Chromosome Cytology, Reproductive Behavior, and Ecology of the Insect Order Neuroptera

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The investigations conducted at the Research Station during the summer of 1970 were a continuation of those initiated the previous summer and were conducted in much the same way. Living material of certain important montane species was secured and a preliminary cytological examination was made, in the field, of male testes (meiosis) and of the early embryonic stages in eggs laid by females (mitosis). Additional eggs were allowed to hatch and the resulting larval stages were either preserved for future study and description, or were transported alive back to my laboratory at the University of Illinois. These latter were used to initiate laboratory cultures and these have allowed experimental investigations into such aspects of the biology of the species as their diapause phenology and courtship behavior as well as more detailed studies of their cytology. Additional adult specimens collected during the summer provided information, through the examination of gut contents, on adult food habits and, of course, all field work during the summer added to accumulating knowledge of the distribution of the habitats of different species through the regions studied.

A second feature of this past summer's field work was a collaboration with Professor Sally Hughes-Schrader of Duke University who is currently investigating the mechanics of meiosis in the Hemerobiidae, a family very closely related to the Chrysopidae. The males of the Neuroptera have long been known to possess the cytological peculiarity of having their sex chromosomes unsynapsed during meiosis, although these X and Y chromosomes segregate quite normally during the first meiotic anaphase. Certain European members of the Hemerobiidae belonging to the genus *Kimminsia* have been reported to be exceptions to this rule by forming a true sex bivalent in normal fashion during meiotic Prophase I. Since species of *Kimminsia* are rather specialized neuropterans, it has seemed likely to us that either the observations on the European species have been incorrectly interpreted or these insects have recently evolved a new mechanism for the disjunction of the meiotic sex chromosomes. In either case a reexamination of the meiotic cytology of *Kimminsia* seemed called for and since in the Nearctic Region this is essentially a western boreal group, the region of Jackson Hole was admirably suited to this undertaking. In addition to this study, a number of other species of hemerobiids were collected for Professor Hughes-Schrader's more extended studies of meiosis in this family.

PRELIMINARY SUMMARY OF RESULTS

Cytology of the Chrysopidae - A total of four species, representing the genera *Chrysopa* (2 species), *Eremochrysa* (1 species), and *Meleoma* (1 species) was secured and examined cytologically. The karyotypes and sex-determining mechanisms of these species are summarized in Table I.

TABLE I - Chromosome Cytology of Species Studied

Species	Karyotype	Sex Determination
Chrysopa apache	2n = 12 (12R)*	X:Y (X>Y)
C. n. sp.	2n = 12 (10R + 2J)	X:Y (X=Y)
Eremochrysa canadensis	2n = 12 (10R + 2J)	X:Y (X=Y)
Meleoma emuncta	2n = 12 (12R)	X:Y (X=Y)

*The abbreviations used for chromosome shape are: R = rod-shaped (acrokinetic) chromosome, with a near-terminal kinetochore; J = J-shaped chromosome, with obviously subterminal kinetochore; V = V-shaped chromosome (metakinetic), with a median kinetochore.

Probably the most important ramifications of these findings are those which relate to the karyotypes of Chrysopa n. sp., Eremochrysa canadensis and C. apache. The new species of Chrysopa is quite similar in appearance and ecology to C. oculata and C. pleuralis, both of which were studied in some detail last year. Cytologically C. n. sp. differs strikingly from both C. oculata and C. pleuralis in the form of the Y chromosome, which is a very tiny element in the latter two species while it is much larger and indistinguishable from the X chromosome in the undescribed species. These three species form a very homogeneous species group within their subgenus which differ strikingly from the other members of the subgenus in their karyotypes. Quite obviously the processes of speciation within this small group of three species has involved important modifications of the sex-determining mechanism.

The securing of specimens of Eremochrysa canadensis and C. apache has permitted the first examinations of the karyotypes of two very distinctive taxonomic sections of the Chrysopidae. E. canadensis is a member of the unusual subgenus Lolochrysa, and the inclusion of a pair of J-shaped chromosomes in its karyotype was an unexpected discovery since the three other species of this genus whose chromosomes are now known (all belonging to the subgenus Eremochrysa) have all 12 of their chromosomes acrokinetic. Whether this difference is simply a unique feature of E. canadensis or will turn out to be distinctive of the subgenus Lolochrysa is not yet known; however, the occurrence of a pericentric inversion in the ancestry of either the species of the subgenus Eremochrysa or of E. canadensis is strongly indicated.

