Non Banded and C-banded Karyotypes of Ten Species of Short Horned Grasshoppers (*Acrididae*) from South India

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Summary  The non-banded and C-banded karyotypes of 10 species of South Indian short horned grasshoppers of the family *Acrididae* with diploid number 23 in males and 24 in females were studied. All the species except *Dociostaurus species A.* and *Leva indica* have shown telocentric chromosomes. Interspecific non-banded and banded karyotypic comparison and its evolutionary implications are discussed.

Key words  Acrididae, Grasshoppers, Chromosomes, Karyotype, C-banding.

Karyotype forms the cytological basis of species identity. Acrididae is known for its karyotypic uniformity or conservatism. But the instances of karyotypic variation with respect to number and morphology of chromosomes are observed in natural populations, which will add to the evolutionary pattern of a species.

One of the mechanisms of species differentiation is the C-banding of chromosomes. C-banding technique has proven very effective for chromosomal identification and characterization and the pattern of C-banding has been found to be characteristic for a species or at least to a group of species (Kalkman 1984). King and John (1980) have found a remarkable degree of C-band variation between many species of grasshoppers. In addition, Acrididae showed a C-band variation even within the same species (Shaw *et al.* 1976, Webb 1976, John and King 1977).

In the present paper the karyotype and the distribution of C-heterochromatin in 10 species of Acrididae are presented and the possible evolutionary significance has been discussed.

Materials and methods

The males and females of 10 species belonging to 3 sub families of Acrididae were collected in and around Mangalore University Campus, South India and chromosome preparations were made using hepatic caeca following the standard Colchicine-hypotonic-cell suspension-flame dry technique. The flame dried slides were treated for C-banding following the method of Sumner (1972) with little modifications. The chromosomes were classified after Levan *et al.* (1964) and appropriate karyotypes were constructed.

Results and discussion

The somatic chromosome preparations of the species of Tryxalinae, Oedipodinae, Catantopinae in the Acrididae under study exhibited XX : XO pattern of sex determining mechanism.

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Non banded chromosomes

All the species are characterized by a common diploid number (2n=23 (♂), 2n=24 (♀)). They have only telocentric chromosomes except in Dociostaurus species A. and Leva indica. The morphometric details and chromosomal features are shown in Table 1 and Fig. 1 respectively.

Tryxalinae

In the 4 species studied (Table 1), of the 11 pairs of autosomes it is only in the last 3 pairs (9–11) of small chromosomes considerable variations in the size are observed. The remaining 8 pairs (1–8) are large to medium size in nature (Fig. 1). The 10th pair of autosomes in Aiolopus thalassinus tamulus is almost the same size of 9th pair when compared to other three species wherein both 10th and 11th pairs are almost equal in size. In addition, the 9th pair of autosome in Dociostaurus species A. is a true biarmed submetacentric chromosome whereas in other three species they are telocentrics (Fig. 1b).

Oedipodinae

Like in the previous sub family, the 4 species (Table 1) revealed large to medium telocentric pairs (1–8) and the remaining 3 pairs (9–11) are small and show variations. The 9th pair in Leva indica is heteromorphic having a metacentric and a telocentric chromosome (Fig. 1h). The 11th pair of Acrotylus humbertianus is the smallest pair and the chromosomes are distinct and exhibit clear short arms (Fig. 1g).

Catantopinae

The 2 species (Table 1) possess 8 pairs (1–8) of large to medium sized and 3 pairs (9–11) like in other species of small telocentric autosomes.

The X chromosome is comparatively larger in all the species except in Aiolopus thalassinus tamulus (second largest—Fig. 1d) and Spathosternum prasiniferum (Third largest—Fig. 1j) (Table 1).

C-banded chromosomes

The C banded chromosomes in different species of Tryxalinae, Oedipodinae and Catantopinae have revealed the distribution of heterochromatin in different ways. The centromeric and pericentromeric blocks of heterochromatin have been observed in all the species investigated, while conspicuous intercalary (interstitial) and terminal (telomeric) heterochromatin distribution were found only in Dociostaurus species A. (Fig. 2b) and Stauroderus bicolor (Fig. 2c) and X chromosomes of Leva indica exhibit telomeric C-heterochromatin (Fig. 2h).

The interspecific comparison of total heterochromatin content of the complement, revealed that in the subfamily Tryxalinae, the Stauroderus bicolor has shown maximum amount of (28.34%) heterochromatin while Acrida exaltata has shown small amount of (16.7%) heterochromatin and those of Dociostaurus species A., and Aiolopus thalassinus tamulus contained 23.87% and 24.65% of heterochromatin respectively.

