

Chromosome Uniformity in Lacertidae: New Data on four Italian Species

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Abstract. The chromosome complements of *Podarcis filfolensis*, *P. tiliguerta*, *P. wagleriana* and *Archaeolacerta bedriagae* were analyzed in bone marrow somatic mitoses as well as in meiotic diakinesis. All four species are characterized by the typical lacertid karyotype consisting of 38 chromosomes (36 acrocentric macrochromosomes plus 2 microchromosomes). Adaptive stability of karyotypes, as a result of a canalization process of chromosomal evolution, and absence of complex social behaviour promoting population subdivision and inbreeding, are the evolutionary factors presumably correlated with the remarkable conservativeness of karyotype observed within the family Lacertidae.

Introduction

The lizard family Lacertidae is characterized by a remarkable karyotype stability. Data are available in the literature for 3 species belonging to 8 genera, i.e. *Acanthodactylus*, *Algyroides*, *Eremias*, *Lacerta*, *Ophisops*, *Podarcis*, *Psammodromus* and *Takydromus*. Thirty of these species show identical chromosome complements consisting of 36 acrocentric macrochromosomes plus 2 microchromosomes (GORMAN, 1973). On the other hand, even in the species having a reduced diploid number, e.g. *Lacerta lepida* ($2n = 36$) and *Lacerta parva* ($2n = 24$), the fundamental number remains constant (N.F. = 38), the karyotypes being rearranged through centric fusions. More complex is the case of *Lacerta vivipara*, in which OGUMA (1934) and CHEVALIER (1969) found distinct female heterogamety. This species, characterized by the diploid number $2n = 36$, lacks the typical pair of microchromosomes (MARGOT, 1946; CHEVALIER, 1969) and probably has intraspecific chromosome variation through its widespread range. Intraspecific karyotype variability also probably occurs in *Lacerta strigata*. KUPRIYANOVA (1968) found in this species the basic 38-chromosome karyotype, whereas ORLOVA and ORLOV (1969) describe a different chromosome set in which one pair of acrocentric chromosomes is replaced by a submetacentric one.

The basic 38-chromosome pattern is present again in the parthenogenetic and bisexual species of Caucasian rock lizards (genus *Lacerta* sensu ARNOLD, 1973) (DAREVSKY, 1966; KUPRIYANOVA, 1969), though the existence of a heteromorphic pair of chromosomes was demonstrated in the chromosome complements of males and intersexes of

L. armeniaca as well as in the female karyotype of *L. rostombekovi* (DAREVSKY et al., 1973, 1977).

Sexual chromosome heteromorphism, suggested by GORMAN (1969) for *Lacerta trilineata* and *Eremias olivieri*, was also evidenced in *Algyroides marchi* (PALACIOS and ELVIRA, 1979). In this species both sexes have the typical lacertid diploid number ($2n=38$), but one of the male macrochromosomes is characterized by the presence of two satellites.

In order to point out the genetic relationships among the Italian species of lacertid lizards by means of both multiloci electrophoretic studies (NASCETTI et al., 1981) and karyological investigations, we have analyzed the chromosome complements of 7 species belonging to the genera *Archaeolacerta*, *Lacerta* and *Podarcis*. Our data concerning *Lacerta viridis*, *Podarcis sicula* and *P. muralis* agree with the data previously reported by MATTHEY (1931, 1949), DALLAI and BARONI URBANI (1967) and GORMAN (1969).

The aim of this paper is to describe the chromosome pattern of three closely related and allopatric lizards, i.e. *Podarcis filfolensis*, *P. tiliguerta* and *P. wagleriana*, and to compare their karyotype with that of the Bedriaga's rock lizard, *Archaeolacerta bedriagae*.

Material and Methods

The following samples were utilized for the karyological analysis:

- a) *Archaeolacerta bedriagae paessleri* (MERTENS, 1927). 2 ♂♂ and 2 ♀♀ from Mt. Limbara (North Sardinia), May 1981.
- b) *Podarcis filfolensis maltensis* MERTENS, 1921. 2 ♂♂ from Xlendi (Gozo), September 1981 and 1 ♀ from Balzan (Malta), August 1980.
- c) *Podarcis tiliguerta tiliguerta* (GMELIN, 1789). 1 ♂ from Cagliari (South Sardinia), April 1980 and 1 ♀ from Mt. Limbara (North Sardinia), September 1980.
- d) *Podarcis wagleriana wagleriana* GISTEL, 1868. 1 ♂ and 2 ♀♀ from Scopello (Trapani, West Sicily), May 1980.

