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The Chromosomes of a Primitive Species of Beetle: *Ytu zeus* (Coleoptera, Myxophaga, Torridincolidae).

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ABSTRACT.—For the first time the chromosomes of a species of Myxophaga (*Ytu zeus*) are studied. It has a chromosome number similar to that considered to be ancestral to Coleoptera ($2n = 20$). The sex chromosome system is of the XY type, though the way X and Y behave during meiotic prophase I (PI) and metaphase I (MI) suggests a close relationship with the Xy_p mechanism. [beetle, Coleoptera, cytology, evolution, Myxophaga, sex chromosomes, Torridincolidae, *Ytu zeus*]

The karyotypes of 2160 species of Coleoptera have been listed by Smith and Virkki (1978). Two thousand of those species belong to the sub-order Polyphaga, 159 to Adephaga, and a single one to Archostemata. To date, nothing has been published on the karyotypes of Myxophaga. The last two mentioned sub-orders comprise together less than one hundred species around the world, but since they are relicts of ancient and primitive beetles (Crowson 1967), the knowledge of the chromosomes of their species is important for a better understanding of the evolutionary trends within the order Coleoptera.

Archostemata include two families, Cupeidae and Micromalthidae, although the inclusion of the latter family is still under discussion (Reichardt 1973). Myxophaga comprises the families Sphaeridae, Lepiceridae, Torridincolidae, and Hydroscaphidae. During the last decade, several species and genera of Brazilian Myxophaga were described (Reichardt 1971, 1973; Reichardt and Hinton 1976; Reichardt and Vanin, 1976, 1977; Vanin 1978).

Species of the family Torridincolidae are insects less than 2 mm long living in hygropetric habitats and feeding on algae. Within the family, four genera have been described: the monotypic *Torridincola* from Rhodesia and the Brazilian genera *Ytu* (17 spp.), *Hintonia* (2 spp.) and *Claudiella* (1 sp.). The species *Y.*

zeus occurs in several localities in the four Southern States of Brazil (São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul). The species is easily recognizable because of the presence in the males of white setae on each side of the prosternal process as well as in the metasternum (Reichardt 1973).

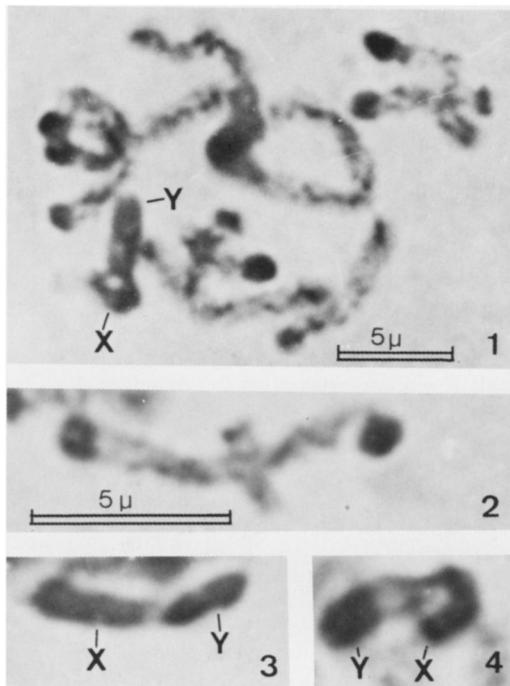
In the present paper information on the chromosomes of the tiny species *Y. zeus* is reported and the relationships of its karyotype with those of the more evolved sub-orders discussed.

MATERIALS AND METHODS

Several hundreds of specimens of *Y. zeus* were collected during a period of two years (1982–1983) from a permanent colony living in a natural water spring on the road side at 12 km W of Torrinas, São Paulo, Brazil.

Male specimens were dissected in a drop of isotonic insect solution and the testes directly squashed in a drop of 1% lacto-acetic orcein. Few of the slides contained useful cells because of the small size of the testes.

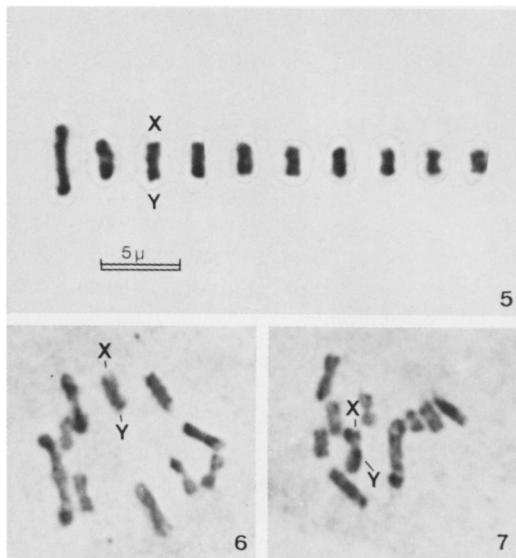
Efforts to obtain somatic metaphases in embryo cells for study of chromosome morphology were carried out without results. The small size of the eggs (approx. 0.4 mm in diameter) and a hard chorium were the main reason for the failure.



