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Karyotypes of four bird species of the order Passeriformes

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The karyotypes of four bird species in the order Passeriformes have been studied. The results further confirm that in birds, the karyotypes of closely related species are only slightly different. One of the species investigated, *Chloris chloris*, shows a special feature. Chromosome No. 1 can be either an st chromosome or an sm chromosome probably due to a pericentric inversion.

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Related species of birds have very similar karyotypes. In some orders several species have karyotypes that appear to be identical when stained with orcein. Within these orders, however, some species can differ from related ones by one or more centric fusions. This is the case with regard to *Anser* and *Branta*, *Gallus* and *Phasianus*. Structural rearrangements within species have been reported from the orders Passeriformes and Charadriiformes. These rearrangements are pericentric inversions. In this investigation two pairs of related species are discussed one of which contains a pericentric inversion.

Material and methods

The following species have been investigated:

Order	*Family*	*Genus* and *species*
Passeriformes	Motacillidae	*Anthus trivialis*
		Motacilla alba
	Fringillidae	*Chloris chloris*
		Emberiza citrinella

Material of all species was collected as eggs from wild populations of birds in southern Sweden.

The chromosome preparations were made from embryos incubated about five days. Small pieces of tissue were pretreated for 25 min at 37°C in a solution of 0.9% Na-citrate and 0.1% colchicine and then orcein-squashed. All measurements were made on prints magnified to 5500×. The figures in the tables and the idiogrammes are mean values of three individuals. Chromosome length is presented in microns and in percent of the length of one autosome set plus one Z chromosome, A+Z.

Observations

A. *Anthus trivialis*

The 2n chromosome number is about 80. The largest chromosome is about 5.2 microns long and 12.1% of A+Z, the smallest is about 0.4 microns and 0.9% of A+Z. In the nine largest chromosomes and the W it is possible to distinguish two

