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Nutritional, morphological, and behavioural considerations for rearing birds for release

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1. Introduction

Establishing sustaining populations of birds from breeder-farm stock is one of the most original wildlife management techniques, especially for some of the galliform species. However, there have been major failures of introduction-restocking programmes during recent years. BANKS (1981) itemized the releases of Galliform species in USA from 1969–1978, and showed that almost every release failed. Modern game farming techniques are often for the sole purpose of hunting. Such birds are raised according to poultry rearing techniques and little survival is expected beyond a few days after the release date. The abrupt release method so commonly used only exacerbates the problem of adjusting to wild conditions.

Managers resort often to hybridization and the importation of exotic strains in last-ditch attemps to re-establish viable populations of birds, such as the Ring-necked Pheasant (*Phasianus colchicus torquatus*). It appears to be more fashionable to adopt this approach rather than examine closely and recognize deficiencies in modern agriculturally-modified habitats. Moreover game agencies have not critically examined the way in which rearing techniques predispose released birds to survival in the wild (see for example, HAENSLY et al. 1985). This is because most of the people involved directly with such programs are trained as game managers or foresters, and have scant training as biologists, and especially as nutritionists and behaviourists.

Many factors determine the survival of wild birds in their habitat. Prominent among them are the adaptive social, sexual, cover-seeking, predator avoidance, and foraging behaviours. The maintenance of a positive energy balance within the habitat occupies a major portion of birds' daily activities, and this presupposes that they can acquire a balanced, wild diet and that they possess the intestinal properties to thrive on such a diet.

This paper indicates why feeding only commercial rations to young birds could be a maladaptive practice, in that it may preclude conditioning of the gut to a wild type of diet. It may also impede the development of a whole repertoire of optimal foraging, selective behaviours which are vital for survival in the wild. This paper emphasizes herbivores and omnivores but the general principles apply to carnivores as well.

2. The nature of the herbivore digestive system

The crop, gizzard, small intestine and caeca have different, complementary functions which, together, mediate digestive efficiency and energy balance. While there are species-specific differences in the relative size of individual components of the gut, the basic anatomical plan is common to all avian herbivores and omnivores. BARNES & THOMAS (1987) have shown that the mass of different parts of the gut of waterfowl species reflects the food habits of herbivorous, omnivorous and carnivorous species, i. e. there is an appropriate gut for a certain type of diet.

The crop is a highly-distensible diverticulum of the oesophagus which retains ingested food: it lacks digestive function. This organ allows large amounts of food to be eaten rapidly, and enables birds to hold a large amount of food prior to roosting and then digest that food during the night, as in Ptarmigan (*Lagopus* spp.; IRVING et al. 1967). Marked crop or oesophageal development may be vital to enable birds to consume the large amount of food needed to satisfy peak energy demands from their habitat.

The gizzard grinds large food items, aided by abrasive grits. Simultaneously, digestive juices released from the proventriculus are mixed with the fine particles. The ability of the gizzard to break down tough, fibrous foods depends upon the development of the gizzard muscles.

The small intestine digests chemically small food particles and absorbs the products into the bloodstream. While seasonal and diet-related changes in the galliform gut are related to changes in its weight and length (THOMAS 1984), there is a strong likelihood that changes in the density of the villi may also occur (see FENNA & BOAG 1974). The paired caeca are very prominent organs in all herbivorous waterfowl and Galliformes, attesting to the importance of vegetable matter in the diet. The principal function of caeca is to ferment complex carbohydrates released but not absorbed in the small intestine and fermentation of small particles of plant fibre received from the small intestine. Other possible functions include nitrogen recyclying from uric acid and the synthesis of vitamins, such as folic acid (MOSS & HANSSEN 1980).

The size of the parts of the gut may change seasonally due to differences in the composition of the diet and/or the rate of consumption. These changes have been reported for both galliform and anseriform species (FENNA & BOAG 1974, KEHOE & ANKNEY 1985, MILLER 1975, MOSS 1972, 1974, PENDERGAST & BOAG 1973). The digestive system may fulfill other functions. Lesser Snow Geese (*Anser c. caerulescens*) females in the sub-arctic do not feed extensively during laying and mobilize protein from the gut to form yolk and albumen (THOMAS 1983). Female Snow Geese and Canada Geese (*Branta canadensis maxima*) undergo fasting during incubation and draw on the digestive system extensively to provide nutrients for existence energy (MAINGUY & THOMAS 1985).

