KARYOTYPIC DATA ON THIRTEEN SPECIES OF NEARCTIC CARABID BEETLES (COLEOPTERA)[1]

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ABSTRACT: Mitotic and meiotic chromosomes of thirteen Nearctic species of carabid beetles have been studied. The male haploid chromosome number varies between n=11+X and n=21+X. The results obtained allow the following conclusions: (1) The 2n=37 karyotype has been found in eight species, one of them belongs to the Limbata Stylifera group, thus corroborating its widespread occurrence among the main lineages of the family. (2) Data on *Amara (Celia) moerens*, 2n=37, fit the hypothesis about the ancestrality of this number for the genus Amara. (3) The trend towards low-numbered karyotypes observed in the tribe Lebiini has much progressed in *Cymindis chevrolati,* 2n=24.

The chromosome number is already known for more than 750 species of the family Carabidae. Most cytogenetic studies on the Nearctic fauna have been concerned with the genus *Bembidion* (160 species: Maddison, 1985; Smith, 1953). The chromosome number of other groups of Carabidae from this region were described in 50 species and compiled in Smith and Virkki (1978) and Serrano and Yadav (1984). New results on Nearctic species have been added by Galián *et al.* (1990a, 1992). The aim of this work is to increase the basic knowledge of the cytotaxonomy of North American carabids, by adding the results obtained in 13 Canadian and Mexican species, and discussing briefly their cytotaxonomic significance.

MATERIALS AND METHODS

The species analyzed were collected in the localities listed in Table 1. Results were obtained from one to four male adults per species. Identifications were made by G.E. Ball and D. Shpeley (Edmonton, Canada) and P. Moret (Paris, France). The beetles are deposited in the Departamento de Biología Animal, Universidad de Murcia (Spain). Specimens of the three unnamed species of *Platynus* are also deposited in the U.S.N.M., Smithsonian Institution, Washington, D.C. Karyological analyses were carried out on testes using a routine orcein-squashing method described elsewhere (Galián *et al.,* 1990). Chromosomes were tentatively arranged in pairs by size and shape (karyogram) in order to show gross features such as symmetry of the karyotype, occurrence of heteromorphic chromosomes, etc.

[1] Received June, 1993. Accepted October 3, 1993

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RESULTS

Results are summarized in Table 1.

Genus *Omophron.* Spermatogonial metaphases of *Omophron ovale* have 2n=36 chromosomes gradually decreasing in size, making a symmetric karyogram (Fig. 1). The X chromosome might be a submetacentric element of intermediate size and the Y is the smallest element of the karyogram. This identification is in agreement with meiotic observations in which there are 18 bivalents one of which is heteromorphic (Fig. 5).

Genus *Diplous.* The diploid number of *Diplous californicus* is 2n=37. There is a large submetacentric pair (Fig. 2). The second pair is submetacentric and it is of the same size as an odd metacentric element, probably the X chromosome. The other pairs are mediocentric and gradually decreasing in size. Metaphase I cells have 18+X elements. Metaphase II cells are of two types, with 18 and 18+X.

Genus *Pterostichus.* The haploid number of the two species of *Pterostichus* is n=18+X. Spermatogonial mitosis of *P. melanarius* shows 2n=37 chromosomes making a symmetric karyogram (Fig. 3). The X chromosome may be a submetacentric element of intermediate size. In *P. herculaneus* only meiotic observations were available. Metaphase I cells of both species (Figs. 6 and 7) show 18 autosomal bivalents with terminal chiasmata and the X univalent usually situated peripherally. Metaphase II cells are of two types with n=18 and n=18+X.

Genus *Agonum*. The diploid number of spermatogoniae of *Agonum corvus* is 2n=39. The karyogram is made up of meta- and submetacentric chromosomes gradually decreasing in size (Fig. 4). The X chromosome is identified as a mediocentric element about the size of the largest pair.

