

Mechanics of Soft-Bodied Legged Locomotion: Are Caterpillars Worms with Legs?

ABSTRACT

Worm-like body shapes are thought to be some of the earliest evolved body plans for soft moving organisms. This simple cylindrical shape is often modified through evolution with the addition of limbs and other structures to improve how an animal interacts with the environment. This project asks a very fundamental question: how do such soft appendages change the way a soft-bodied worm-like organism moves? The caterpillar, tobacco hornworm (*Manduca sexta*), offers a great system to answer this question.

Using a custom-built force sensor array, the investigators directly measure forces the caterpillar legs exert during normal crawling. By matching the movements of the body to forces in different directions it is possible to accurately describe how different legs help the caterpillar crawl and climb. This study will also measure changes in body pressure to establish how caterpillars differ from non-legged soft invertebrates such as leeches and earthworms. It is expected that because the caterpillar has legs to anchor the body, it will rely less on stiffening its body with fluid pressure for fine movement control. The experiments will test if legs allow soft animals to exploit stiff structures in their environment as a continually changing skeleton. In effect the caterpillar can conform to the shapes that it crawls upon.

Understanding the functional benefits of appendages on a worm-like morphology not only provides insights to soft material control, but also gives clues to why different caterpillars have different numbers of legs. Practically, this project pushes the technical limits of biomechanical measurement. It will also expand our understanding of animal locomotion and contribute to current theories of legged systems, both animals and machines. Conceivably, this project can benefit engineering and the development of soft robots and devices.