Figs. 1-4. *Y. zeus*, diplotene. 1. Nine autosomal bivalents plus XY; 2. Bivalent with sub-distal chiasma; 3. X and Y pairing end to end; 4. Both ends of X pairing with Y.

DESCRIPTION

The diploid chromosome number of the male of *Y. zeus* in $2n = 20$ with nine pairs of autosomes plus X and Y (see metaphase I (MI) of Figs. 5, 6, and 7). The prophase stages are awkward to analyze because each autosome bears a bulk heterochromatic block at one of its ends that sticks together in a few larger blocks, making impossible the identification of each pair. In a few nuclei it was possible to distinguish all the pairs revealing a single chiasma in the distal or subdistal end of the euchromatic arm of each bivalent (Figs. 1, 2). The largest bivalent is easy to recognize because of its size, and because, during prophase, its heterochromatic block is larger than those of the remaining pairs. From pair 2 to pair 9, the autosomes decrease gradually in length (Fig. 5). In MI it was observed that each autosome



Figs. 5-7. *Y. zeus*, MI. 5. Bivalents according to decreasing length, X and Y pairing end to end; 6. X and Y pairing end to end; 7. X and Y pairing according to Xy_p model.

has two arms, the small one of which corresponds to the heterochromatic block, and is free of chiasmata (Figs. 5, 6, and 7). A single chiasma in the distal or subdistal region of the larger arm (Fig. 2) connects the homologues.

The sex chromosomes are represented by a heteromorphic XY pair, the smaller component measuring about 80% of the larger one in length. Most probably the large element is the X chromosome and the small one the Y. During first prophase both chromosomes are completely heterochromatic and associate in two different ways. Sometimes the X and the Y are connected end to end as in Fig. 3. More frequently, the X curves, forming an arch with both ends connecting with one of the Y ends as in Figs. 1 and 4. In this case the X chromosome seems to be shorter than Y because of its curvature, and because the Y chromosome shows a constriction that separates a large segment from a small one that actually pairs with the both ends of X. If the large segment of the Y chromosome is omitted, the mechanism looks

like an Xy_p system, as can be observed in Fig. 4. It was impossible to determine whether the XY association is chiasmatic or nucleolar.

DISCUSSION

In 1950 Smith postulated the formula $911 + Xy_p$ as primitive for the whole Coleoptera, suggesting furthermore an increase of the chromosome number through fissions during the evolution of Adephaga. The only species of Archostemata so far studied has a haploid ($\delta = 10$)-diploid ($\text{♀} = 20$) set of chromosomes (Scott 1936, 1941). Therefore, the chromosome number observed in *Y. zeus* is consistent with that found to be ancestral for Coleoptera.

The Xy_p sex chromosome system occurs in all families of Polyphaga, including more than half of the two thousand species searched. Within Adephaga it has been reported in some primitive species of Carabidae (Sanyal 1971; Manna and Lahiri 1972) and Dytiscidae (Suortti 1971). It has been found by Virkki (1967, 1970) in some primitive Polyphaga like the fleabeetle *Forsterita* and the trogid *Glarexis* sp., considered to be the most primitive living scarab genus, and also by Manna and Lahiri (1972) in the "protobrentid" *Cylas formicarius*.

Because of the large size of the Y chromosome, the sex chromosome system of *Y. zeus* differs from the Xy_p model. However, the way X and Y associate in the majority of the nuclei during diplotene-metaphase I period resembles Xy_p , with the X chromosome forming an arch with its both ends pairing with one end of the Y. According to Virkki (pers. comm.) the "device" is originated by terminal contacts and its relationship with a typical Xy_p is obscure since it was not possible to detect nucleolar substance that normally occurs in Xy_p . Two possibilities could explain the present XY of *Ytu*: (1) this system shows an early step of development of the Xy_p system in which the XY chromosomes still remain quite comparable in size; (2) the system has already reached an Xy_p stage and

then developed further, adding constitutive heterochromatin in the non-pairing segment of the Y chromosome. The authors favor the second alternative because Myxophaga and Polyphaga arise from a common root where a typical Xy_p should have been already established. It should be noted that a typical-looking Xy_p has been reported in the related Order Megaloptera (Hughes-Schrader 1980). Furthermore, an XY resembling the double-contact XY's of *Y. zeus* has been described by Takenouchi (1970) in a weevil (*Ceuthorrhynchus*), where it cannot be of ancient origin. The second alternative could be supported through C-banding of the Y.

The presence of heterochromatic blocks, sometimes comprising an entire arm, has been already observed by Smith (1956) in several species of the genus *Chilocorus*, and by Smith and Virkki (1978) in several other species of Coleoptera.

According to Smith and Virkki (1978), the pattern of chiasma distribution that characterizes Coleoptera is one per bivalent, the single chiasma usually localized in the distal half of one euchromatic arm. *Y. zeus* follows this pattern of distribution, but with even more distally localized chiasmata. This kind of chiasma distribution decreases the amount of genetic recombination between homologues, and eventually the genetic plasticity of the species.

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