Genus *Platynus*. The diploid number of *Platynus nugax* is 2n=37. The karyogram is made up of 18 autosomal pairs and one element about the size of the largest pair that may be the X chromosome. The haploid number of *Platynus chloreus* is n=18+X. Metaphase I plates (Fig. 8) show 18 autosomal bivalents and a univalent usually laying at the periphery. Metaphase II cells are of two types with n=18 and n=18+X. The haploid number of *Platynus* sp. 1 and *Platynus* sp. 3 is n=18+X. Metaphase I cells of *Platynus* sp. 1 (Fig. 9) show 18 autosomal bivalents and a univalent usually situated at the periphery. Metaphase II cells are of two types with n=18 and n=18+X (Fig. 10). Meiotic observations indicate that the haploid number of *Platynus* sp. 2 is n=21+X (Fig. 11). The X univalent is situated peripherally and may be the largest element of the karyotype according to the observations of metaphase II plates. In this stage there are cells with n=21 (Fig. 12) and cells with n=22 (Fig. 13) which have the large X chromosome. The haploid number of *Platynus variabilis* is n=21+X. At diakinesis (Fig. 14) the two largest pairs form two chiasmata, pairs three and four form one interstitial chiasma and the other

bivalents have only one terminal chiasma. The X chromosome is identified as one element of small size which condenses precociously in the earlier stages and in metaphase I is situated peripherally.

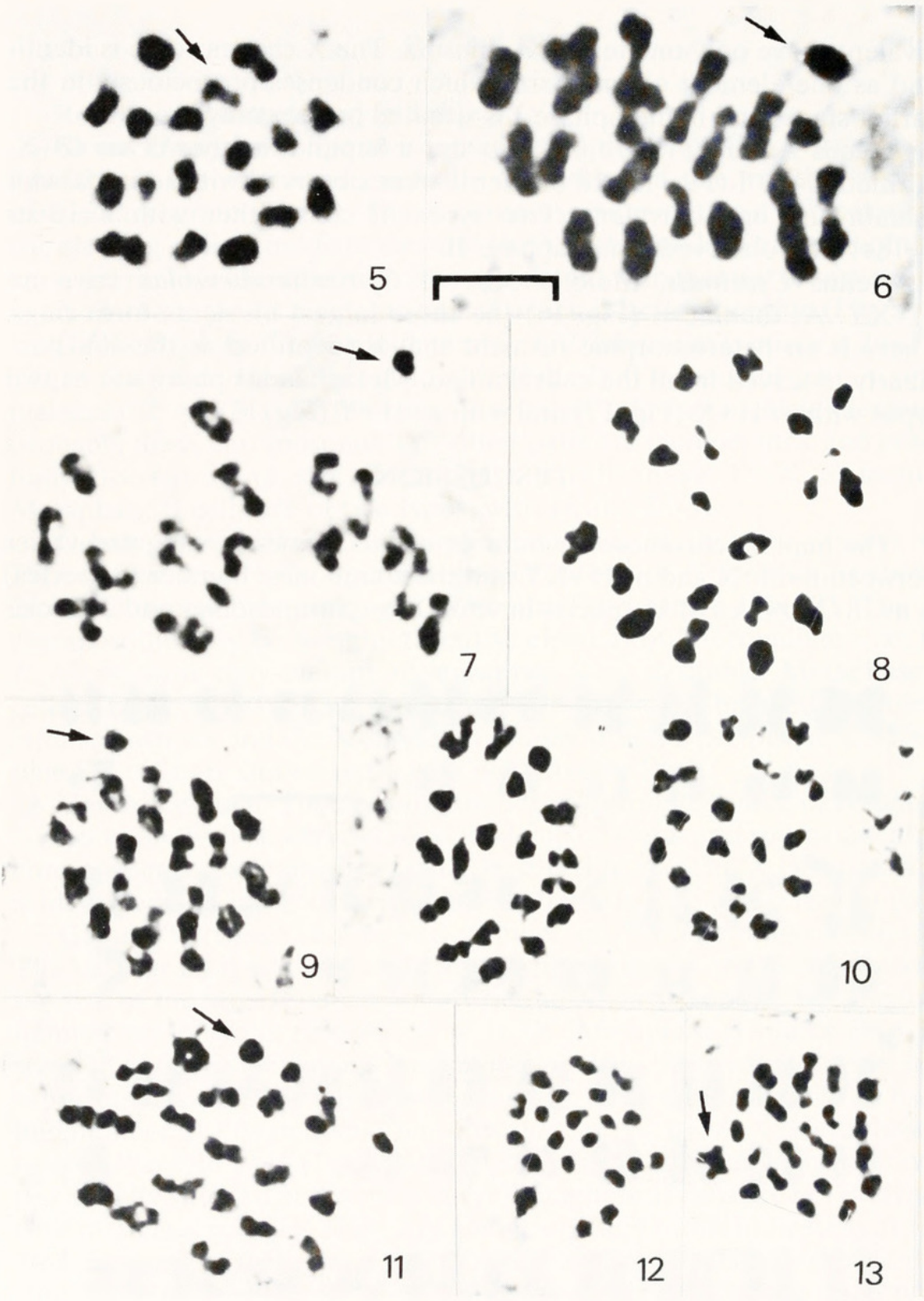
Genus *Amara.* *Amara moerens* has a haploid number of n= 18+X. At metaphase I (Fig. 15) 18 bivalents were observed with terminal chiasmata and one univalent. Two types of cells either with n=18 or n=18+X are observed at metaphase II.

