Non-destructive Methods to Determine the Diets of Birds

HUGH A. FORD, NEVILLE FORDE
and SUSAN HARRINGTON

We discuss a variety of methods of collecting information on the diets of birds, including observation, examination of faeces, emetics and stomach-flushing. Stomach-flushing is described in detail. We believe it has certain advantages over other methods; it samples food from the upper parts of the gut before most digestion has occurred and incurs very low mortality. Advantages over collection of birds are that the same individuals can be resampled and birds that are being studied ecologically and behaviourally can also be sampled. It also overcomes the ethical objections to killing large numbers of birds.

Identification and analysis of samples are briefly discussed.

Very little information has been published on the diets of Australian passerines (the papers of Lea and Gray 1935 are an exception). Such information is an important part of any ecological study of individual species or avian communities. In addition, data on diet are needed to evaluate a species' role as a predator of harmful insects or its status as a pest of man's crops.

Such data that have been available are from stomachs of birds that have been purposefully or accidentally killed. The results of Lea and Gray (1935) are from birds collected for the South Australian Museum. There is increased opposition to killing birds for scientific study and collecting for museums tends to be concentrated on poorly represented species, groups of particular taxonomic interest or for age and sex information. Therefore ecological studies, which are now becoming more popular in Australia, have usually involved the killing of moderate numbers of birds to obtain details of diet. Besides the ethical objections to killing birds there are scientific reasons why alternative methods for determining diet are desirable. First, the same individuals can be sampled several times, and secondly, behaviour and other aspects of ecology of the same individuals can be collected. Generally, now, either birds are collected from outside major study areas, where they could be taking different food from the birds under study, or some of the birds whose behaviour is being observed are sacrificed.

Alternative methods of obtaining information on diet have been used overseas during the last decade but these have not been widely used in Australia nor have they been mentioned in the Australian literature. In the present paper we intend to describe and assess such methods in the hope that they will be more widely used in the future.

Observation

One simple method, whose value should not be underestimated, is direct observation. For honeyeaters and lorikeets feeding on flowering plants, careful observation is necessary to determine whether nectar, pollen or insects are the major food being taken. Nectar is difficult to find in the alimentary canal of birds, as it is so rapidly absorbed. Pollen, on the other hand, is easily found in the gut and faeces of honeyeaters and lorikeets and there is some dispute as to its importance in their diets. Careful observation by Hopper (1980) revealed that lorikeets feed in two different ways on eucalypt flowers; slowly to collect pollen and more quickly to collect nectar.

In observing feeding behaviour it is important not to presuppose what the bird is doing or eating. Paton (1980), by carefully watching honeyeaters, found that a significant amount of their supposed insect-feeding was in fact harvesting carbohydrate foods such as manna and honeydew.

However, there are many biases in direct observation. Nectarivorous and frugivorous birds may congregate around flowering or fruiting plants and attract attention. When the same birds have dispersed and are feeding on insects they are less likely to be observed. Some methods of catching insects, such as hawking, are much more conspicuous than others. Certain types of insects, like larvae and stinging hymenopterans, need more careful handling than others, and when captured by birds are more likely to be identified by the observer. Despite these problems, direct observation, along with some analysis of gut contents or faeces, usually permits an assessment of the range of items in the diet of a bird and an estimate of the relative importance of these items.

Examination of Faeces

Faeces are easy to collect but suffer from the disadvantage that some items, e.g. seeds and soft-bodied insects, will be almost entirely digested, and almost all other items are broken up into small fragments. This makes identification difficult. However with practice many insects can be identified, at least to order. The diet of frugivorous birds can be determined from faeces as the seeds of most fruits eaten by birds pass through the gut undigested. A few very large seeds are, of course, not swallowed (e.g. Black Apple *Planchonella australis*).

Faeces may be collected fresh in the field by careful observation. For instance Davies (1977) collected fresh droppings of Pied Wagtails *Motacilla alba* and Bryant (1973) collected droppings from beneath House Martin *Delichon urbica* nests. Both were able to identify the family of flies and some other orders of insects that the birds were eating, from undigested wings in the faeces. Wooller and Calver (1981) used faecal samples to determine diets of Singing Honeyeaters *Lichenostomus virescens*, Spinifexbirds *Eremiornis carteri* and White-winged Fairy-wrens *Malurus leucopterus*.