Somatic metaphases have been evidenced in bone marrow cells by using standard air-drying techniques. Vinblastine sulphate (Velban) was injected in vivo (2.5 µg for each 2 g of body weight) as cytostatic medium. The hypotonic solution used was KCl 0.035 M and the fixative was 3:1 methanol-acetic acid. The meiotic preparations were obtained from testes according to the technique of EVANS et al. (1964). Both mitotic and meiotic preparations were stained by Giemsa 4% in phosphate buffer pH 7.

Results and Discussion

No variation in karyotype morphology among the three related insular species *Podarcis filfolensis*, *P. tiliguerta* and *P. wagleriana* was evidenced in spite of their high degree of intra- and interspecific morphological variability (fig. 1). On the other hand *Archaeolacerta bedriagae*, belonging to a genus more closely related to *Lacerta* than to *Podarcis* (GORMAN et al. 1975; LANZA et al. 1977), shows no apparent deviation from the chromosomal pattern of the three wall-lizards (Fig. 2). All four species, like many others in the family are characterized by the diploid number $2n = 38$ (36 acrocentric chromosomes and a pair of microchromosomes). Nineteen bivalents are revealed by the analysis of meiotic diakinesis. Asymmetric or heteropycnotic bivalents, indicating sex-chromosome heteromorphism, were not observed (Figs 2b and 3).

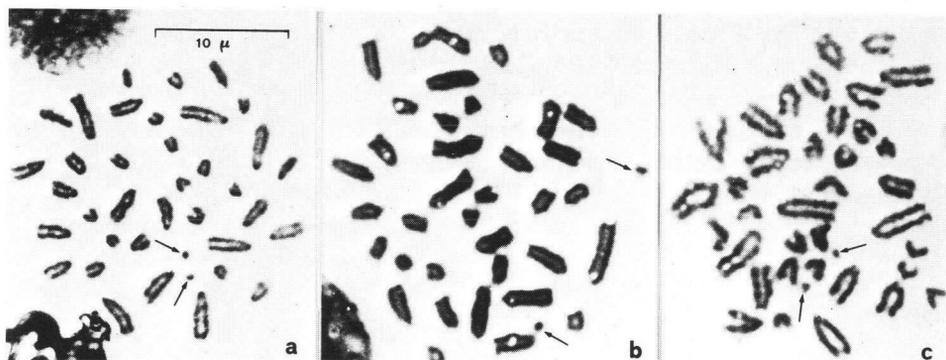


Fig. 1. Somatic metaphases from bone marrow cells of male lizards (a) *Podarcis tiliguerta*. (b) *Podarcis wagleriana*. (c) *Podarcis filfolensis*. The arrows indicate the pairs of microchromosomes.

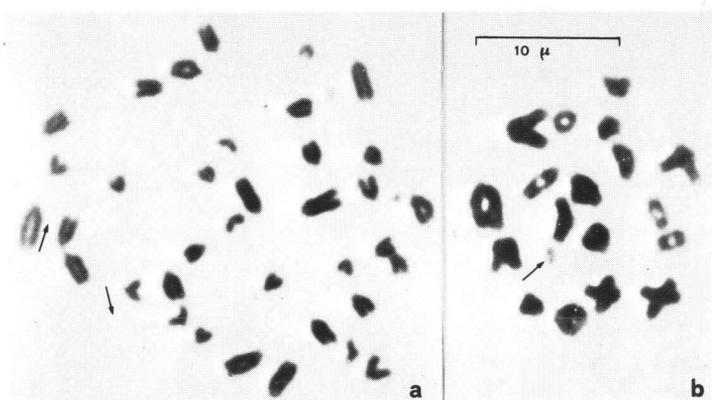


Fig. 2. *Archaeolacerta bedriagae*. (a) Somatic metaphase from bone marrow cells. (b) Meiotic diakinesis from testis cells. The arrows indicate: (a) the two microchromosomes and (b) the small bivalent due to the pairing of the microchromosomes.

