

Animal gaits: Footfall sequence.

Animals with four legs are faced with a good many more choices in the order in which their feet hit the ground than are two-legged creatures like ourselves. There are six possibilities for each foot striking the ground separately (4-beat gaits), eight possibilities (four of which are mirror images) for two feet striking separately and two together (3-beat gaits), 3 possibilities for feet striking in pairs (2-beat gaits), four theoretical possibilities for three feet striking together and one separately (2-beat gait) and one possibility for all four feet striking together (1-beat gait). Not all are normally used by real animals, and of those that are used, some are appropriate for faster speeds than others. Those which are not used by the horse or the dog are grayed out.

Here are the 4-beat possibilities, with the left hind listed first in all cases:

1. Left hind, left fore, right hind, right fore. With even timing and no suspension, this is the normal walk sequence and also the basis (often with uneven timing) of the "easy" gaits. It is also the footfall sequence of a very relaxed, uncollected lope, or slow canter, though in that case there is a brief period of suspension between one forefoot and the following hind foot, and the other fore and hind diagonal strike the ground very close to each other.
2. Left hind, left fore, right fore, right hind. This is the rotatory gallop sequence, with a period of suspension between the right fore and the right hind (single suspended rotatory gallop) and sometimes another between the left hind and the left fore (Double suspended rotatory gallop.) Most mammal species show a definite preference for either the rotatory or the transverse gallop, but most are capable of doing either. A horse "disunited" at the gallop, for instance, is simply performing a rotatory gallop, which is a good deal less comfortable for the rider.
3. Left hind, right hind, left fore, right fore. This is the transverse gallop sequence, with a period of suspension between the right fore (the lead fore) and the left hind. There could be a second period of suspension between the right hind and the left fore, giving a double suspension transverse gallop. This does not seem to occur normally in horses, but it may occur at times in lighter animals, including those who normally utilize a rotatory gallop.. At a walking pace sequences 2 - 5 would require extreme shortening and lengthening of the body, which is probably why these footfall sequences occur in horses only with suspension. Animals with extreme longitudinal flexibility (e.g., ferrets) might be capable of using these gallop footfall sequences without suspension, though I am aware of no proof, one way or the other.
4. Left hind, right hind, right fore, left fore. This is a mirror image of the rotatory gallop described above. It is a rotatory gallop, but with the rotation going in the opposite direction and the main suspension phase between the left fore and the left hind.
5. Left hind, right fore, left fore, right hind. This is a mirror image of the transverse gallop, but on the left lead rather than the right. The main suspension period is between the left fore and the right hind.
6. Left hind, right fore, right hind, left fore. This sequence is used very rarely in normal locomotion, probably because the hind leg would be landing while weight was on the foreleg of the corresponding side, virtually guaranteeing interference between the fore and hind leg on the same side. It may occur in an overcollected trot, where the hind foot touches down a fraction of a second before the diagonal forefoot. Muybridge also recorded it as a walk in a baboon. but it is unclear whether this was an oddity of the particular baboon used. Certainly the animal was moving slightly diagonally, with the hind foot invariably placed to the left of the fore foot.

The three-beat possibilities are similarly listed below. Note that those actually used in locomotion have one fore and one hind foot striking the ground together.

1. Left hind, right hind and left fore together, right fore. This is the idealized transverse canter sequence on the right lead, with suspension between the right fore and the left hind.
2. Left hind, right hind and right fore together, left fore. This would be an idealized rotatory canter. I have no photographic sequences of this, but I would expect the slow canter of a dog to be close to this.
3. Left hind, both forelegs together, right hind. This may occur when jumping or changing gaits, but not as a normal mode of progress.
4. Left hind, right hind, both forelegs together. This is a mirror image of sequence 3.
5. Left hind and right fore together, left fore, right hind. Idealized transverse canter, left lead. There is a suspension period between the left fore and the right hind.
6. Left hind and left fore together, right fore, right hind. Idealized rotatory canter, rotation in opposite direction from 2.
7. Left hind and right hind together, left fore, right fore. I would not totally rule this out in, say, rabbits, but it is not a normal mode of progress in most mammals.
8. Left hind and right hind together, right fore, left fore. This is a mirror image of 8, and is equally unlikely as a progressive gait.

The 2-beat gaits with two feet moving together are somewhat smaller in number (three.) Two of these possibilities are actually used in locomotion. The third could be used in a kind of "inchworm" mode of progress by animals with long, flexible spines or by animals that progress in a series of leaps, but I have no evidence that it is actually so used.

1. Left hind and right fore together, followed by right hind and left fore. This is the trot, utilized as an endurance gait by a large number of mammals. Because the supporting feet are located diagonally from each other, the trot is often referred to as a diagonal gait. With diagonal support the line of support is closer to passing under the center of mass than is the case with lateral support. There is normally a suspension phase between the two diagonals, at least in animals built so that there is a possibility of the hind foot coming down at or ahead of the position just vacated by the forefoot on the same side - without suspension, the forefoot would still be at the position needed for the descending hind foot. Animals can be trained to hold the trot at a speed where a canter or gallop would be more efficient in terms of energy expended. This is seen in trotting races with horses and in the show ring with dogs. In dressage, the piaffe and passage are basically trots slowed to the point where almost no forward motion occurs. It should be noted that in a real trot, as opposed to an ideal one, there is often a slight difference in when the foreleg and the diagonal hind leg strike the ground. In horses trotting at speed, the forefoot normally strikes just slightly ahead of the diagonal hind foot. This actually gives the walk footfall sequence.
2. Left hind and left fore together, followed by right hind and right fore together. This is the pace, again utilized as an endurance gait by some mammals (e.g., the camel). It is also common as a relief gait that uses slightly different muscles than the trot. Because the legs on the same side of the body move together, the pace is sometimes referred to as a lateral gait. Like the trot, there is normally a suspension phase between the two periods of lateral support. The line of support is farther from the center of mass than is the case for diagonal support, and pacing animals consequently sway from side to side as they move. This is most notorious in the camel, but true pacing (rather than ambling) horses are

anything but comfortable to ride. They are, however, very slightly faster in harness. The tendency to trot or pace is inherited in horses, though some horses can be trained to either gait. The pace with the laterals exactly together is an ideal. A more common footfall sequence is for the hind leg to touch down just before the front leg on the same side. Again, the deviation is toward the walking footfall sequence.

3. Left hind and right hind together, left fore and right fore together. This is not a recognised gait in horses or dogs, though playing puppies may use it. I would not rule out the possibility that this "bunny hop" might actually be used by rabbits, for instance.

2-beat gaits with one beat given by three legs moving together are not known to correspond to any type of normal animal locomotion.

The 1-beat gait (all four legs at once) might conceivably be used by the springbok in its leaps, but this is less a mode of progression than a display of fitness and possibly a way of spotting predators.

[Return to Animal motion index](#)