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A Scale for Weighing Birds at Habitual Perches.—Repeated weight measurements of adult birds in the wild are often difficult to obtain because of problems associated with trapping and disturbing the birds. Body weights for only 2 species of the world's raptors have been followed through the breeding season (Newton 1979); daily and seasonal weight change for other bird species are only slightly better known (see Palmer 1963). As weight is usually considered a measure of a bird's condition, weight changes are useful data since they may reflect the energetic costs associated with a particular activity and/or a bird's foraging efficiency (Drent and Daan 1980). The simple and non-disturbing method for obtaining accurate weights of wild birds described here should thus prove helpful to field ornithologists.

We designed and tested a compact, weatherproof, and relatively inexpensive electronic scale for birds at perches. This scale takes advantage of the fact that many birds use habitual perches and will often shift to artificial perches if these are placed at their habitual sites (Hall et al. 1981; pers. obs.). Our balance uses a transducer which is easily incorporated into an artificial perch and from which remote readings of weight can be made. We used 2 such scales during studies of breeding Ospreys (*Pandion haliaetus*), and found the method accurate and effective. We think the method could also be used with other birds. Although Sibly and McCleery (1980) have developed an electronic balance for remote weighing of ground-nesting birds, their method does not appear readily modified to weigh birds at perches.

Design and construction.—The perch-scale consists of 2 main units: (1) the perch, incorporating the transducer (Fig. 1); and (2) the batteries, amplifier (Fig. 2), and recorder unit, which are easily contained in a 14 × 28 × 17.5 cm weatherproof army surplus ammunition box. A bird landing on the perch deflects the tranducer, a metal beam with 4 deflection sensing strain gauges bonded to it, via the plunger. As the tranducer deflects, the strain gauges change resistance which develops a voltage proportional to weight. This voltage is then read remotely. The 2 units are portable (ca. 8 kg with batteries), and easily installed at a site (Fig. 3).

The scale's accuracy is improved if perch length is kept short so a bird remains centered over the plunger when it lands on the perch; such centering minimizes friction between the plunger and its guide. Silicon spray or a hard wax applied to the plunger also helps reduce friction. A 24-cm perch gave accurate weights and was adequate for Ospreys to feed and rest on. We experimented with a more expensive plunger mechanism (a machined stainless steel plunger contained by teflon bushings within the guide), but found that precision was not improved enough to justify the added cost and effort.

The perch unit base can be quickly attached to a perch site using C-clamps or duct tape. It helps to modify a perch site so that the perch base rests on a firm, flat surface which keeps the perch steady and perpendicular. We installed wooden perch sites beside 18 Osprey nests (Fig. 3), along with "mock" perch-scales (wooden perches that roughly resembled the scales), to ensure rapid installation and acceptance of our scales as we moved them among nests. However Ospreys often accepted perch-scales quickly without being previously exposed to "mock" perches.