3. The nature of wild birds' diets

The diet of wild herbivores and omnivores is not a constant phenomenon. The species of plants and animals consumed, and their contribution to the diet, may change drastically both within and among seasons, depending upon their availability and nutritional value. Protein values are highest in the spring-summer period when insects and new polant growth comprise a major fraction of the diet, at which time the fibre content of the food is lowest. This time usually coincides with reproduction and development of the young, both of which are expensive in terms of energy and protein needs.

The fibre content of many plant foods is higher during the late summer, autumn, and winter. Such foods provide principally energy, coincident with the increasing energy needs of birds. While increased fibre levels impede digestion and the assimilation of nutrients, the appearance of concentrated packages of energy such as seeds, fruits, buds, and tubers helps to satisfy the increased energy expenditure during those seasons. Wild foods are bulky, often fibrous items, whose nutrient density is less than that of commercial feeds. Protein levels less than 18 percent normally confront Ring-necked Pheasants throughout much of their mid-western range of North America (KORSCHGEN 1964). Acorns consumed by Western Tragopans (*Tragopan melanocephalus*) require an expansive crop to contain them and extensive grinding in a strong gizzard to remove the outer indigestible parts. Lush vegetation consumed by California Quail (*Lophortyx californicus*) necessitates longer caeca to ferment and absorb its nutrients than when drier vegetation is consumed (LEWIN 1963).

Thus survival may depend on having a gut conditioned anatomically and physiologically to bulky, and often low quality, diets. Probably no bird (except for certain grouse species) can derive all of its nutrients from a single plant species, so the adoption of a varied diet is a vital nutritional strategy (KORSCHGEN 1964). While birds may forage optimally for those plant or animal items which yield most nutrients per unit time, or energy expended, a balanced nutritional intake is mandatory over the long term, even at the expense of energy conservation. Individual birds must be prepared for this contigency, both behaviourally and anatomically. Conversely, attempts to manage or re-establish species' habitats must ensure that the principal plant and animal food bases are both present and abundant to allow birds to satisfy their requirements across all seasons.

4. The properties of commercial foods

Feed manufacturers produce rations which are nutritionally balanced, non-limiting in vitamin and micro-mineral content, and normally constant in composition. They do vary, however, according to the stage of growth (starter or grower) and whether the birds are breeding (breeder or maintenance rations; SCOTT et al. 1963, SUMMERS et al. 1972, WOODARD et al. 1977). The diets are based upon the principles of economic returns to growers, high conversion efficiency to carcass or eggs, and rapid growth. Such diets have not been developed from the perspective of raising birds in captivity for re-introduction to wild habitats where they will persist. Unlike poultry, wild birds satisfy their nutrient needs by consuming a variety of food items and by developing specific appetitive behaviours. Maximum digestibility of commercial diets is produced by fine-grinding of the ingredients, followed by steam pelletting. The latter process partially hydrolyzes complex carbohydrates and increases the accessibility of digestive enzymes to cell-bound nutrients. Such rations quickly disintegrate in the moist upper digestive tract, thus requiring little muscular effort on the part of the gizzard. Birds may not have to consume large amounts (volumes) of commercial rations to satisfy their needs because the rations are nutritionally very concentrated and have high digestibilities. There is thus little stress to promote the expansion (hypertrophy) of the crop/oesophagus and the grinding capacity of the gizzard.

While such traits are economically advantageous to commercial growers, they are seriously maladaptive to species which are destined for release in wild habitats. The moisture content of commercial feeds is below 12 percent, thus shorter intenstines will suffice, especially in view of the high digestibility. Similarly, the lower fibre content of commercial feeds enhances digestibility. This is then reflected in the lesser development and smaller size of the caeca, as witnessed by MOSS (1972) in captive Red Grouse (*Lagopus l. scoticus*; see also the reports by SAVORY & GENTLE 1976a, 1976b on *Coturnix c. japonica*). Consequently, birds with such intestines and caeca would not derive, immediately, much nutritional benefit from more fibrous, wetter and less-digestible foods, which need to be consumed in greater quantities.

Commercial rations are designed to be fed on an ad libitum basis to achieve optimal growth rates and rates of egg laying. The constant availability contrasts strongly with the situation in wild habitats where active foraging in patchy environments precedes feeding. The monotypic, all-providing commercial diet does little to promote different foraging behaviours and nothing to promote specific appetitive behaviours within captive birds.

