A TECHNIQUE FOR PROTEIN RESERVE ESTIMATION IN LIVE REDSHANK *Tringa totanus*

by N.C.Davidson

The major energy reserve in birds is fat (e.g. Newton 1969, Evans and Smith 1975). Protein is also stored, mainly in the pectoral muscles (Kendall et al. 1973), and is particularly used when food intake is insufficient to replace nitrogenous excretion from the liver (Evans and Smith 1975). In assessing the nutritional state of a bird it is necessary to examine both fat and protein reserves. Several methods of estimation of the fat content of live birds have been developed, notably the use of a visually estimated fat score (McNeil 1969), and the estimation of lean weight (and hence fat by subtraction from fresh weight) from wing and/or bill length (McNeil and Cadieux 1972, Mascher and Marcström 1976, Pienkowski et al. 1979, Davidson in prep.). The estimation of protein reserves in live birds is more difficult since the changes in its size are small in comparison with the total weight of the bird: 'normal' variation is at almost 1.5% of the lean weight, and even when a bird dies of starvation the fall below normal level is at most 4.5% of the total lean weight. Changes of this magnitude are masked in the total weight of a bird by the variability of the lean weight induced by other factors such as fat, gut contents and water content. In this note I outline the preliminary results of a method of protein reserve estimation based on a simple measurement easily obtainable during the processing of a catch of live birds. The redshank used for this analysis were collected on the Ythan estuary, Scotland (57°20'N, 2°00'W): specimens in good condition were collected during October and November 1978, and those in poor condition died of starvation during the cold weather in January and February 1979.

The measurement is shown in Figure 1 and is made at the mid-point of the keel of the sternum. A specially modified pair of calipers is required, with the points of the jaws cut off to leave a length of 'h' approximately equal to half the height of the keel (so that variation in measurement 'w' is large). In Redshank, 'h' is taken as 7mm. Measurement 'w', the 'muscle width' is taken as follows: 1) open the calipers and rest the central bar on the mid-point of the keel and at right-angles to the keel (see Fig. 1); 2) close the calipers so that the feathers, but not the muscles, are compressed; 3) read measurement 'w' off the calipers.

The protein reserves can be estimated from width 'w' as an index of either i) Lean Dry Muscle as a percentage of total lean body weight (LDM), or ii) a Standard Muscle Volume (SMV), derived from measurements of the skeletal attachment of the flight muscles (for details see Evans and Smith 1975). As the length of the muscles along the sternum is fixed, weight increases approximately in proportion to the cross-sectional area of the muscle. Muscle width 'w' is a linear measure and so may be expected to vary with the square root of the area. Thus the muscle indices have been transformed to square roots for comparison with 'w' (Figures 2 and 3). The correlations and formulae for protein reserve estimation are:

$$SMV = (0.0153 + 0.245)^2;\ r = 0.914,\ n = 32,\ P < 0.001$$

$$LDM = (0.0574 + 1.377)^2;\ r = 0.883,\ n = 32,\ P < 0.001$$

The variation in muscle width around the regression is primarily due to variations between individual birds: larger birds have a larger muscle width for a given muscle index value. The two samples used to make the estimate represent the extremes of winter condition: Redshank in November are likely to be near their peak winter condition (Davidson 1979), so most changes in protein reserve will lie between these extremes. In determining the level of protein reserves for a sample, a muscle index measurement should be made for each individual and the mean subsequently calculated, rather than estimating an index from the mean muscle measurement for the sample.

In spring, most wader species increase their protein reserves above the normal winter level shown here, as a migratory and breeding reserve: muscle widths above the upper limit of about 25mm. in the October/November sample may indicate this increase. Lower than normal winter levels can occur in mid-winter (Davidson 1979) and may also be found during the breeding season as a result of egg production and other breeding stresses (Jones and Ward 1976). The value 'w' cannot fall below about 3mm in Redshank, because of the keel, sternum and compressed feathers included in the measurement, even if a small amount of muscle remains only in the angle between keel and sternum.