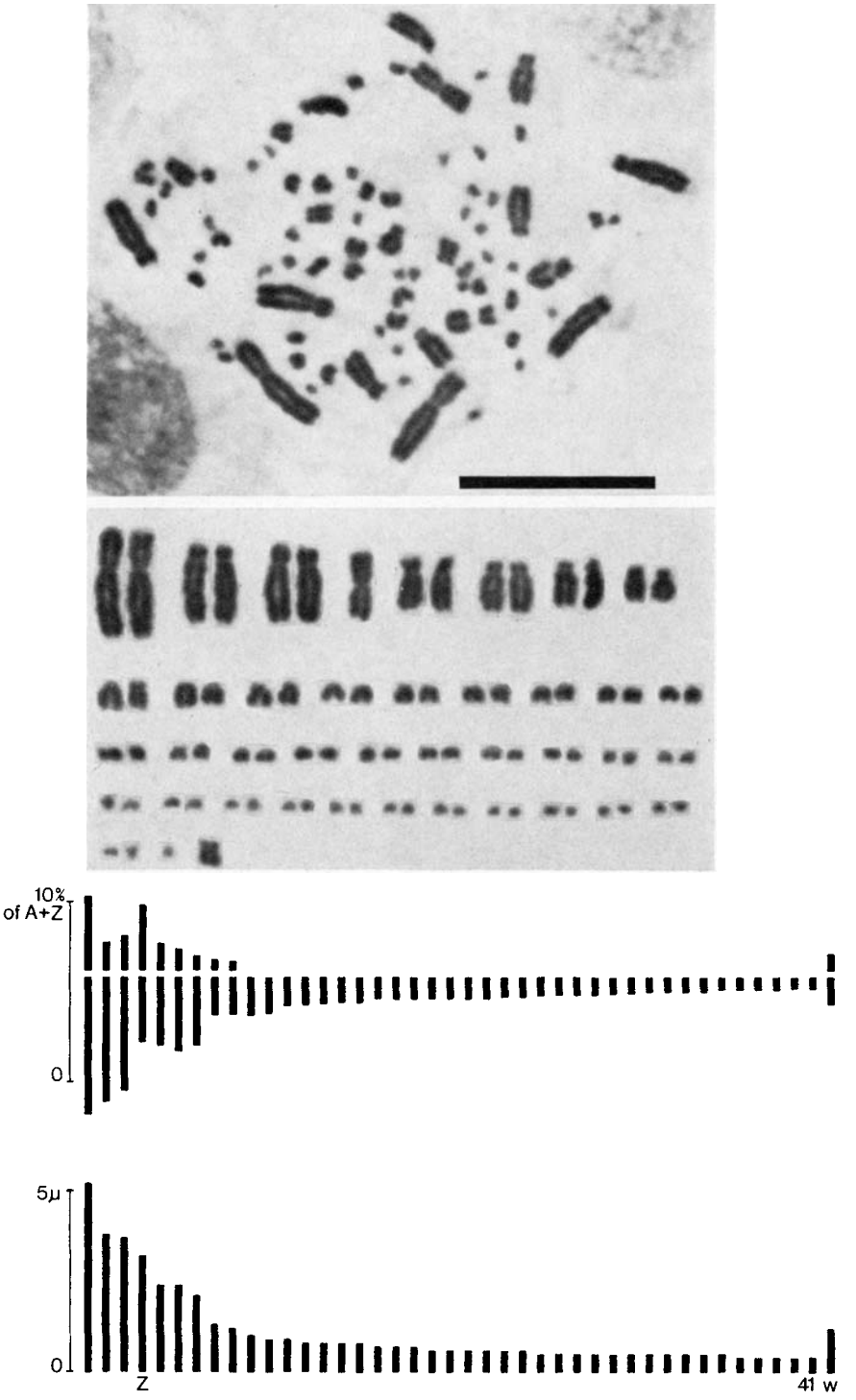

Fig. 1. *Anthus trivialis*, female metaphase chromosomes and idiogram.

Table 1. The karyotype of *Anthus trivialis*

Chromosome No.	Lenght in μ	% of A+Z	Designation	Arm ratio
1	5.2	12.1	sm	1.9
2	3.8	8.9	st	4.1
3	3.7	8.6	st	3.2
4 Z	3.2	7.5	m	1
5	2.4	5.7	sm	2.4
6	2.4	5.7	st	3.1
7	2.1	4.9	st	3.8
8	1.3	3.1	sm	2.8
9	1.2	2.9	sm	3.0
10	1.0	2.4		
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40	0.4	0.9		
W	1.2	2.8	m	1.6

arms. Nos. 1, 5, 8 and 9 are sm chromosomes, Nos. 2, 3, 6 and 8 are st chromosomes and No. 4, the Z, is an m chromosome. The Z is about 3.2 microns long and 7.5% of A+Z. The W is an m chromosome in size equal to No. 9, about 1.2 microns long and 2.8% of A+Z (Fig. 1, Table 1).

B. *Motacilla alba*

The 2n chromosome number is about 78. The largest chromosome is about 4.1 microns long and 13.7% of A+Z, the smallest about 0.3 microns and 0.8% of A+Z. Chromosome Nos. 1–5 are m–st chromosomes, all others are t chromosomes. The size of Nos. 4 and 5 are the same, but the Z chromosome, here indicated as No. 5, is an sm chromosome with arm ratio 1.9, while autosome No. 4 is an sm chromosome with arm ratio 2.4. The Z is about 1.9 microns and 6.4% of A+Z. The W chromosome is a t chromosome, in size between No. 8 and 9, about 0.9 micron long and 2.9% of A+Z (Fig. 2, Table 2).

C. *Chloris chloris*

The 2n chromosome number is about 78. The chromosome lengths are from about 3.4 microns and 10.8% of A+Z to about 0.3 microns and 0.9% of A+Z. In this species chromosome No. 1 can be of two types, either an st or an sm chromosome. In the material investigated no. 1a, the st, is about 3.4 microns and 10.8% fo A+Z. No. 1b, the sm, is about 3.1 microns and 9.8% of A+Z. As the st chromosome is the longest one, the difference can not be a deletion in the short arm. Thus the difference in arm ratio between 1a and 1b must depend on a movement of the centromere, a shift or a pericentric inversion. The investigation of this species is based on five embryos from two clutches, and all of them were heterozygous for chromosome No. 1.

Chromosome No. 2 is an m chromosome, Nos. 3 and 7 are st chromosomes, Nos. 5 and 6 are sm chromosomes. The Z chromosome, No. 4, is an m chromosome about 1.9 microns and 5.8% of A+Z. The W is a t chromosome and difficult to distinguish. It is most likely one of the largest t chromosomes, about 0.9 microns and 2.8% of A+Z.

The karyotype of *Chloris chloris* is characterized by rather small chromosomes, a W that is difficult to distinguish and a polymorphy for the arm ratio of chromosome No. 1 (Fig. 3, Table 3).