Among the species of Oedipodinae maximum amount of total heterochromatin content of the complement was observed in Morphacris fasciata (38.47%) and a small amount of heterochromatin (17.15%) was observed in Leva indica, while 25.85% and 29.17% of heterochromatin were seen in Acrotylus humbertianus and Oedaleus abruptus respectively.

In Oxya velox a total of 46.43% and in S. prasiniferum a total of 26.59% of heterochromatin were observed in the subfamily Catantopinae.

Acrididae in general have shown two types of karyotypes, one with the diploid number of 23 chromosomes in males and 24 in females (Cryptosacci) and the other type with 19 in males and 20 chromosomes in females (Chasmosacci). In the present study, all the species seem to belong to
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Species</th>
<th>Male 2n number</th>
<th>Chromosome size groups</th>
<th>Range of relative length (LR) of autosomes (µm)*</th>
<th>Nature of chromosomes</th>
<th>Nature of X chromosomes</th>
<th>L5 of X chromosomes (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Acrida exaltata</td>
<td>23</td>
<td>4 5 2</td>
<td>(34.5±0.72)</td>
<td>—</td>
<td>All</td>
<td>144.57±0.41</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>(122.4±0.46)</td>
<td></td>
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</tr>
<tr>
<td>2.</td>
<td>Dociostaurus species A.</td>
<td>23</td>
<td>4 5 2</td>
<td>(37.05±0.78)</td>
<td>—</td>
<td>9th 1–8; pair</td>
<td>147.15±4.34</td>
</tr>
<tr>
<td></td>
<td>Stauroderus bicolor</td>
<td></td>
<td></td>
<td>(128.38±2.11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>Aiolopus thalassinus tamulus</td>
<td>23</td>
<td>4 6 1</td>
<td>(39.06±0.39)</td>
<td>—</td>
<td>All</td>
<td>138.51±1.52</td>
</tr>
<tr>
<td></td>
<td>fasciata</td>
<td></td>
<td></td>
<td>(119.48±1.32)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td>Morphacris thalassinus tamulus</td>
<td>23</td>
<td>4 5 2</td>
<td>(34.26±0.36)</td>
<td>—</td>
<td>All</td>
<td>119.14±1.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(124.74±0.83)</td>
<td></td>
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<tr>
<td>5.</td>
<td>Morphaeus thalassinus tamulus</td>
<td>23</td>
<td>5 3 3</td>
<td>(34.2±0.68)</td>
<td>—</td>
<td>All</td>
<td>135.48±2.26</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(124.22±2.2)</td>
<td></td>
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</tr>
<tr>
<td>6.</td>
<td>Oedaleus abruptus</td>
<td>23</td>
<td>4 4 3</td>
<td>(29.47±0.32)</td>
<td>—</td>
<td>All</td>
<td>141.47±1.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(131.65±1.02)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>7.</td>
<td>Acrotylus humbertianus</td>
<td>23</td>
<td>4 5 2</td>
<td>(39.12±0.94)</td>
<td>9th</td>
<td>9th pair</td>
<td>143.27±2.85</td>
</tr>
<tr>
<td></td>
<td>Leva indica</td>
<td></td>
<td></td>
<td>(125.62±1.37)</td>
<td></td>
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</tr>
<tr>
<td>8.</td>
<td>Oxya velox</td>
<td>23</td>
<td>4 6 1</td>
<td>(44.84±0.9)</td>
<td>—</td>
<td>9th pair</td>
<td>141.02±2.7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(113.67±3.06)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Spathosternum prasiniferum</td>
<td>23</td>
<td>4 4 3</td>
<td>(34.18±0.6)</td>
<td>—</td>
<td>All</td>
<td>112.86±2.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(135.82±2.52)</td>
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</tbody>
</table>

Fig. 2. C-banded karyotypes of a) *Acrida exaltata*, b) *Docioastaurus species A*, c) *Stauroderus bicolor*, d) *Aiolopus thalassinus tamulus*, e) *Morphacris fasciata*, f) *Oedaleus abruptus*, g) *Acrotillus humber-\texttt{t}ianus*, h) *Leva indica*, i) *Oxya velox*, j) *Spathosternum prasiniferum*. Arrows indicate submetacentric and metacentric pairs.
Cryptosacchi group. The telocentric nature of chromosomes were observed in the present study is in line with the earlier reports (Hegde 1981, Kumaraswamy and Rajasekarasetty 1984). The presence of short arm in the chromosomes of *Aiolopus thalassimus tamulus* and *A. humbertianus* is consid-