One problem occurs when there is a superficial fat layer over the muscle surface, as this is included in the measurement and so gives an overestimate of muscle condition. However in Redshank this fat layer, at least during winter, is seldom thicker than 1 mm at the point of measurement and this error did not affect the relationships in Figures 2 and 3, thus appearing to be within the limits of measurement error and variations in muscle size. The technique should be applicable to other species, with measurement 'h' being larger for larger species as indicated below, but care should be taken when an extensive fat layer is present: this applies to most species in spring and to plovers throughout much of the winter as well.

In addition to providing an estimate of protein reserves in live birds, the detection of individuals with low protein reserves is useful when examining fat levels. The estimation of lipid levels from wing and bill length (see references in the introduction) is only valid for individuals in good nutritional condition: once protein reserves start being used, total lean weight also becomes reduced. These individuals can then be excluded from lean weight and fat calculations. Once further samples have been analysed it may be possible to use the muscle index of LDM as a percentage of LW to calculate lean weights for these poor condition birds. Whilst these lean weights will in many instances be close to the fresh weights, individuals do not always use all their fat reserves before drawing on protein reserves (Evans and Smith 1975, Davidson in prep.).

It must be stressed that this is a preliminary report and that much further work is needed. For Redshank the priority is to examine birds with a nutritional state between that of the starved and good condition samples. In other species, the protein index formulae need to be derived. 7mm. is probably a suitable value of 'h' for Ringed Plover *Charadrius hiaticula*, Golden Plover *Pluvialis apricaria*, Grey Plover *P. squatarola*, Knot *Calidris canutus*, Sanderling *C.alba* and Dunlin *C.alpina* while a value of 10 mm. would be appropriate for Godwits *Limosa* spp, Curlews *Numenius* spp, and Oystercatcher *Haematopus ostralegus*. It is important to note however that the equations for Redshank given here are not applicable to other species, even for those for which the same value of 'h' is used, as interspecific differences exist in protein reserve levels, particularly between the plover and sandpiper groups of waders. To study these problems, I would be grateful for any fresh (or deep-frozen soon after death) carcasses of Redshank, and individuals of any species that are thought to be in poor condition (e.g. found dead, low fresh weight etc.).

Acknowledgements

I am grateful to Steven Baillie who supplied the Redshanks on which the analyses were made, and to Dr. Peter Evans and Mike Pienkowski for comments and extensive, sometimes heated, discussions on many and frequent earlier drafts of this note.

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N.C.Davidson, Department of Zoology, University of Durham, Science Labs., South Road, Durham DH1 3LE, England

Note: Those who attended the WSG Nottingham meeting should note that the method described above supersedes that given at the meeting.

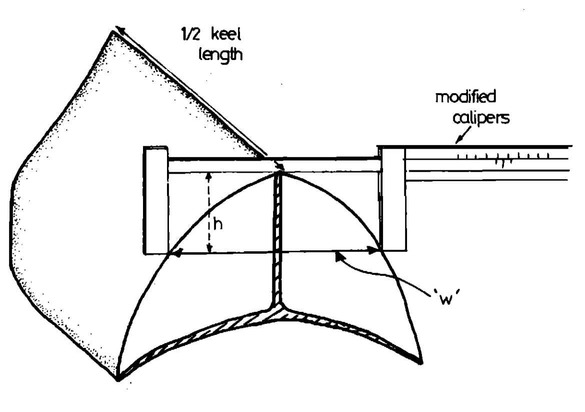

Figure 1. Diagrammatic cross-section through the sternum and flight muscles to show the position and technique of measuring 'w'.

Figure 2. Correlations between muscle measurement 'w' and the square-root of the Standard Muscle Volume (SMV). Solid line is the least squares regression.

Figure 3. Correlations between muscle measurement 'w' and the square-root of Lean Dry Muscle as a % of total Lean Weight. Legend as in Figure 2.