Karyological Heterogeneity in the Falconiformes (Aves)

It is a long-standing problem whether the diurnal birds of prey (Falconiformes) constitute a natural group, or are of polyphyletic origin. During the past century, many authors brought out widely divergent views on the classification of the order and the possible ties to other avian taxa, a full historical review of which was given in 1972 by SIBLEY and AHLQUIST[1]. Presently, the Cathartidae (New World vultures) are generally recognized as a separate suborder, Cathartae, and are sometimes believed to have affinities to the Ciconiiformes or Pelecaniformes[2,3]. BROWN and AMADON[4] also place the Falconidae (falcons and caracaras) in an individual suborder, Falcones. A possible relationship of this group to the Strigiformes is still debatable[1,3]. The third suborder, Accipitres, includes the Accipitridae (hawks, eagles, kites and Old World vultures, by far the most extensive assemblage in the order) and the monotypic families Sagittariidae (secretary bird) and Pandionidae (osprey). A relationship of the secretary bird to the Cariamidae (Gruiformes) has also been postulated[3], while the osprey has been alined with various other groups of falconiformes.

In the literature, records are found on chromosome studies in only 3 falconiform species, *Buteo buteo*[5], *Falco tinnunculus*[5] and *Haliaetus leucocephalus*[6], although HOFFMANN[7] lately investigated the secretary bird and 4 eagle species (personal communication). Recent studies by the author (unpublished work) of chromosome material, obtained from leucocyte cultures[8], of 16 species of the order lead to the conclusion that the Falconiformes consist of 4 karyologically very distinct groups. Karyotypes of representative species of each of these groups are shown in Figure 1.

The first group includes the Cathartidae, two species of which, the Andes condor (*Vultur gryphus*) and king vulture (*Sarcorhamphus papa*), showed identical karyotypes with 3 pairs of large and 2 pairs of medium-sized biarmed macrochromosomes, 1 pair of small metacentrics, and a number of small acrocentrics which gradually decrease in size and emerge into a large group of microchromosomes. The *Z* chromosome is a medium-sized submetacentric, the *W* a smaller almost metacentric element. The chromosome number is approximately 80, but because of the extremely minute size of the smallest microchromosomes, only seldom are all of them seen.

The second group includes the Falconidae. The karyotypes of 2 species, the caracara (*Polyborus plancus*, subf. Polyborinae) and lanner falcon (*Falco biarmicus*, subf. Falconinae) are both characterized by the presence of only 1 single pair of biarmed macrochromosomes. All remaining macrochromosomes are acrocentric, and gradually decrease in length to the size of microchromosomes. No definite information is available on the morphology of the sex chromosomes. The approximate diploid number of *Polyborus* is 82, that of *Falco* which shows less microchromosomes (see also ref.[5]) is 52.

The third group exclusively includes the secretary bird (*Sagittarius serpentarius*). In its karyotype 36 macrochromosomes, all biarmed and of medium to small size, are clearly distinguishable from the large group of approximately 44 microchromosomes. The possible *Z* and *W* chromosome both belong to the macrochromosomes.

The last group includes the Accipitridae. 11 species of this family, belonging to the subfamilies Accipitrinae (hawks), Buteoninae (buzzards, eagles), Milvinae (kites)