erated to be the centric chromomeres or the extensions of the centromeres (John and Hewitt 1968). The occurrence of a metacentric chromosome in *Leva indica* and a submetacentric pair in *Do-

ciostaurus species* even with male diploid number of 23 chromosomes, suggested that this change in the chromosome form may be due to structural rearrangements within the complement it-

self *i.e. due to pericentric inversion. Similar situation has been reported in a locust *Chortoicetes termi-

nifera* (Hewitt and John 1971); in Australian *Catantopid*, *Percassa rugifrons* (John and Freeman 1975); in *Acrida exaltata* (Hegde 1981) and in *Gastrimargus africanus* (Aswathanarayana et al. 1981, Channaveerappa and Ranganath 1997).

It is possible that only smaller autosome pairs (9–11) are vulnerable for changes and the re-

maining autosomes including the sex chromosomes are more or less conserved in the grasshopper species analysed.

It is advocated that the possible mechanism of change effecting the distribution of C-heterochromatin have operated in different ways in different geographical areas (Santos et al. 1983). The absence of correlation between C-heterochromatin and genome size was also reported by King and John (1980). Santos et al. (1983) did not find any clear relationship between similarities in C-

banding patterns and taxonomic proximity and this is true in the subfamily Tryxalinae, Oedipodi-

nae or Catantopinae as seen in the present study.

The comparison of interspecific C-banding patterns of the same subfamily has no clear corre-

lation. The species from the same genus have not shown uniformity in their C-banding pattern (Shaw et al. 1976, Webb 1976, John and King 1977, Webb and Neuhaus 1979, Santos and Giraldez 1982). Same situation has been observed in the present study where genera coming under different subfamilies show some C-banding similarity (*Stauroderus bicolor, Oedulius abruptus*) while, the species from the same subfamily differ in their C-band distribution pattern (*S. bicolor, Aiolopus thalassimus tamulus, Acrida exaltata*).

The C-band study revealed differences in heterochromatin distribution with reference to the size and the intensity of bands and presence or absence of interstitial or telomeric bands as reported by earlier workers (Kumaraswamy 1977, Hota and Patnaik 1989, Yadav and Yadav 1993, Subhudhi 1993). For instance, total heterochromatin content of the complement in *Aiolopus thalassimus tamu-

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### Table 2. C-band distribution in acrididae species analysed

<table>
<thead>
<tr>
<th>Species</th>
<th>C-band sites</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family: Acrididae</strong></td>
<td>Centromeric</td>
</tr>
<tr>
<td><strong>Sub Family: Tryxalinae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Acrida exaltata</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Dociostaurus species A.</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Stauroderus bicolor</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Aiolopus thalassimus tamulus</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><strong>Sub family: Oedipodinae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Morphacris fasciata</em></td>
<td>1, 11, X</td>
</tr>
<tr>
<td><em>Oedaleus abruptus</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Acroryulus humbertianus</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Leva indica</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><strong>Sub family: Catantopinae</strong></td>
<td></td>
</tr>
<tr>
<td><em>Oxya velax</em></td>
<td>1–11, X</td>
</tr>
<tr>
<td><em>Spathosternum prasiniferum</em></td>
<td>1–11, X</td>
</tr>
</tbody>
</table>
lus has been measured at 24.65% in the present study while Channaveerappa and Ranganath (1997) have reported 43.76% for the same species of Mysore population. *Morphacris fasciata* has shown 36.47% of total heterochromatin while in a related species *Morphacris citrina*. Channaveerappa and Ranganath (1997) have reported the same to be 35.53% for Mysore population. *Oxya velox* in the present study has shown 46.43% of the total heterochromatin, while in the related species *Oxya fus-covittata*, Channaveerappa and Ranganath (1997) have reported 41.99% of the heterochromatin. The difference in the heterochromatin content might be due to the environmental factors or geographical differences in the distribution of species.

Many characteristic features of heterochromatin such as its dynamism, repeated nature, genetic inactivity and possibility of reactivation of genes indicate that it must have had to play a significant role in cytoevolutionary process in Acridoidea. Restriction of C-heterochromatin to centromeric region might facilitate whole arm translocation. White’s (1973) proposition that even the smaller changes in the amount and distribution of heterochromatin may have contributed towards speciation in grasshoppers as observed in *Dociostaurus species A.*, *Stauroderus bicolor* and *Leva indica*.

Acknowledgements

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References


Santos, J. L. and Giraldez, R., 1982. C-heterochromatin polymorphism and variation in chiasma localization in *Euchorthip-


