



25th International Ornithological Congress 22-28 August 2010 (www.i-o-c.org)

S31 Complex functional-morphological adaptations of birds to flight

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***This symposium is dedicated to Walter J. Bock and Evgeny N. Kurochkin to honor their contributions to the evolutionary biology and history of birds**

Adaptive co-evolution of avian hind limbs and flight in birds

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Modern birds comprise a compact group with the relatively uniform bauplan. As an important locomotor module, their hind limbs underwent considerable modifications on the way from theropod ancestors to neornithine birds. Viewed as a sequence of modifications through time, these changes can be divided into preadaptive ones, and those directly related to the flight ability. As bipedalism and the adducted position of the hind limbs appeared in the archosaurian lineage long before the emergence of the first bird, these features should be considered prerequisite. The enlargement of the pectoral girdle and the reduction of tail have shifted the center of gravity cranially away from the ancestral position between the acetabula of the pelvic girdle. This changed aligned the femur more horizontally as the first feature directly related to the flight. The mechanical decoupling of the tail and hind limbs allowed a reduction of caudofemoral muscles. This reduction is expressed to this extent only in birds and is, thus, the second feature that is a prerequisite for the acquisition of maneuverable flight. The reduction of the powerful caudofemoral retractors of the femur transmitted the function of femoral retractors on muscles, starting from postacetabular portion of the pelvis, thus making them more powerful, and requiring more space for the origin. This requirement was achieved by a caudal expansion of the postacetabular pelvis, the third feature that is related to flight. In addition, a cranial expansion of the preacetabular part of the pelvis, to which the powerful Mm. iliотrochanterici attach, is necessary to counteract the supination imposed on the femoral shaft by the caudofemoral retractor muscles. As the avian ancestor became volant, selection against an increase in body weight became especially strong. The decrease in body weight through the reduction of the tail and the associated bulky caudofemoral muscles is a fourth flight-related feature. The anisodactyl foot, which is a unique and ancestral characteristic of birds can be considered as a prerequisite for the appearance of flight, but not directly related to it.