Alternatively, faeces may be collected from captured birds. The method developed by NF is to place birds for about a half hour in a darkened box lined with absorbent paper. After "use" the paper is labelled and folded up and the droppings kept dry until later examination when they are scraped off into dishes of water or alcohol. Samples have been collected from several hundred birds in this way and there appears to be little more trauma than birds experience with normal mist-netting and banding procedures.

A better method would be to place birds in boxes with a wire-netting base which faeces can pass through onto a plastic sheet (Paton 1979). This prevents them from being dispersed as they are by birds in paperlined boxes. Faeces can then be placed in tubes containing 70% alcohol while still moist. This prevents any decay of the material and makes examination easier.

Even pollen grains can be identified from the faeces of honeyeaters by microscopic (x 40) examination (Paton 1979, 1981, Collins 1980). Analysis of faeces is obviously less suitable for determining diets of seed-eating birds, though pieces of testa (seed-coat) may pass through undigested and more complex, biochemical methods of identification may be possible.

Use of Emetics

Prys-Jones *et al.* (1974) used a 1% solution of Antimony Potassium Tartrate, which was administered into the stomach with a syringe and length of 2 mm diameter plastic tubing. They treated 78 birds, mostly House Sparrows *Passer domesticus* and buntings *Emberiza citrinella* and *E. schoeniclus*, but also a few insectivorous birds (mostly *Parus melanolophus*). About two-thirds of the birds regurgitated food, but two died. There is also a suggestion that some birds that did not regurgitate died after release. Holmes (in prep.) used a similar method on North American insectivorous birds and experienced some mortality.

HF tried this method on three New Holland Honeyeaters *Phylidonyris novaehollandiae*. None regurgitated and two died a short time after administering the emetic. The method was discontinued but it may well have value in more insectivorous or graminivorous birds. It is possible that honeyeaters, because of their nectarivorous habit both tolerate large volumes of liquid in their guts and also absorb solutes more rapidly than do other birds.

Stomach-flushing

Moody (1970) obtained food from swallows and martins by flushing their alimentary canals with warm saline. Brensing (1977) flushed birds' stomachs with warm tap water. He treated over 2 000, mostly insectivorous, birds in this way with great success. A similar method has been used with lizards, frogs, turtles and crocodiles (Legler 1977; Legler and Sullivan 1979; Taylor *et al.* 1978). Payne (1980) extracted seeds from finches by inserting a tube attached to a syringe and withdrawing the plunger of the syringe.

The method that we used is adapted from that of Brensing. (As the original paper is in German we describe it here in detail.)

All that is needed is a 10 ml plastic syringe, about 15 cm of flexible plastic tubing of about 4 mm in diameter, a plastic filter funnel and 10 ml collecting tubes. Tap-water is used and as most of the study has been conducted in spring and summer this has not generally been warmed. However on cool days or early mornings the full syringe should be placed in the sun to warm. The end of the tube that enters the bird should be made as smooth as possible, either by filing or passing through a flame. Brensing (1977) suggests the end be dipped into glycerine. Make sure that the tube is full of water so that air is not pumped into the bird.

The bird should be held firmly in the hand as for banding except with the head held firmly between the thumb and first finger, at either side of the gape. The beak can then be forced open carefully and the end of the tube inserted into it above the tongue, which may become caught in the tube. The end of the tube should then be gently passed down the oesophagus into the stomach. It is easier to do this if the neck of the bird is gently stretched. If any resistance is experienced, usually it is where the oesophagus reaches the stomach, the tube can be gently manipulated back and forth about 5 mm to 2 cm depending on the size of the bird. Once the tube enters the stomach the tube passes more easily for another few cms. Once the end of the tube is in the stomach, water is injected slowly (take 5-10 seconds) from the syringe, about 1 ml for small birds such as thornbills and fairy wrens, 2 mls for Eastern Yellow Robins *Eopsaltria australis* and whistlers and 4 mls for Grey Shrike-thrushes *Colluricincla harmonica*. The tube should then be rapidly withdrawn and the bird held over the filtre funnel onto which a collecting tube is attached. In about two thirds of cases the bird regurgitates the water and some of the contents of its stomach. If it does not regurgitate or if only a little water and no food comes out then the process can be repeated, usually with success.