Genus *Cymindis.* Meiotic cells of *Cymindis chevrolati* have n= 11+XY. At diakinesis (Fig. 16) the three largest bivalents form rings. There is an heteromorphic bivalent that is identified as the XY pair, clearly observed in all the cells studied. Metaphase II plates are of two types with n=11+X (Fig. 17) and with n=11+Y (Fig. 18).

DISCUSSION

The haploid chromosome number of the species investigated varies between n=21+X and n=11+XY and the commonest number (8 species) is n=18+X. Males of 11 species have XO sex chromosomes and 2 species

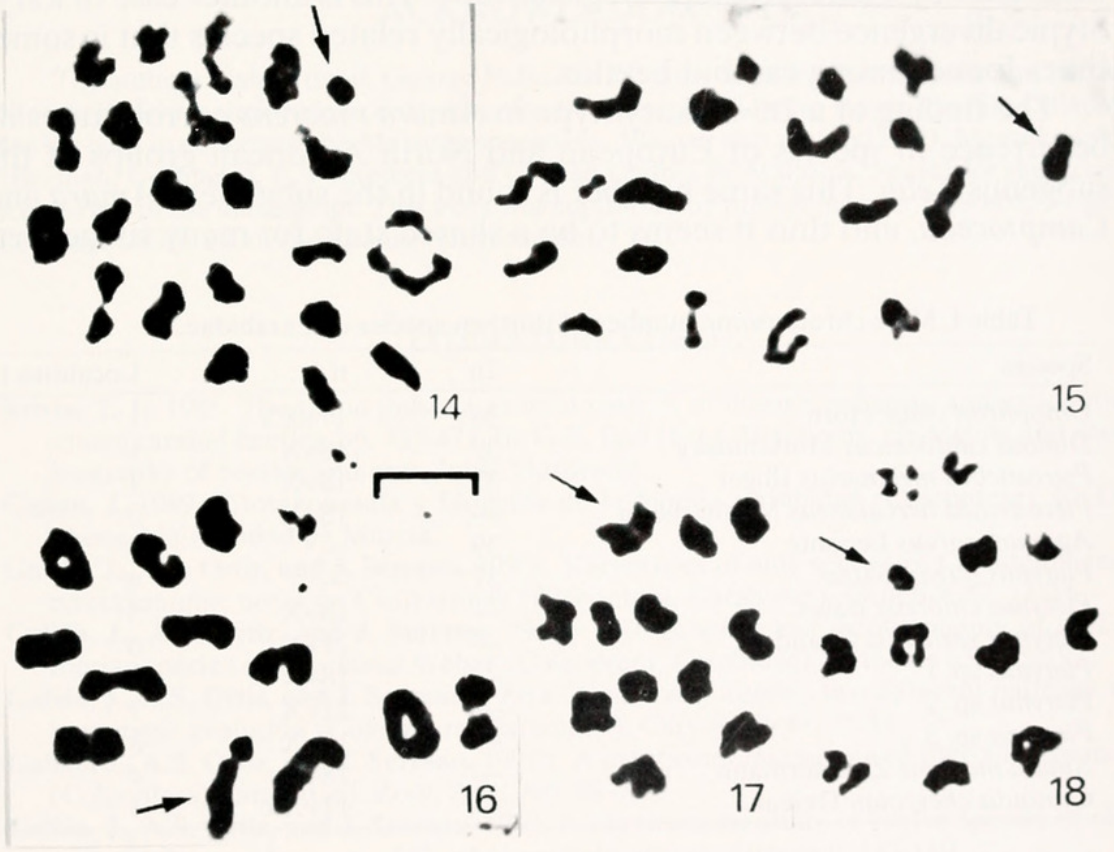
Figs. 1-4. Tentative karyograms of: (1) *Omophron ovale,* 2n = 36; (2) *Diplous californicus,* 2n = 37. (3) *Pterostichus melanarius,* 2n = 37. (4) *Agonum corvus,* 2n = 39. Sex chromosomes (XY or XO) are figured to the right. The bar equals 5 μm.