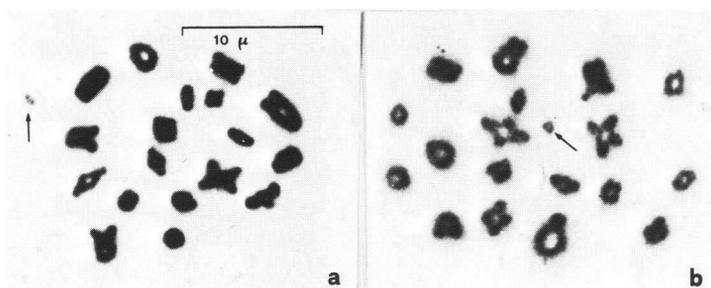


Fig. 3. Meiotic diakinesis from testis cells of lacertid lizards. (a) *Podarcis tiliguerta*. (b) *Podarcis wagleriana*. The arrows indicate the microchromosome bivalents.

The fact that such a karyotype is virtually identical to the one shared by thirty species of the family Lacertidae is a further evidence of the remarkable chromosomal uniformity existing in this taxon. This indicates that chromosomal rearrangements did not play an important role in the evolution of the recent lacertid lizards (see also GORMAN et al., 1970). Moreover, the 38-chromosome karyotype of the Lacertidae is quite distinct from the typical saurian karyotype, the majority of lizard families being characterized by a fundamental number different from 38 (usually 48 ± 2), few macrochromosomes (generally metacentric) and many microchromosomes (GORMAN, 1973).

Two main factors seem to be correlated with the peculiar chromosomal stability exhibited by the lacertid lizards: 1 – “canalized” evolution (sensu BICKHAM and BAKER, 1979) of a highly adaptive karyotype; 2 – absence of ethological requirements inducing fixation of chromosomal rearrangements.

Although many types of chromosomal rearrangements may occur without changing the chromosome number (see WHITE, 1978), we feel, in agreement with BICKHAM and BAKER's (1979) assumption that “for each adaptive zone there is an optimum karyotype”, that the lacertid lizards presumably “experienced their karyotypic revolution when they first entered their adaptive subzone”. Afterwards, the progressive canalization of chromosomal evolution, as a result of selective advantages of gene arrangements, led to the achievement of an “optimum” karyotype. Since the chromosomal rearrangements would have decreased the heterokaryotype fitness, any subsequent chromosomal mutation altering the nature of linkage groups was eliminated by natural selection. Thus the lineage became karyotypically stable, further morphological adaptive diversification not being accompanied by relevant chromosomal changes.

In Reptiles, examples of morphological diversification without chromosomal diversity are found in the turtles of the suborder Cryptodira, where each family or subfamily is characterized by a single karyotype (see BICKHAM and BAKER, 1979). Nevertheless, while in turtles the pattern of chromosomal stability seems to be correlated with the geological age of each family (see also BICKHAM, 1981), the small amount of karyotype variation found in lacertid lizards cannot be interpreted only on the basis of the inverse correlation between age and chromosomal diversity. In fact, although the primary diversification of the Lacertidae has been more recent than that of other lizard families, i.e. Agamidae, Anguinae, Chamaeleonidae, Scincidae, Varanidae and Xenosauridae, the analysis of the available karyotype data would reveal that none of these ancient families underwent canalized chromosomal evolution. This apparently minimizes the importance of the process of karyotypic canalization in the evolution of lizards and elevates large effective population size as a prime selective agent of chromosomal uniformity.

Within the family Lacertidae, all the species characterized by large deme size and high vagility appear to be extremely conservative in karyotype. On the contrary, *Lacerta vivipara*, considered as a species with small deme size and low vagility (see VERBEEK, 1972), shows intraspecific chromosome variation. These evidences, in agreement with the assumption of the deme size model predicting that taxa with large population size have stable karyotypes (see BUSH, 1975; WILSON et al, 1975, WHITE, 1978), lead to the conclusion that relatively high vagility – and consequent low inbreeding – and absence of complex social behaviour inducing small deme size (see BUSH et al., 1977) are the

evolutionary factors mainly correlated with the extraordinary chromosomal uniformity observed in lacertid lizards.

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