D. *Emberiza citrinella*

The 2n chromosome number is about 80 and the chromosome lengths are from about 4.9 microns and 13.1% of A+Z to about 0.3 microns and 0.8% of A+Z. Chromosome No. 1 is an m chromosome, Nos. 2, 3, 6 and 7 are st chromosomes

Table 2. The karyotype of *Motacilla alba*

Chromosome No.	Lenght in μ	% of A+Z	Designation	Arm ratio
1	4.1	13.7	m	1.5
2	3.1	10.1	st	4.5
3	2.9	9.7	st	4.1
4	2.0	6.6	sm	2.4
5 Z	1.9	6.4	sm	1.9
6	1.7	5.7		
7	1.5	4.9		
8	1 0	3.0		
9	0.8	2.8		
10	0.6	2.1		
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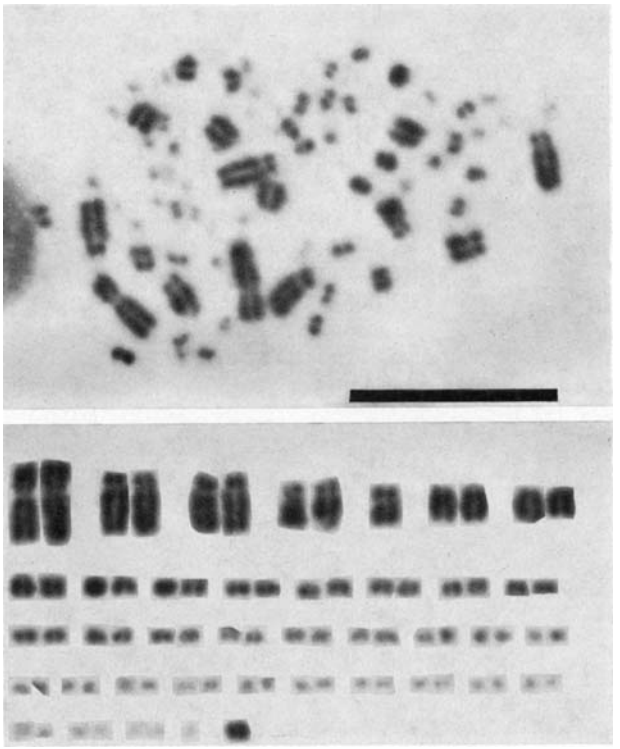
39	0.3	0.8		
W	0.9	2.9		



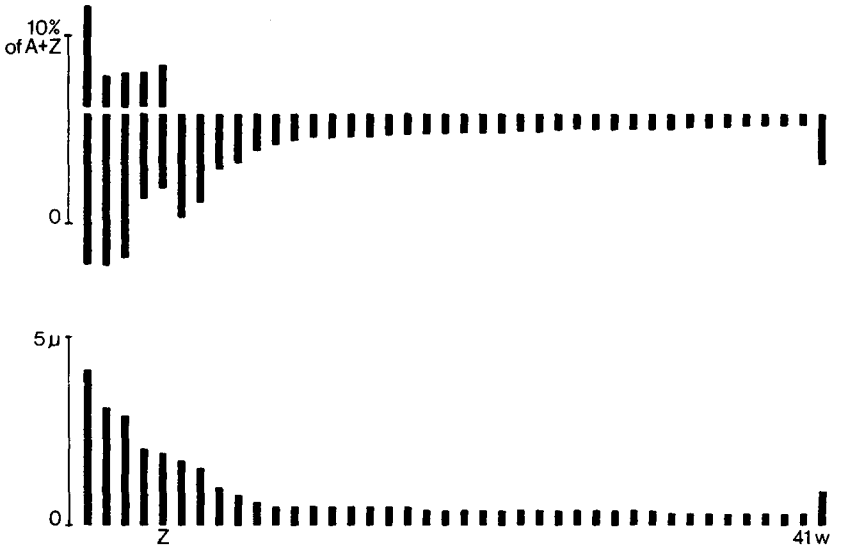


Fig. 2. *Motacilla alba*, female metaphase chromosomes and idiogram.

