar reaction in Choroedocus illustris and Acrida exaltata.

Thus on the basis of the present observations, it may conveniently be suggested that increase in the developmental indices at the increasing temperature and relative humidity is due to rapid consumption of more food material.

The life cycles of Choroedocus illustris and Acrida exaltata are quite similar in biological profile except insignificant delay of moulting behaviour in Acrida exaltata as compared to Choroedocus illustris. Both species have two complete generations in a year and one is overlapping. The first hatching determines the continuance in the development of various stages and the rate of development. Those acridids, which are found in temperate climate with cold winters as found in Aligarh, may be considered as diapause inclined species. Variations in periods and time may be attributed to abiotic regimes experienced by all stages of life cycle. Similar observations by Descamps (1953); Katiyar
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(1960); Chapman (1961b); Uvarov (1966); Rizvi (1985); Lecoq (1991); Marta Cigliano (2000) are in agreement with the present author in contention and observations as well.

Seasonal variations in the field population of *Choroedocus illustris* and *Acrida exaltata* in different months of the year 2001, 2002, 2003 and 2004 have been recorded by the present author. On similar pattern, the observations on European grasshoppers, Italian locusts, red locusts and desert locust have been recorded by Lensink (1963), Adamovic (1959), Richards & Waloff (1954), Uvarov (1966) accordingly.

Adults of these two species are well adapted to all existing ecological changes and were recorded even in December & January but without reproductive activity.

The population studies of *Choroedocus illustris* and *Acrida exaltata* with reference to seasonal variations are based on numerical counting of all stages through random catches and their small-scale movements. Seasonal variations in north India are of special importance because of open Savanna in Aligarh. The present observations are on the similar pattern used excellently by Richards and Waloff (1954) in British grasshopper. It is imperative to have
preferential values of food of habitat as an important factor so much so that the variations in sex populations are also exhibited. The present author agrees with Richards and Waloff (1954) with reference to all parameters used in the study of population dynamics of these two acridids. However, it was not very convincing that predators play a significant role in population fluctuations.

The distribution of acridoids under study may be correlated with the food plants of the area where populations were maintained. Similar correlation has been established by Anderson & Wright (1952); and Iqbal & Aziz (1975). Early stages of *Choroedocus illustris* and *Acrida exaltata* prefers weeds and grasses and invade crop field while entering into advance stages of life cycle, may be attributed to different type of nutritional preference in food plants. This has got support from Basit (1990) who has concluded with the same contention in *G. africanus* and *O. abruptus*.

Food preferences shown by the acridid under study and projectile is in agreement with Basit (1990) while working on *Gastrimargus africanus* and *Oedaleus abruptus* and the basis involved agrees with Livingstone and Pugalenthi (1992) working on nutritional ecology.
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The developmental processes were found to be affected by relative humidity as well recorded in the present species and found similar in effect as recorded by Basit (1990) in *Gastrimargus africanus* and *Oedaleus abruptus*.

The most important aspects of the present studies have been morphometry in relation to suspected gregariousness and chromoecology as bioindicator of the environmental as well as behavioural changes. All morphometrical parameters involved in locust phases have enhance to 16 indices and body parts ratios, thus, analysed have been amazingly found significant confirming that the occasional gregarious behaviour of these two species recorded by Rizvi (1985) is confirmed and supported by chromatic changes as shown by locusts explained excellently by Stower (1959) and also some experiments during morphometrics and chromo-ethology, without any skeptical contention, proves that the two species, though, occasionally gregarious, but definitely inclined towards 'locust in making'.

The fundamental observations made by Tatsute *et al.*, (2000), Schmidt (2001), Rehman *et al.*, (2002) and Colombo (2003) while working on polymorphism in acridid with reference to morphometrics has been found fully justified and in agreement with the present author.
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Occasional gregarization and discontinuous aggregation in *Choroedocus illustris* and *Acrida exaltata* are of great biological significance. Similar excellent observations have been made by Joyce (1952b), Ghouri & Ahmad (1960), Basit (1990) in *G. africanus* and *O. abruptus* respectively. The differences in size, colours in gregarious and solitary individuals suggest that the species under study have the tendency of unstable gregariousness and may become ‘locust in making’

Therefore, present studies though not in totality, may be suggestive that *Choroedocus illustris* and *Acrida exaltata* have a tendency of gregariousness and phase formation ability and comparable to non–gregarious phase and formation of swarmlet requires more extension in its ethological profile with reference to ecological–cum–behavioural–cum–morphometrical studies on the same locust pattern and certainly will complete the information accordingly asked for.