The perch unit can be weatherproofed by sealing the strain gauges with a film of

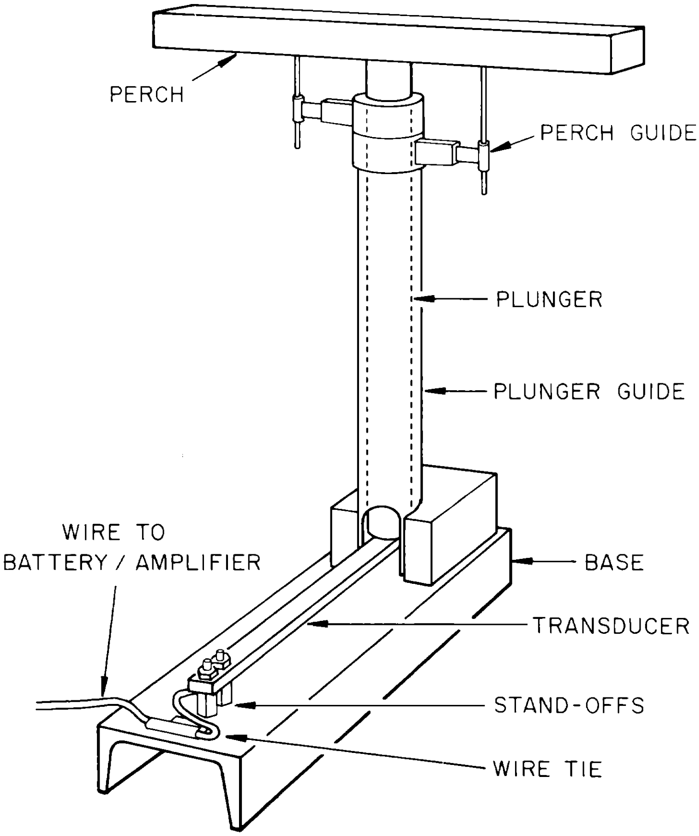

FIGURE 1. Components and design of perch unit for the perch-scale, drawing not to scale. Perch (for Ospreys) is cut from 1.9 × 3.8 cm (1 × 3 in) lumber; plunger is made of 2.2 cm (⅞ in) diameter wooden doweling (ca. 25 cm high), and should be lightly attached with a screw at the center of its base to the transducer (i.e., the screw should not be so tight as to restrict transducer movement). Plunger guide is a section of 2.5 cm (1 in) diameter PVC piping, mounted with epoxy glue in a wooden block that is attached to the perch base with a carriage bolt. Perch guides keep the perch from rotating and are modified toilet tank ball guides available in plumbing supply stores. The transducer beam is Heathkit part No. 100-1701 available from Heath Co., Benton Harbor, Michigan. The perch base is channel aluminum (3 × 7 × 30 cm) which provides a firm attachment for the transducer via the standoffs.

silicon bathroom sealant and by embedding any solder joints in exposed wiring in epoxy glue. A short skirt of water-resistant cloth should cover the top opening between the plunger and its guide; this keeps the plunger dry and free of debris. The ammunition box protects other components of the scale from moisture.

Two 6V lantern batteries supply power to the perch-scale, and fit in the ammunition box. Figure 2 gives circuit diagrams and component specifications for the transducer (top) and amplifier (bottom) units. Zeroing the scale with the zero adjust allows one to com-

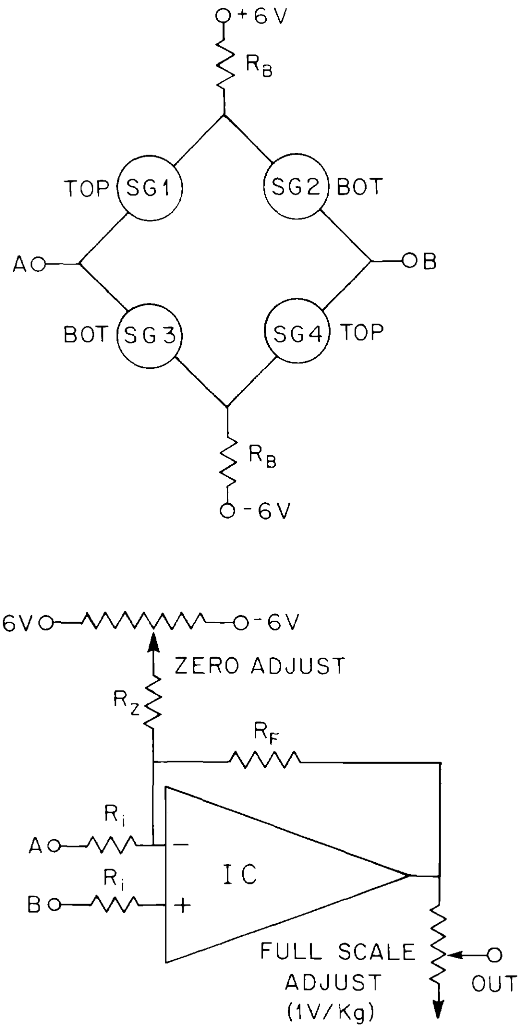

FIGURE 2. Circuit diagram for the transducer (top) and amplifier (bottom) units. Component specifications as follows: fixed resistor values: R_B:500 ohms; R_i:1 Kilohm; R_F = R_Z:1 Megohm; potentiometers (10-turn trim): zero adjust:5 Kilohms; full scale adjust: 5 Kilohms; IC:Operational Amplifier (Chopper Stabilized): Intersil No. ICL 7650CPD (Intersil, Inc., Cupertino, CA). Two external capacitors (0.1 μF) store the correcting potentials on the amplifier nulling units (see specification sheet for ICL 7650). Circuit between transducer and amplifier is completed A to A, B to B.

pensate for different plunger and perch weights on the transducer, as well as for temperature effects that may influence the recorder. Full scale adjust makes it possible to change the amplitude of the voltage output for a given weight, and hence the scale of the recording. The Chopper Stabilized Operational Amplifier minimizes low frequency drift