Figs. 5-8. Metaphase I or diakinesis of: (5) *Omophron ovale*, n = 17 + XY. (6) *Pterostichus melanarius,* n = 18 + X. (7) *Pterostichus herculaneus*, n = 18 + X. (8) *Platynus chloreus,* n = 18 + X. Figs. 9, 10. *Platynus* sp 1 (9) metaphase I, n = 18 + X (10) metaphase II, n = 18 + X, n = 18. Figs 11-13. *Platynus* sp 2 (11) metaphase 1, n = 21 + X (12) metaphase II, n = 21, (13) metaphase II, n = 21 + X. Arrows show tentative identification of sex chromosomes. The bar equals 5 μm, except for Fig. 7 which is 7 μm.

have XY sex chromosomes. The course of meiosis is chiasmatic and the recombination index is low because one chiasma per bivalent is the rule. The exception is represented by *Platynus variabilis* in which the four largest pairs form rings at diakinesis and the others have interstitial chiasmata.

The karyotype with 2n=37 was previously known of Limbata Conchifera and Scrobifera of Jeannel (1941), and has been found now in *Diplous californicus* (Tribe Patrobini), a species included in the Limbata Stylifera. Numbers close to 37 have also been found in the Limbata Balteifera (Galián *et al.*, 1990b) and in the Limbata Simplicia. To this last group belongs the Nearctic species *Omophron ovale,* which has 2n=36 like *O. limbatum* from Europe (Nettmann, 1986). As more data become available a widespread occurrence of a 2n=37 karyotype, or its close derivatives, is corroborated in the main phyletic lineages of Carabidae suggested by Jeannel (1941). The corroboration applies also for Erwin's (1985) system of carabid classification and it supports the hypothesis that



Figs. 14-16. Metaphase I of: (14) *Platynus variabilis,* n = 21 + X. (15) *Amara moerens,* n = 18 + X. (16) *Cymindis chevrolati,* metaphase I, n = 11 + XY. Figs. 17, 18. Metaphase II of *C. chevrolati,* (17) n = 11 + X. (I8) n = 11 + Y. Arrows show sex chromosomes. The bar equals 5 μm.

this number is an autapomorphy for the whole family or appeared early during the first stages of radiation of carabids.

Particular aspects of the tribes

The chromosomal number n=18+X of *Pterostichus melanarius* agrees with that reported for Nearctic individuals by Smith (1960) and for Palearctic ones by Wilken (1973), Kowalczyk (1976) and Nettmann (1986); *P. herculaneus* has also this number. Both species follow the same common pattern found in the tribe Pterostichini, in which n=18+X may be considered the ancestral number of the tribe (Serrano, 1986; Galián, 1989).

The karyotypes of the seven Nearctic species of the tribe Platynini reflect the pattern already known for the tribe based on Palearctic species (Serrano, 1986). The predominant number for the tribe is 2n=37, although there are some species with deviant numbers but keeping in most cases the XO sex system. Incidentally, the species named *Platynus* sp. 1 and sp. 2 were initially separated by the karyotypic results and thereafter by a careful morphological study. This is another case of karyotypic divergence between morphologically related species that is sometimes found among carabid beetles.

The finding of a 2n=37 karyotype in *Amara moerens* corroborates its occurrence in species of European and North American groups of the subgenus *Celia.* This same number is found in the subgenera *Amara* and *Camptocelia,* and thus it seems to be a shared state for many subgenera.

Table 1. Male chromosome number of thirteen species of Carabidae.

