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PORTABLE DEVICE FOR MEASURING SEED HARDNESS

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Abstract.—A new portable device for measuring the hardness of seeds is described. The seedcracker is constructed from a proving ring mounted in a pair of pliers. The device measures 12 × 24 × 25 cm and weighs 2.2 kg. In its present form the device records a maximal fracture force of 222 Newtons, which is sufficient for a wide variety of seeds, but larger forces may be measured by using a larger proving ring. The precision, as estimated by the correlation coefficient of repeated measurements, is 0.999.

APARATO PORTÁTIL PARA MEDIR LA DUREZA DE SEMILLAS

Resumen.—Se describe un aparato portátil para medir la dureza de semillas. El aparato es construido de un anillo o resorte de presión (especie de dinamómetro) montado en una pareja de tenazas; mide 12 × 24 × 25 cm y pesa 2.2 kg. El artefacto ejerce una fuerza máxima para fracturación de 222 Newtons, lo que es adecuado para una gran variedad de semillas. Su presición es de 0.999.

Feeding efficiencies of seed eating birds depend in part on seed hardness and size (Grant 1986, Smith 1987). Determining seed hardness generally requires a seed be cracked and the maximum fracture force recorded. Most material testing devices that measure forces, however, are complex and require trained personnel to operate them (Beckwith and Buck 1973). Moreover, they are not portable in the field. In studies of Darwin's Finches (*Geospiza*) seed and fruit hardness were estimated using an instrument designed by the McGill University Engineering Department (Abbott et al. 1977). In this paper we describe another portable device for measuring hardness. Our device is not restricted to cracking seeds, but may be modified for other uses. For example, with few adjustments the device may be used to record the force required to pierce objects such as leaves.

The seedcracker (Fig. 1) employs a Soiltest PR series, model PR-005 proving ring, available through Soiltest Inc., Evanston, Illinois. Proving rings are essentially very precise springs and have long been the standard in the engineering field for measuring the forces involved in stress and strain. Because proving rings are often the standard by which other force measuring instruments are calibrated and have very high accuracies (Beckwith and Buck 1973), we feel they are advantageous over other force measuring devices. To allow the proving ring to be easily handled we mounted the proving ring to a pair of lineman's pliers. A mounting fixture consisting of a 1.3 × 1.3 cm square steel L shaped bar was welded to the lower jaw of the pliers, and a 7.9 cm 1.3 × 1.3 cm bar was welded to the upper jaw. The bar on the upper jaw provided the mandrel. The

FIGURE 1. Photograph of Smith Seedcracker.

proving ring was then attached to the L shaped bar with a 0.62 cm bolt. An adjustable anvil consisting of a 0.62 cm bolt was then screwed into the top mounting hole of the proving ring (detailed blueprints are available from the authors). This allows the anvil to be adjusted so that the force may be applied axially through the seed into the ring when the seed is crushed. Because stress is proportional to strain (Hetenyi 1950), the deflection (or flattening) of the ring is proportional to the force necessary to deflect the ring. A dial indicator which comes standard with each proving ring measures the distance of the deflection. The placement of the proving ring relative to the plier hinge eliminates errors due to hinge friction, allowing the proving ring to directly measure applied force. The pliers provide a force ratio of 3:1. In other words, a force of 10 Newtons applied to the pliers exerts a force of 30 Newtons on the proving ring. Each proving ring is calibrated by the manufacturer and records force in pounds, kilograms, or Newtons. The accuracy of each ring is determined by the manufacturer of the ring and is estimated by the correlation coefficient of repeated trials. Soiltest Inc. calculated the proving ring shown in Figure 1 to have a correlation coefficient of 0.999. The dimensions of the proving ring pliers are 12 × 24 × 25 cm and the weight 2.2 kg.

To measure hardness the object to be cracked is placed between the upper jaw of the pliers and the anvil of the proving ring. The anvil is adjusted to accommodate different sized objects. The dial indicator located at the center of the proving ring is set to zero. Force is then slowly applied to the handle of the pliers until the seed cracks. The needle on the dial indicator is equipped with a brake which records the maximum deflection of the proving ring. Generally, there is an audible sound when the seed fractures, signaling to the user that the seed has been cracked. The force is easily obtained by substituting the reading from the dial indicator into a formula or table provided by the manfacturer.

In its current form the device is capable of recording a maximal fracture force of 222 Newtons (approximately 50 pounds). This range is adequate for a wide variety of seeds. For instance, the device is capable of accurately measuring very hard sedge seeds with hardnesses of 150 N, intermediate seeds such as sunflower having hardnesses of approximately 50 N and also very soft seeds such as millet which require between 10 and 20 N to crack. For extremely hard seeds a larger proving ring may be employed.

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