MEASUREMENT OF THE CRUSHING FORCE OF THE CRAB CLAW

BY

GURBAX SINGH1), JEFFREY D. BLOCK2) and STEVE REBACH
Department of Natural Sciences, University of Maryland Eastern Shore, Princess Anne, Maryland 21853-1299, U.S.A.

INTRODUCTION

Behavioral ecologists have studied the relationship between foraging behavior and the claw strength of a crab (Blundon & Kennedy, 1982). Crushing strength of the crab claw influences the type and size of its prey and is correlated to the crab size, the area for attachment of the closer muscle, the claw closer apodeme area, and muscle volume (Block & Rebach, 1998).

A custom made hydro-mechanical device has been used for such studies (Govind & Blundon, 1985; Block & Rebach, 1998). In this case, the claw pulls together two steel bars (5 mm in diameter and separated by ~15 mm). This squeezing force is transferred to the piston of a cylinder containing hydraulic oil, which in turn is read as a change in pressure on a pressure gauge. The gauge pressure is calibrated in terms of the applied force.

A modern version of a commercially available force sensor is adapted to measure the claw force. It is primarily designed for a physical science laboratory to investigate the physical principles in which the measurement of force is involved. Such a force sensor typically consists of a proprietary shaped metal block with a strain gauge attached to it with an adhesive. Force to be measured is applied to a hook or a rod screwed into the metal block and the resulting strain causes the resistance of the strain gauge to change. The change in the resistance is converted to a corresponding electrical voltage output. The voltage output, which is proportional to the applied force, is digitized and interfaced to a laptop or a personal computer with an interface box. The change in the voltage over time and hence the applied force can be recorded, displayed on the microcomputer screen in real time, and saved for further analysis. Interface boxes and force sensors with a range of about ± 50 N and a resolution of ~ 0.03 N are affordable and available.

1) Corresponding author; e-mail: gsingh@mail.umes.edu
2) Present address: 1710 Glenpark Drive, Wheaton, MD 20902, U.S.A.
from several vendors: PASCO (1999), Vernier Software (1999), and Team Labs (1999), to name a few.

ADVANTAGES

The contemporary force sensor offers several advantages over the hydro-mechanical device and opens up new areas of research. Some of them are listed below:

1. When interfaced to a laptop, it is an ideal instrument for field measurements. Data logging, analysis, and plotting can be done quickly at site.

2. The crushing force of the claw can be viewed on the computer monitor in real time. Its rise time, width of the crushing pulse, and its repetition rate can now be conveniently studied.

3. It is more precise than a hydro-mechanical device.

4. The gap between the two steel bars which are gripped by the crab claw remains essentially constant in the modified force sensor when compared to the hydro-mechanical device. The displacement in the force sensor is less than 0.13 mm for 20 N of applied force whereas the hydro-mechanical device yields more than twice as much under the same conditions.

5. The width of the gap can be adjusted to simulate preys of different sizes and for different size predators.

6. Fast response of the force sensor opens up other areas of crustacean behavioral research: such as the rise time of the crushing pulse may be related to the mechanism used to open hard-shelled prey, and how often and how fast an animal applies the crushing pulses.

EXPERIMENTAL SETUP

A PASCO (1999) force sensor of ± 50 Newton range was modified for the setup to measure the claw force. The force sensor came with an open hook screwed into the metal block of the sensor. This open hook was replaced with a rectangular shaped closed hook. The force sensor was hung on a laboratory stand and calibrated in Newtons. A U-shaped bar was bolted at the base of the stand such that the lower side of the hook and the back side of the U-bar were held parallel to each other. The two parallel bars formed the mechanism for the claw to squeeze them together, thereby pulling down the hook attached to the force sensor (fig. 1). The force sensor could be raised or lowered to change the width of the gap between the two bars. The output from the force was fed into the microcomputer through an interface box, PASCO (1999) ScienceWorkshop 500. The output could be displayed in real time and saved for further analysis.