Species	2n	n	Localities (*)
Omophron ovale Horn	36	17+XY	1
Diplous californicus Motschulsky	37	18+X	1
Pterostichus melanarius Illiger	37	18+X	1
Pterostichus herculaneus Mannerheim	—	18+X	2
Agonum corvus Leconte	39	—	3
Platynus nugax Bates	37	—	4
Platynus chloreus Bates	—	18+X	5
Platynus variabilis Chaudoir	—	21+X	6
Platynus sp. 1	—	18+X	7
Platynus sp. 2	—	21+X	7
Platynus sp. 3	—	18+X	8
Amara moerens Zimmermann	—	18+X	4
Cymindis chevrolati Dejean	—	11+XY	4

* (1) Nicola River, British Columbia (Canada); (2) UBC Forest, British Columbia (Canada); (3) Thompson River, British Columbia (Canada); (4) La Marquesa, México (México); (5) Piramide de Malinalco. México (México); (6) Bosque de Chapultepec, México D.F. (México); (7) Puerto Lobos, Veracruz. (México); (8) Tenango de Doria, Hidalgo (México).

Serrano (1986) and Galián *et al.* (1991a) have already postulated that this number is ancestral for the genus *Amara.* The data of Smith (1953) for *A. impuncticollis,* 2n=17+XY, indicate that the trend towards decreasing numbers observed in other *Amara* groups is also present in the Nearctic *Celia.*

The number of *Cymindis chevrolati,* n=11+XY, is lower than those reported for six Palearctic species of the same genus (from n=21+X to n=16+XY; Serrano, 1981; Galián *et al.,* 1991b). This observation in *C. chevrolati* agrees with the predictions of the hypothesis of Galián *et al.* (1991b) of a trend towards numbers lower than 2n=37 in the subfamily Lebiinae. This trend is also present in the Australian species of the subfamily Lebiinae (Galián and Moore, in press). According to the hypothesis, *C. chevrolati* is the karyotypically most advanced species of the genus. The study of more Nearctic species is needed before making more accurate comparisons with Palearctic taxa.

ACKNOWLEDGMENTS

The authors wish to thank George E. Ball and Danny Shpeley (Edmonton), and Pierre Moret (Paris) for their help in determinating the beetles and Pedro Reyes-Castillo (Jalapa) for his help in collecting the Mexican specimens. We are also grateful to D. Mossakowski (Bremen, Germany), E. Petitpierre and C. Juan (Palma de Mallorca, Spain) for their critical review of the manuscript. This work was supported by project number PB90-0357-C02-02 of the DGICYT of the Spanish Government.

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SOCIETY MEETING OF NOVEMBER 17, 1993

RAISING SATURNIID MOTHS FOR LABORATORY RESEARCH

Dr. Willlam Telfer
Department of Biology, University of Pennsylvania

For the past 35 years, a back yard orchard of wild cherry, *Prunus serotina,* normally considered a weed tree, has served as food for hundreds, even thousands of saturniid caterpillars destined for the research laboratory. Housed under netting covering individual trees, cecropia moths and other desired species, including luna moths, have been reared annually to provide specimens used for investigating the intricacies of hormonal control and biochemistry of such physiological processes as molting, pupation, and reproduction. Although these rearing efforts are reminiscent of another time and place where the objective was silk production (i.e. Etienne Leopold Trouvelot in Medford, MA, the site of the release of the gypsy moth in North America [see story in *American Naturalist,* 1:30-38, 85-94, 145-149 and Bull. ESA 35(2): 20-22]), only native moths have been encouraged in these rearings in suburban Philadelphia. Not unlike other outdoor rearing efforts, problems of disease were often encountered in the net cages. Dr. Telfer noted that the cecropia is particularly susceptible to this fate. Nevertheless, over the years, these efforts have led to an annual supply of specimens which were brought into the laboratory and placed in refrigerators until their use in experiments designed to investigate the intricate biochemical processes which occur during pupation, molting, diapause, and reproduction of these magnificent native silk moths.

Once in the laboratory, these moths, usually used as pupae, were subjected to intricate surgical procedures designed to test hypotheses to reveal the complex inner biochemical and physiological workings of transformation processes, hormonal control, and reproduction. Most impressive were illustrated microdissection procedures of bisecting pupae and

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