Chrysopa apache belongs to an equally distinctive subgenus of Chrysopa, and the discovery of its karyotype adds yet another example of a taxonomically distinct group of this family possessing a karyotype of 12 acrokinetic chromosomes. Since many of these groups are only very distantly related, their possession of closely similar karyotypes raises the important question of how this similarity was evolved. Other cytological considerations suggest very strongly that ancestral chrysopids had somewhat higher chromosome numbers, in the range of 2n=16, so that it cannot be argued that the common possession of karyotypes with 2n=12 acrokinetic chromosomes in distantly related groups is likely to have resulted from an inheritance from some common ancestor. The possibility, then, is strongly suggested that this wide-spread karyotype represents some sort of efficient solution to the problems of the cellular mechanics of mitosis or meiosis or, perhaps, that it presents an adaptively superior system for the storage or recombination of genotypes. Both of these ideas are worthy of future investigation, as they have general relevance to the study of the factors governing the evolution of genetic systems.

Reproductive Behavior - As noted in my previous annual report, studies of the reproductive behavior of chrysopids necessitates a rearing of virgin males and females. Difficulty was again encountered in achieving this because of the generally low temperatures of the region of Jackson Hole which, in spite of the heating system installed in the lab last year, so slowed down the development of my insects that I deferred investigations of this aspect of the biology of these species until I had returned to the University of Illinois. At the present time Chrysopa apache and Eremochrysa canadensis have been studied in some detail by myself and one of my students and certain obvious differences between each of these species and between these species and others in the family have been recorded. The courtship of C. apache is especially interesting and shows certain similarities to species of the genus Nodita. The exact meaning of these similarities is not yet clear at the moment.

Ecology - Analysis of adult food habits, using stomach contents, has provided the food habits of three of the four species studied during the summer. The new species of Chrysopa is certainly a predator on aphids and certain other small, leaf-inhabiting Homoptera. In this feature it is also like its two other close relatives in the region of Jackson Hole, and the question of just what the detailed ecological differences between these three species actually entail is an intriguing one. C. apache, Eremochrysa canadensis, and Meleoma emuncta all seem to feed on pollen and the complex of fugal species growing on the aphid honeydew which commonly coats the surfaces of leaves during the summertime.

The diapause stage and the approximate environmental control (where present) initiating diapause has been determined for the four species studied during 1970 as well as for the six species brought back to my lab from the field in 1969. These relationships are summarized in Table II.

TABLE II - Diapause Biology of Species Studied in 1969 and 1970

Species	Diapause Stage	Induction of Diapause
Chrysopa apache	3rd instar larva	facultative (short days)
C. coloradensis	prepupa	" "
C. excepta	"	" "
C. oculata	"	" "
C. pleuralis	"	" "
C. n. sp.	"	" "
Chrysopiella n. sp.	"	obligate
Eremochrysa canadensis	"	facultative (short days)
E. punctinervis	2nd instar larva	" "
Meleoma emuncta	prepupa	" "

In all of these species except the new species of Chrysopiella it has been determined that the presence or absence of diapause in a given generation is largely determined by the length of the environmental photophases, with short days (10 hours light/24 hours) inducing 100% diapause response and long days (16 hours light/24 hours) inhibiting diapause in 100% of the test animals. The particular developmental stage which is utilized for diapause, when it is induced, seems constant for any give species, although different species utilize different stages. I term such a pattern, in which each generation has the potentiality of either developmental pathway, facultative.

In contrast, the pattern of development of the new species of Chrysopiella seems to always involve a diapause in the prepupal stage, with environmental signals such as the photoperiod and temperature being completely ineffective in inhibiting the onset of this diapause. I term such a pattern (which incidentally restricts a species to a single generation a year) obligate, since no other developmental pathway is available. Obligate patterns such as that shown by the new species of Chrysopiella are somewhat unusual in temperate-zone insects and within the Chrysopidae I know of only one other case. The ecological reasons why these two species of this family depart from the more general pattern of facultative life cycles are presently unknown and are certainly worthy of careful study.

Studies on Meiosis in the Hemerobiidae - As noted above, this investigation is being carried out by Professor Hughes-Schrader of Duke University and I have only received preliminary word from her as to how these studies are progressing since she was away from her laboratory until early October. Material was secured representing six species of the genera *Hemerobius* (3 species), *Kimminsia* (1 species), *Micromus* (1 species), and *Wesmaelius* (1 species). She has informed me that a study of the species *Hemerobius stigma* reveals the existence of a chromosomal polymorphism in the Jackson Hole population which she had also encountered in her studies of this species in the vicinity of Durham, North Carolina. In both of these locales, some individuals of the population are heterozygous for a pair of homologous autosomes of dissimilar size so that during meiosis an asymmetrical bivalent is formed. Other individuals of the same population have both members of this pair of chromosomes identical in size and shape. The meaning of this polymorphism is not clear at present, but its presence in two populations separated by a distance of over two thousand miles is certainly suggestive that the adaptive role that it plays is important.

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