Table 3. The karyotype of *Chloris chloris*

Chromosome No.	Lenght in μ	% of A+Z	Designation	Arm ratio
1a	3.4	10.8	st	3.5
1b	3.1	9.8	sm	4.9
2	2.5	7.8	m	1.4
3	2.5	7.7	st	3.1
4 Z	1.9	5.8	m	1
5	1.7	5.4	sm	2.5
6	1.7	5.4	sm	1.7
7	1.5	4 6	st	3.2
8	0.9	2.9		
9	0.9	2.8		
10	0.8	2.6		
.				
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39	0.3	0.9		
W	0.9	2.8		

and Nos. 4 and 5 are sm chromosomes. Among the smaller chromosomes at least one pair of m and one pair of m–sm chromosomes can be distinguished with a size between No. 12 and No. 18. The Z chromosome is No. 4. It is about 2.6 microns and 7.0% of A+Z. The W chromosome is large, between No. 7 and No. 8 in size, about 1.2 microns and 3.3% of A+Z. It is an m chromosome (Fig. 4, Table 4).

Table 4. The karyotype of *Emberiza citrinella*

Chromosome No.	Lenght in μ	% of A+Z	Designation	Arm ratio
1	4.9	13.1	m	1.4
2	3.8	10.1	st	3.4
3	3.5	9.3	t	7 4
4 Z	2.6	7.0	sm	2.5
5	2.3	6.1	sm	2.8
6	2.1	5.4	t	7.2
7	1.9	5.0	st	3.7
8	1.2	3.3	t	
9	1.0	2.7	t	
10	0.8	2.3	t	
.				
.				
.				
40	0.3	0.8		
W	1.2	3.3	m	1.4

Discussion

After this investigation was finished several papers describing karyotypes from the order Passeriformes have been published. This makes it possible to carry out comparisons with other related species and in one case with the same species from another part of its distribution area.

In the family Motacillidae, *Anthus trivialis* from Novosibirsk has been investigated by BULATOVA (1971). The karyotype derived from her analysis is quite similar to the karyotype specified by us with the exception that now also the Z and W have been identified. The other member of the family, *Motacilla alba*, has been compared with *Motacilla flava* (HAMMAR 1970). The chromosome number of the two *Motacilla* is the same, 2n=78, but there are some small differences in the sex chromosomes. The Z is of the same size, No. 4 in both species, but in *Motacilla alba* it is an sm chromosome while it is an st chromosome in *M. flava*. The W chromosome is a t chromosome in *M. alba* and an sm chromosome in *M. flava*.

Chloris chloris has a karyotype similar to that of *Carduelis spinus* of the same family (Fringillidae) as described by TAKAGI (1972). The karyotype of *Serinus canarius* (OHNO et al. 1964) is also similar to that of *Chloris chloris*. Only small differences in the centromere positions of the larger chromosomes differentiate these three members of the family Fringillidae from each other. There is, however, one special aspect of the karyotype of *Chloris chloris*: chromosome No. 1 can be either an st or an sm chromosome.

Chromosomal polymorphism in birds has previously been described for *Zonotrichia albicollis* (THORNEYCROFT 1966) *Vanellus vanellus* (HAMMAR 1970) and for six species of the genus *Junco* (SHIELDS 1973). In *Zonotrichia albicollis* there is a phenotypical polymorphism related to the chromosomal polymorphism leading to a selective breeding that seems to maintain heterozygosity in the population (THORNEYCROFT 1966). The data of *Chloris chloris* is based on only five specimens from two clutches and therefore no similar conclusions can be drawn.

The three genera, *Chloris*, *Zonotrichia* and *Junco*, of the family Fringillidae seem to have very similar karyotypes and at least two of them, *Zonotrichia* and *Junco*, are closely related. In all three genera chromosomal polymorphism have