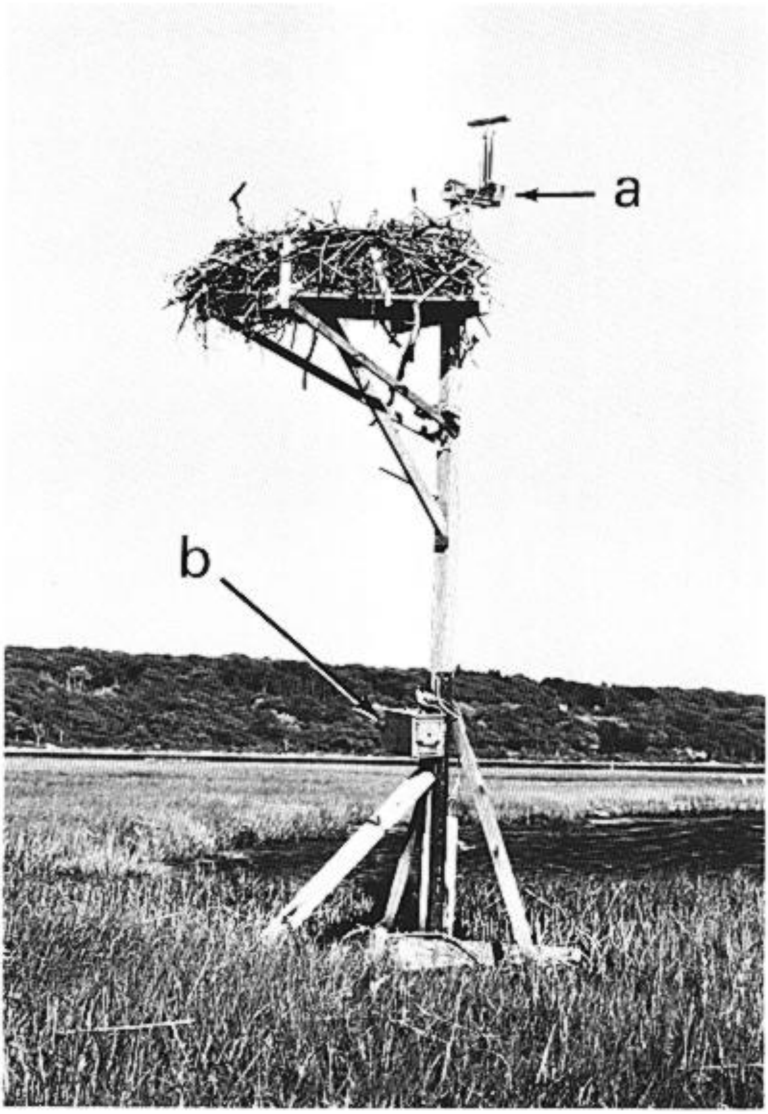

FIGURE 3. Perch-scale mounted at Osprey nest. Perch unit (a) is connected to battery, amplifier, and recorder unit (b) with waterproof wire as shown in Figure 2.

while boosting a low input voltage. We recorded voltage output using a small 6V powered field chart recorder (Rustrak model no. 288), which also fit in the ammunition box along with its battery. Calibrating the scale with a known weight allows the conversion of electrical readings to weight.

Accuracy.—We tested 2 of these perch-scales during 4 months of Osprey field studies. The transducer itself is specified ±1% accurate (Heathkit 1977), and we found similar accuracy (±1–2%) for both scales when static objects of known weight were fairly well centered on a perch. Such objects on either end of a perch could vary 3–4% of their true weight; however this seems accurate enough for most field study needs. The scales' accuracy and consistency in the field were demonstrated in 2 ways: (1) Individual Ospreys that used a perch-scale repeatedly over short periods of time (during which we know they did not feed) showed highly repeatable weights (±1–2%). (2) On 3 occasions a bird was weighed at both scales within a few minutes. Each time this happened its recorded weight did not differ significantly (±1–2%), results similar to what we had found using static objects on different scales during indoor testing.

Temperature change appeared to have little effect on the transducer output but did cause the Rustrak recorders to drift by as much as ±10% with a ±15–20 C temperature shift. This problem could be solved by initially zeroing the scale at a point which allowed for both positive and negative drift; thus one would always have a zero point for reference on the recorder. Painting the ammunition boxes reflective colors kept temperature effects to a minimum.

