With regard to taking weights of the birds ringed and trying to work to the accuracies suggested, we would have to empty out any feathers, droppings, etc. in the weighing bag and reweigh it between each bird processed. This is something I could (would) not do when a catch of 50 or more white-eyes, swifts, weavers, etc. are waiting to be ringed and processed. My first priority is, and always will be, the birds' welfare, and I am not prepared to hold birds longer than is absolutely necessary to try to get the suggested accuracies which are not, to my mind, justified in my work.

If Mr. Robson stops to consider for one moment - if one bird's actual weight is 8,4 g and it is rounded off to 8,0 g, the next one which has an actual weight of 8,5 g is rounded off to 9,0 g the error for averaging weights is rectified and with such a big sample (over 800 specimens), the error is negligible. A computer program has been run where a random sample of numbers was taken between 8 and 15 to establish the differences in the averages when figures were rounded off to the nearest whole number and when they were not. The answer was that there was no difference at all until the numbers were recorded to the fourth decimal place.

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Professor Les Underhill was shown the above correspondence and invited to comment.

ERRORS IN MEASUREMENTS

The correspondence generated by Bunning (1985a, 1985b) and Robson (1985) raises several important issues of which ringers need to be aware.

Accuracy of Measurements

Ultimately it is the quality of the instrument that determines the maximum accuracy with which it is possible to measure. A set of Pesola balances (say 30 g x 1 g, 100 g x 1 g, 300 g x 2 g and 1 000 g x 10 g) makes it feasible to measure the mass of birds up to 1 000 g with a relative error of at worst 2%. For example, on a 100 g balance, which serves for birds between 25 g and 95 g (allowing for the bird bag or cone), mass can readily be determined to the nearest 0,5 g - a 2% error for the 25 g bird and a 0,5% error for the 95 g bird. Birds weighing less than 25 g should not be weighed on a 100 g balance, nor should birds under 95 g be weighed on a 300 g balance.

Balances also need to be checked several times a year against a set of standard masses. A bias of just a few grams developing over a year can easily produce a statistically significant conclusion that birds are becoming lighter or heavier! Bird bags and cones also need to be checked - the accumulation of faeces during a day's ringing can easily make your favourite 5 g bag weigh 7 g or 8 g.

A related aspect is that birds lose mass continuously after capture. Sanderling *Calidris alba* lose an average of 1,2 g (2,5% of initial mass) in the first hour and 5 g (10,3%) after 13 hours (Schick 1983). Nearly identical mass losses have been reported for the Dunlin *C. alpina*, a wader of similar size (Lloyd *et al* 1979). For the Cape White-eye *Zosterops pallidus*, the overnight (12 to 13 hours) loss in mass was 1,4 g (12%) (Whitelaw 1985). If the period between ringing and weighing is more than a few minutes it seems sensible to record this to the nearest quarter of an hour. If it can be demonstrated that rates of mass loss are fairly constant across a range of species (here is a project for someone), then we can quite simply apply a set of correction factors to compensate. An example of a study that has done this is Maron & Myers (1985).

Consistency of measurements between observers

Nisbet *et al* (1970) describe how four experienced ringers independently measured the wing lengths of 401 dead birds. Differences of up to 2% between observers were not unusual, while occasionally differences of 5% occurred. Summers *et al* (in press) show how certain structures can be measured more precisely than others. Thus another project for someone to tackle is to ring and measure birds, to replace them in a holding box and to process them again as retraps, either by the same ringer (to examine the variability of a single observer) or by another ringer (to examine the variability between observers).

An important part of the training of ringers is to standardize measurement techniques. Trainees shold be taught from the outset to weigh and measure with the same precision that will be expected of them as qualified ringers. Trainees should expect their trainers to remeasure and reweigh their birds to ensure that both are applying the same techniques. This is particularly true of wing measurements. Svensson (1984) describes three different ways of determining wing length - unflattened wing (minimum chord), flattened wing, and flattened and straightened wing (maximum chord). His comparison of the methods show differences between 0% and 6%. He favours the maximum chord method as being the most reproducible. This is the method recommended by most ringing schemes. Even this method can be altered by measuring with the wing opened out at right angles to the body instead of lying parallel to the body of the bird (Summers *et al* in press).

Accuracy with which means should be reported.

The key quantity that helps decide how many significant figures to retain in reporting a mean is the standard error, defined to be the ratio, standard deviation over the square root of the sample size, s.e. = $s/\sqrt{n}$. If the mean of 100 measurements is 17,1782 with standard deviation 1,3142 then the standard error is s.e = 0,1314. Some fairly sophisticated statistical theory (see for example Barford 1967, pp 37-40) shows that the accuracy of the standard error is such that the odds are 2:1 that the true value for the standard error lies between s.e. - s/n and s.e + s/n. For our example, this interval is 0,1183 to 0,1445. The first decimal place is the same, so is not in dispute, the second place is a bit dubious, and the third and fourth are garbage. We should thus report the mean as 17,18 with standard error 0,13, frequently written as 17,18 ± 0,13.

Turning to Bunning (1985a, Table 3) the sample for July has n = 36, and s = 0,89. The standard error is 0,15, and, since s/n = 0,03, the 2:1 odds interval is 0,12 to 0,18. The first decimal places agree, but the second is very dubious. The mean and standard error should be given to one decimal place: 11,5 ± 0,2. The largest sample is for March; this has size 339 with s = 0,93. The standard error, s.e. = 0,05, and s/n = 0,003, so that two decimal places can be justified with this sample size.

Note that this procedure does not depend in any way on the accuracy with which the original measurements were taken. However, in general, if the measurements are made more precisely, the standard deviation will tend to be smaller, and a desired accuracy can be achieved with a smaller sample. See Barford (1967) for a full discussion of this point. It is a well-established fact that the mean of a series of crude measurements can be remarkably accurate. Many of the fundamental constants in physics were first determined by repeated experimentation and measurement with Heath Robinson apparatus. When more sophisticated equipment became available, many of the earlier values were found to be very close to the true values.

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