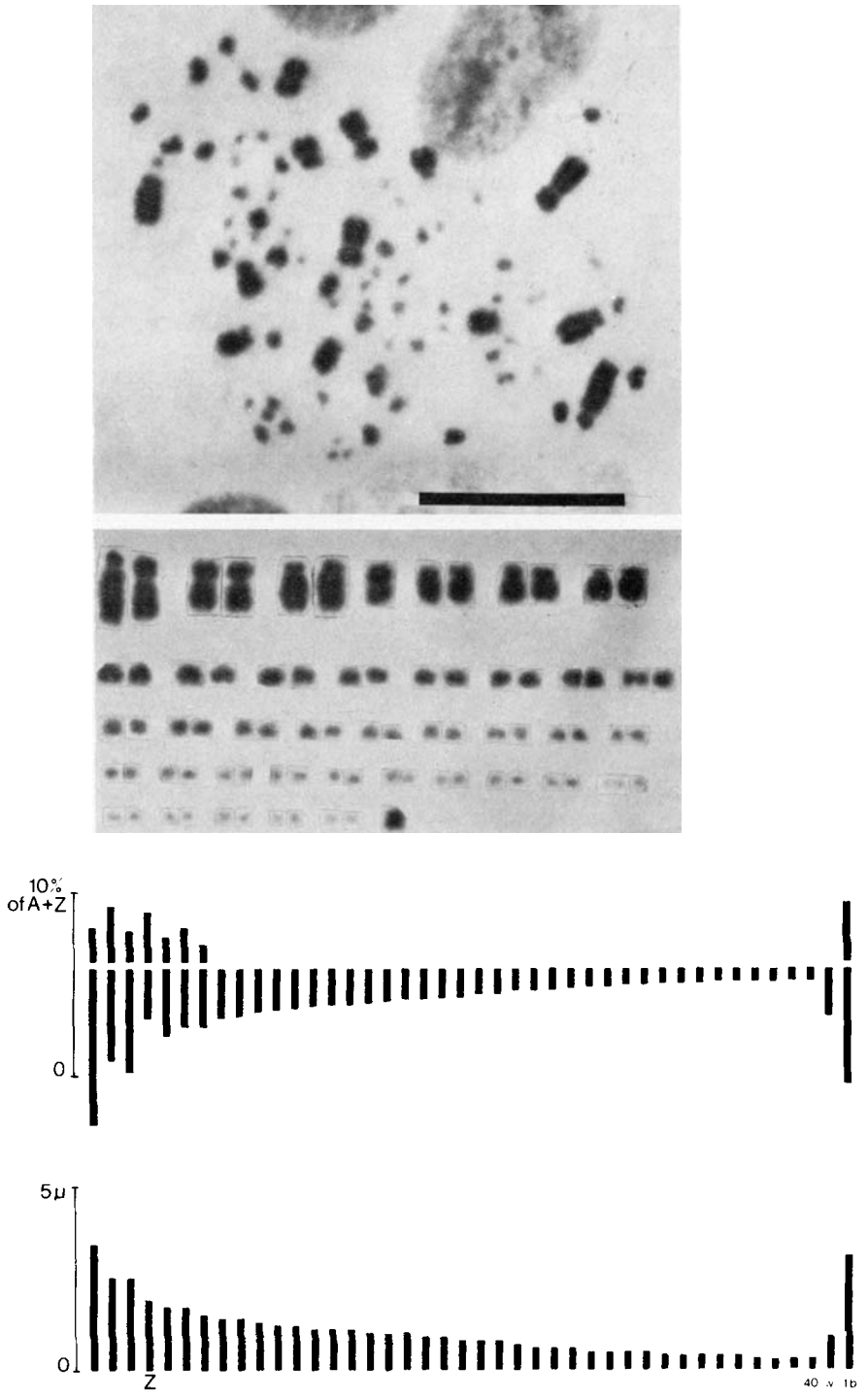

Fig. 3. *Chloris chloris*, metaphase chromosomes and idiogram of a female heterozygote for the centromere locus in chromosome no. 1.