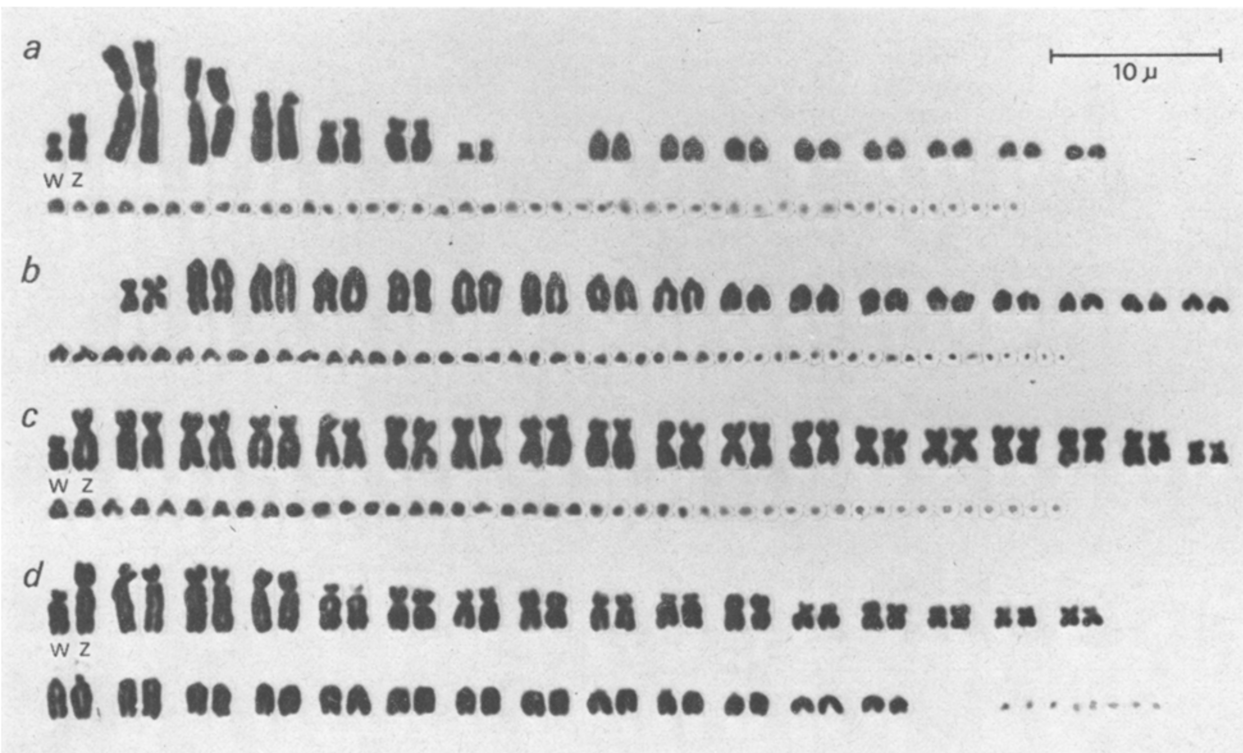

Fig. 1. Representative karyotypes of 4 species of Falconiformes. a) female Andes condor (*Vultur gryphus*, F. Cathartidae); b) caracara of unknown sex (*Polyborus plancus*, F. Falconidae); c) female secretary bird (*Sagittarius serpentarius*, F. Sagittariidae); d) female cape vulture (*Gyps coprotheres*, F. Accipitridae). Only the larger chromosomes in each karyotype are matched in pairs.

and Aegypiinae (Old World vultures), were studied. Although there is a relatively wide range in diploid numbers, the karyotypes in this group constitute a firm unity. There are always only 8 microchromosomes, which are clearly marked off from the large group of macrochromosomes. The latter are of medium to small size and can all be plainly characterized by their centromeric position. The numbers of acro-, meta- and submetacentric macrochromosomes vary from one species to another. Without exception, the *Z* chromosome is one of the longest submetacentrics; the *W* is smaller and less easily recognizable. The highest diploid number so far found (78) occurs in the northern gosh-hawk (*Accipiter gentilis*), the lowest (60) in the bearded vulture (*Gypaetus barbatus*).

Unfortunately, no information is available on the karyotype of the osprey (*Pandion haliaetus*). This could probably throw more light on its real affinities within the order.

Beyond doubt the Falconiformes display a much wider karyological variety than any other avian order. This is the more striking since in birds often clear karyological similarities exist between even widely separated orders[9, 10]. The differences between the above groups are so well marked that it seems unjustified to speculate on possible relationships between them. The only obvious tie of a falconiform group to other avian orders concerns the Cathartidae. Recently chromosome complements nearly identical to those of the cathartids were found in representatives of the Gruiformes and Ciconiiformes by Hoffmann (*Bugeranus carunculatus*)[7] and myself (*Anthropoides virgo*, Figure 2; *Gallirallus australis* and *Phoeniconaias minor*; unpublished work). In this respect it would be of interest also to obtain data of the Pelecaniformes.

The complements of the Accipitridae are most uncommon among birds, because of the extremely low number of microchromosomes. No karyotypes are known in the class Aves, with which they could be compared, neither within nor outside the Falconiformes. The karyology does not add conclusive information on the possible relation between Falconidae and Strigiformes. A falconid chromosome complement could be derived from an owl karyotype[5, 9] with no less difficulty than from any other typical bird karyotype. The complement of the secretary bird might suggest some distant relation to the Falconidae with respect to the rough macro-microchromosome division, to the Accipitridae, however, with respect to the high number of biarmed macrochromosomes. Information on karyotypes of Cariamidae may be conclusive as to their possible affinities to *Sagittarius*.

Fig. 2. Karyotype of male *Anthropoides virgo* (Gruiformes).

Although the karyological data available now seem to stress separation of the Cathartidae from the Falconiformes, the absence of common traits between the remaining groups and between any of these and any other avian order, leaves the question as to their mono- or polyphyletic origin as yet unanswered. Their most unusual assemblage of karyotypes, however, strongly encourages further studies.

Summary. Chromosome studies in 4 families of Falconiformes, Cathartidae, Falconidae, Sagittariidae and Accipitridae showed that the karyological variety in this order is much wider than in any other avian order, which underlines the heterogeneous character of the group. Of the 4 families only the Cathartidae show karyological similarities with other avian groups (Gruiformes, Ciconiiformes), while the karyotypes of the Accipitridae are most uncommon among birds, because of the presence of only 8 microchromosomes.

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Male-linked Translocations and the Control of Insect Pest Populations

The simplest of the types of translocation which could be used for insect pest control[1] is one linked to the *Y* chromosome or male-determining gene. Heterozygotes for such male-linked translocations mated to normal females show semi-sterility and produce heterozygous males and normal females, so that the translocation could be automatically perpetuated in a laboratory colony.

A release experiment in a village near Montpellier, with a male-linked translocation in *Culex pipiens*, has been

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