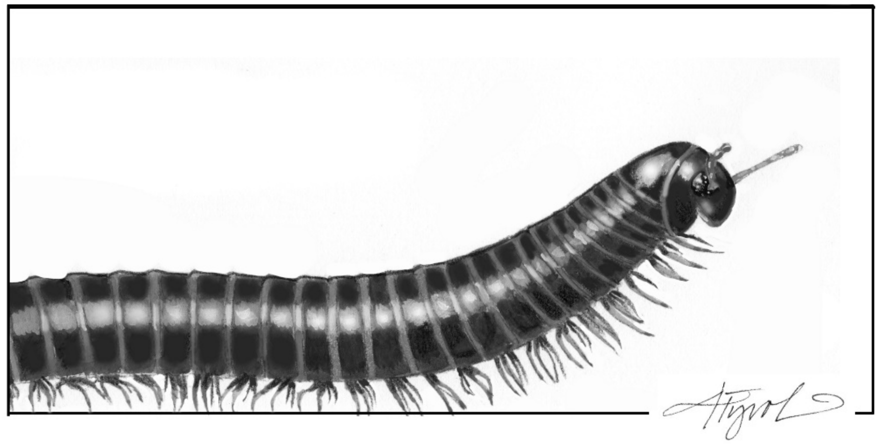
# The Outside Story

## Walking with Many Legs

### By Rachel Sargent Mirus



Grinning and giggling, my one-year-old son ran across the living room, only to trip over his own feet and faceplant on the carpet. Sometimes, two legs can be too many to coordinate. How, then, do invertebrates walk with six, eight, or hundreds of legs?

In some ways, walking for insects, arachnids, and myriapods (a group that includes millipedes and centipedes) isn't that different than it is for us. We are able to switch between fast and slow speeds, from walking to jogging when we're in a hurry or sprinting when we're about to miss the bus. We use these different gaits to match our circumstances. Likewise, invertebrates are able to change their gaits and speed of movement as needed.

Exactly how scientists study and explain gaits and changes in speed varies between mammals and invertebrates. Scientists studying four-legged mammals consider each different leg coordination pattern – when different legs are striking the ground at different times relative to each other – to be a gait. Thus, horses, for example, can switch between walking, trotting, cantering, and galloping, with each gait having a characteristic pattern of footfalls and a comfortable range of speeds.

Changes to how legs coordinate with each other don't necessarily match changes to how the rest of an animal's body moves, however. When it comes to many-legged invertebrates, it makes sense to focus on whole body movement when considering gaits, said Tom Weihmann, arthropod biomechanics researcher at the University of Cologne.

Consider insects, for example. These six-legged animals have two basic gaits. Their low-speed "walk" is a wave-like leg pattern where the legs flow up and down in a smooth rhythm and the body remains relatively level. Insects also have a fast tripodal "running" pattern where three legs are on the ground at a time, two from one side and one from the other, alternating side to side and causing their body to rise and fall as they move.

To coordinate leg patterns at different speeds, invertebrates rely on their sophisticated nervous systems to adjust the timing of their leg movements. In most cases, the rearmost pair of legs sets the pace, and all the forward legs follow. So, if the legs are working as a wave, that wave starts from the animal's back end.

Just as humans may jog before breaking into a sprint, insect and other invertebrate gaits show a continuum in changing speeds. Some species can shift between leg coordination patterns that are efficient at certain paces. For example, Weihmann's research has investigated how cockroaches change gaits as their speed changes. Many cockroaches use the wave leg pattern when moving slowly, but they have elastic structures built into their hind hips that allow them to store and recycle vertical momentum as they move up and down during their faster tripod gait. The elasticity of their hips stores vertical movement from the upwards bounce of that gait so they don't need as much energy to push themselves off the ground after the downwards bounce. Over many steps, this strategy saves energy.

While the tripod gait can be energy efficient, the wave gait has its advantages, too. The wave gait causes horizontal wiggling in the body of a many-legged walker, which helps stabilize the animal against sideways slips, thereby allowing invertebrates to traverse slippery or unreliable terrain with less tripping.

Animals with more than four pairs of legs, including woodlice, millipedes, and centipedes, can't synchronize leg sets to recycle energy from up and down body motions, so they tend to stay level at all speeds. Centipedes are flexible enough to bend their bodies side to side at higher speeds, allowing them to increase their step length, much as humans can increase our pace by lengthening our stride.

At high speeds, some invertebrates use fewer legs to push off the ground with each step. Cockroaches achieve this by tilting their bodies, so their forward legs spend less time on the ground. Ghost crabs use a different strategy: despite having ten legs, at their top speed of 4 1/2 miles per hour, these crabs run on just two of those legs. Fewer legs on the ground increases the up and down body motions of these invertebrates, which helps with energy efficiency and stability over uneven ground.

So, it seems, being bipedal can have advantages after all.

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