As designed, the scale is most accurate weighing large birds in the 0.5–5.0 kg range. To weigh smaller birds accurately, one would need to increase the gain of the amplifier circuit and/or use a transducer with a more flexible beam. Inexpensive strain gauges that can be glued to such a beam are available. The entire perch unit could be scaled down to "fit" smaller birds.

Toleration by birds.—We rotated 2 perch-scales among 18 Osprey nests during all stages of the nesting cycle and left them in place for periods of from 2 h to 2 days. The Ospreys always accepted and nearly always used these artificial perches as soon as they arrived at a nest site. Depending on the nesting stage and related factors, birds spent anywhere from 2 min to 9 h (overnight) at one time on a perch. Because the transducer deflected little in registering a bird's weight, the perch-scales probably had the same solid "feel" as the perches the birds were used to.

In several cases we first set up perch-scales at Osprey nests after pairs were incubating and found them immediately accepted and used, suggesting that "mock" perches may not be necessary. The only important placement criterion was that a perch be the highest resting spot at a nest. Although most study nests were on artificial platforms (Fig. 3), as are ca. ⅔ of the Osprey nests in the New York State-New England coastal region (Spitzer and Poole 1980), we also set up perch scales at 3 dead tree nesting sites, and 2 of these were immediately used.

Ospreys also accepted perch-scales as replacements for their feeding perches which, in the open salt marsh habitat where we studied these birds, were usually artificial perches placed low to the ground near nests. When used at feeding perches, the scales helped to quantify feeding frequency and prey weight.

This perch unit design might well be modified to support an entire nest, if the nest was not too large and if the species would accept such an artificial site. With small nests such a modification could prove less bulky than Sibly and McCleery's (1980) nest balance.

Battery longevity.—Since we visited nests during our study every 3–4 days, and since Ospreys were not disturbed by the unit attached to the nest pole, we were able to change batteries or chart paper as often as needed. Large lantern batteries (Eveready No. 731) would power the perch-scales for ca. 2 weeks of continual use; the recorder battery (Eveready 510S) and its chart paper lasted about 1 week each. For species more susceptible to disturbance, one could place the recorder, batteries, and amplifier unit farther from a perch or in a blind. Such a remote recording set up, combined with installation of the perch unit at a site when birds were not there, should allow perch-scales to be used with species known for their sensitivity to disturbance.

Cost.—With the exception of the recorder, materials for each perch-scale cost about $60 (1981 prices), including the batteries; the transducer is the most expensive part ($28). Rustrak recorders sell for ca. $200 new, but used recorders and replacement parts to keep them going can often be found less expensively. It is also possible to monitor the scale with an electrical voltage meter, if a self-recording set-up is not needed. Such meters cost ca. $15–20.

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Sex Determination of Adult Whimbrels.—The sex of an adult Whimbrel (*Numenius phaeopus*) is not readily distinguishable in the field. Whimbrels are monomorphic with respect to plumage pattern and color. Although females tend to be larger than males, size overlap for any individual character is too high to enable separation of a useful proportion of a sample into male and female groups.

In the course of a field study of the Whimbrel, I used discriminant function analysis (DFA) to sex live birds. DFA weighs characters by their power of discriminating between groups (the discriminant weight) using data from a reference group (Cooley and Lohnes, Multivariate Data Analysis, John Wiley and Sons, Inc. Toronto, 1971). A discriminant score was calculated for each individual in the reference and field group by summing the products of the discriminant weight and the measurement for each character. The discriminant score of each individual in the field group was then compared with the critical scores for the 2 sexes in the reference group. Two computer programs were used: Discriminant Analysis Program for 2 Groups (DISCR2, D. Power) to determine the discriminant score of all individuals, and the BMD07M Stepwise Discriminant Analysis (Health Sciences Computing Facility, UCLA) to determine a posteriori probability values of correct classification.

In this study, the reference group consisted of study skins of 20 female and 20 male adult Whimbrels housed in the Department of Ornithology at the Royal Ontario Museum, Toronto, Ontario. Specimens were collected from across Canada with over 80% from Manitoba and Ontario; only those taken in May, June, or July were included. Ten characters were measured on the museum specimens to 1 mm using dial calipers. The same measurements were taken to 1 mm using vernier calipers on 79 live birds nest-trapped in June and early July of 1973 to 1976 near Churchill, Manitoba. A series of histograms revealed that shrinkage due to drying in the museum specimens distorted 6 of the characters thus preventing their use for comparisons with field measurements. Tarso-meta-