Dogs in motion: Interdependencies of skeleton, muscles and locomotion

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The domestication of wolves has led to an incredible diversity of dog breeds be it in size, weight, build or general appearance. Reasons for this highest diversity among all domestic animals are to be sought in the intrinsic variability of wolf populations and individuals and the ten thousands of years of selection. The locomotory apparatus was in the focus of selection, too.

We studied 327 dogs from 32 different breeds among them Appenzeller, Bernese and Entlebucher mountain dogs in the world's largest study so far in order to find the effect of selection onto the motion of different breeds. We expected strong differences especially knowing the fortyfold difference in weight between a Chihuahua or a Dachshound and a Great Dane – or do show all breeds despite all differences more or less the same locomotion?

The results was surprising because the difference between ten dogs of one breed were almost always larger than the mean values differ between breeds. In contrast to our expectations dog's motion has remained rather unchanged despite the long history of domestication. Especially the proportions of the limb elements like thigh or lower leg are pretty much the same, and especially the length of the upper arm in relation to the other forelimb elements (shoulder blade, lower arm, midcarpals) varies between the different breeds to less than one percent. It is obvious that kinematics are the same when proportions are the same. In reality slight or putative difference have been overstated while all breed have a great deal in common.

The relative step length – scaled to wither's height – of the Dachshund and Great Dane is e.g. 1.3 and 1.2 in the walk (both make 30% or 20% longer steps than their wither's height) or 1.9 and 1.8. in the trot. The respective values for the hindlimbs are for the Dachshound 1.6 and 2.1 but 1.4. and 2.0 for the Great Dane.

The impact of scapular rotation and translation on progression has been overlooked for long time. Thanks to high-speed X-ray movies we could show that scapula rotation accounts for about two-thirds of forelimb step length in all dog breeds. Therefore it is not surprising that the effective amplitude (touch down-lift off-difference) is 34° (walk) and 39° (trot) in the Dachshound or 37° and 44° in the Great Dane. e.g. values for the Mountain dogs in the same gaits are: 36°/40° (Bernese), 33°/45° (Appenzeller) and 32°/38° (Entlebucher). So, the basic pattern is highly similar in all dogs. The main insight of our study might be that dogs have kept their original wolf-like motion.

The talk will present the basics of dog locomotion explaining them with movies and animations. The whole study has been published in English and German in our book ("Dogs in motion", "Hunde in Bewegung"), in which we also present extensively and at best the current knowledge on this topic. The reader will find all information on bones, muscles, joints, kinematics as well as the dynamical aspects of locomotion. As we have included a DVD with more than 300 films (high-speed movies, high-speed X-ray movies, 3D-animations) we hope to open a door to a new and better understanding of dogs in motion.