Occasionally the water plus some of the contents of the alimentary canal pass out through the cloaca immediately after injection and before removal of the tube; this occurs more often on the second attempt. It is thus a good idea to hold the rear of the bird over the filtre funnel while injecting. Often the bird defaecates as well as regurgitating, and the faeces too should be collected. The food and/or faeces can then be washed into the collecting tube with alcohol from a wash bottle, and labelled and returned to the laboratory for identification of the contents.

The method is relatively simple but does require some practice to achieve reasonable success. Also it is an advantage to have an assistant, for instance to hold the filtre funnel. Permits are of course necessary for stomach-flushing.

Nevertheless we have experienced some difficulties which will be discussed briefly.

1. It is often hard to open a birds' beak, especially for larger birds like cuckoo-shrikes. Usually they will peck at an object like a finger (not advisable for shrike-tits) and once partly open the beak can be prised fully open. Special care needs to be taken with birds with thin delicate beaks (e.g. spinebills).

2. A tube of 4 mm diameter is possibly too thick for very small birds, maybe one of 3 mm diameter would be more suitable.

3. Often one cannot predict which end of a bird the water and gut contents are going to appear so it is a good idea to perform the whole procedure over a sheet of plastic.

4. Brensing warns that, if the end of the tube is not in the crop, water may enter the epiglottis and lungs of the bird and could drown it. Fortunately we have not experienced this, possibly because we heeded Brensing's warning, but one of his birds died in this way.

5. Finally, birds digest their food very rapidly, so that, to obtain easily identifiable material, birds should be flushed as soon as possible after capture, and mist-nets should be checked frequently.

The stomach-flushing method is successful in nearly all cases in obtaining some of the contents of the gut, usually of the crop. However, it is likely that some items, especially larger insects, are not removed as easily as smaller or more fragmented items. Thus the picture of the diet obtained from this method may be biased.

The major reason for developing this method was to avoid killing birds, so we need to be sure that it achieves this aim. Most of the work has so far been carried out at Eastwood State Forest near Armidale, NSW by HF. Up to December 1980, 144 birds had been flushed, and thirteen had been flushed a second time. Twenty-eight species, ranging from pardalotes and thornbills to cuckoo-shrikes and wattlebirds have been treated. All, except for two Diamond Firetails *Emblema guttata,* have been insectivores or honeyeaters. There have been no casualties, though birds often gasped for a few minutes after regurgitating. A few birds appeared very lethargic for a time and were held in a bag for up to an hour. All however recovered and flew away strongly. Brensing (1977) only lost one bird, from drowning, out of the 2 000 he treated.

It is possible that the insertion of a tube into the crop causes internal damage to and consequent death of the bird. However it is possibly no more uncomfortable than swallowing a large beetle, which many birds eat. Thirty-one of the 157 treated birds (including the thirteen birds flushed twice) have been recaptured and a further twenty-eight have been seen again (in all over 37%). This is comparable to the rate that we have found in birds that have not had their stomachs flushed. Thus there is no reason to believe that stomach-flushing causes any significant mortality to birds.

Identification of Items

Identification of insects is a task for specialists so it is necessary to make a collection of common insects from the study area and have these identified. Then become familiar with them both whole and dismembered. Legs frequently pass through birds relatively unaffected by digestion and are usually diagnostic for most groups of insects. Beetles, ants and bugs are the groups most frequently taken by gleaning birds whereas flies and Hymenoptera of various types are taken by birds that hawk. With experience some identification to the level of family can be made from "The Insects of Australia" and supplement (CSIRO 1970). Insects and diet samples need to be examined under the binocular microscope.

Similarly with graminivorous and frugivorous birds collections of seeds and fruits need to be made locally and identified.

Conclusions

Faeces are the most easily collected materials to determine diets of at least insectivorous and frugivorous birds. However samples are likely to be biased in favour of less digestible items.

Emetics are unsuitable for honeyeaters, but could perhaps be attempted with graminivorous birds like finches and parrots.

Stomach-flushing is a successful method, at least for insectivorous birds. With practice it is not too difficult to perform.

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H. A. Ford,*
N. Forde,†
S. Harrington*

* Department of Zoology,
University of New England,
Armidale, N.S.W. 2351

† Faculty of Applied Sciences,
Adelaide College of Arts and Education,
Underdale, S.A. 5032