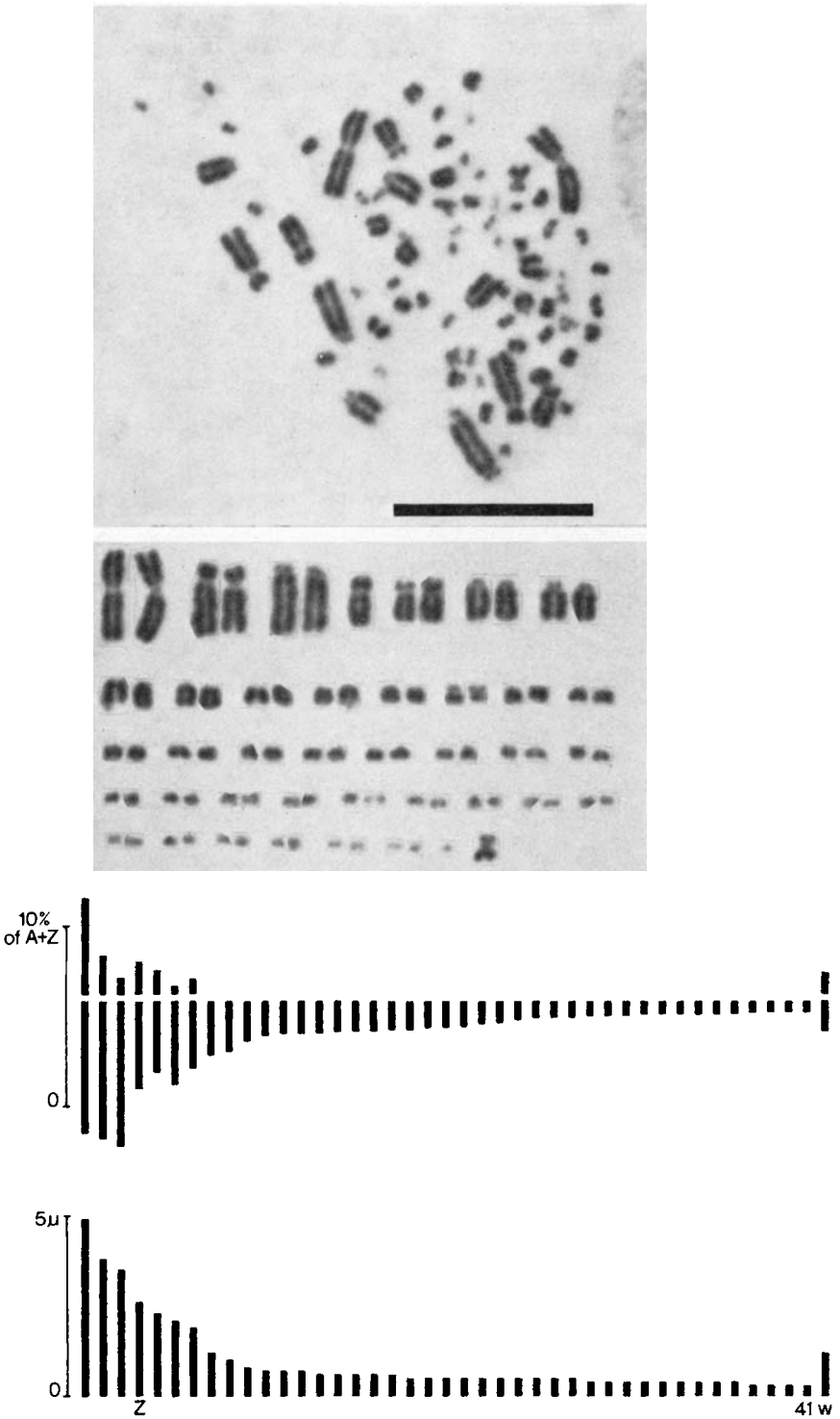

Fig. 4. *Emberiza citrinella*, female metaphase chromosomes and idiogram.

been reported. All polymorphism seems to bee due to pericentric inversions.

In *Chloris chloris* there is a pericentric inversion in chromosome No. 1 so that this chromosome can be either an st or an sm chromosome. In *Zonotrichia albicollis* (THORNEYCROFT 1966) and in all species of *Junco* described (SHIELD 1973), chromosome No. 1 is an sm chromosome.

In *Zonotrichia albicollis* chromosome No. 2 or 3 is either an st or an m chromosome (THORNEYCROFT 1966) and in *Junco* No. 2 can be either an st or an sm chromosome (SHIELD 1973) while in *Chloris chloris* No. 2 is an sm and No. 3 is an st chromosome.

In *Junco* there is one more chromosome pair involved in chromosome polymorphism. No. 5 can be either an st or an m chromosome. In *Zonotrichia albicollis* and *Chloris chloris* No. 5 is an st chromosome.

The Z chromosome, No. 4, is in *Chloris chloris* an m chromosome while it in *Zonotrichia albicollis* and the *Junco* species is an st chromosome.

Emberiza citrinella has a karyotype quite similar to that of *Emberiza flavientris* (HIRSCHI et al. 1972). In *E. citrinella* chromosome No. 4 is the Z, and the W is an sm chromosome 1.6 microns long. *E. citrinella* also has great similarities to *Carduelis spinus* (TAKAGI 1972). However, there seem to be differences in the centromere position of the larger chromosomes.

This investigation confirms the great stability of the karyotype among related bird species but it also demonstrates that within some species there may occur a chromosomal polymorphism probably due to pericentric inversions.

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