5. Interactions between food items, foraging behaviour, and the gut

Newly-hatched wild precocial chicks are introduced to a wide array of potential foods by the brooding female. Recognition of palatable food items is rewarded and endorsed through feeding and, progressively, chicks acquire a repertoire of foraging behaviours. Exposure to a diversity of food items enhances the versatility of the foraging behaviour, which sequentially allows the young to forage optimally both in precocial and altricial species. The entire alimentary canal of the growing birds adjusts physically to the properties of the ingested foods. It is also highly probable that for species which engage in marked fermentation of fibre (such as all species of grouse) the micro-flora are acquired, in part, from the types of vegetation consumed, since all vegetation carries the microbes conducive to its decomposition. Thus the diet, foraging behaviours, gut dimensions and digestive capability are to be viewed as one interactive nutritional complex. One step initiates the action and subsequent steps complement it. The array of foraging behaviours are equally important to a wild bird as a properly conditioned digestive system.

6. Implications of body size for survival in the wild

The production of large-bodied birds may not enhance survival in the wild. While it is true that the relative energetic cost of existence is less for larger birds than smaller birds, the absolute energy requirements of large birds are greater, and that is the ecologically important criterion (KLEIBER 1975). This point is crucial to a young bird learning to cope with its wild habitat. The notion of being large-bodied does not imply equally large digestive organs and probably the best combination would be a smaller-bodied bird with a proportionately larger digestive tract. Such a bird could be produced by restricting the nutrient density and augmenting the bulk of its early diet.

Larger birds would probably have a greater fasting resistance but, in a released situation, the need to invoke fasting resistance is tantamount to admitting a lack of appropriate foraging behaviours, or an unproductive habitat. Approximately a quarter to one-third of a bird's live weight comprises muscles associated with flying and running. The best rearing approach would be to let the individual bird determine through exercise-related hypertrophy how large those muscles should be.

7. Recommendations for the feeding of young chicks

Rearing programmes should be aware of the dietary shifts that young birds experience over the initial few weeks of life and try to simulate them in the feeding. The importance of insect life in early chick growth cannot be over-emphasized. The feeding of insect larvae as opposed to purely chick starter mash achieves a behaviour reinforcement as well as providing high quality protein for growth (see SCOTT et al. 1963). Rather than provide energy as a concentrate dispensed from a feed hopper, disperse cracked cereal grains and a variety of other small high energy seeds throughout a thin straw substrate. This reinforces active foraging and keeps chicks occupied. Fresh green vegetation should be accessible to young birds to allow for a balanced, diverse diet and also to provide physical stimulus for a extra caecal and intestinal growth. Wild weed seeds which are removed from commercial grains are an excellent natural food. The fruiting plant species should also be grown in the young birds' captive environment. Fibre in the diet increases with the onset of late summer and young Galliform birds should be prepared for this by introducing them to coarse root crops of any number of species. Once young birds have gained a diverse foraging repertoire and an appropriate gut morphology, the natural changes in gut morphology attending dietary shifts can occur, in much the same ways as in wild grouse (THOMAS 1984). In a situation where young birds are due for release, a management strategy might be to increase the amount of energy in the diet for about two weeks prior to release. This would likely have the effect of promoting the deposition of fat in the body, which could give the young birds an assured source of internal energy while they become proficient foragers in wild habitats.

An important feature of herbivory which has not been considered in the rearing of birds is the presence of anti-herbivore compounds and how they are dealt with by the herbivorous bird. These compounds, existing as secondary compounds and mycotoxins, are ubiquitous and interfere with the metabolic process (PALO 1984). However, species of birds routinely consume plants which contain marked amounts of these compounds, such as Sage Grouse (*Centrocercus urophasianus*) eating sage (*Artemisia* spp.), Ptarmigan (*Lagopus* spp.) eating willow (*Salix* spp.), Black Grouse (*Tetrao tetrix*) eating birch (*Betula* spp.), and conifer needle-eating grouse species such as Capercaillie (*Tetrao urogallus*) and Spruce Grouse (*Canachites canadensis*). Presumably enzymatic systems exist at the level of the gut and liver to denature and eliminate these potentially noxious chemicals. However the enzyme systems may have to be induced and exposure to these chemicals before release may facilitate wild birds' feeding and prospering on such diets. PALO (1984) has shown that these secondary compounds are usually concentrated in the current year's growth, which also tends to be the most nutritious for herbivores. Thus wild birds must balance selection of plant parts for nutrient density with an ability to detoxify such compounds. This consideration must apply especially to releases of tetraonid species which are well known for their consumption of twigs and buds with high levels of secondary compounds.

Mortality of re-introduced birds is always to be expected for a variety of reasons. Death due directly or indirectly to starvation is commonly encountered. Given that mortality will occur, we should ask if a feeding programme which produces significant mortality of young before release, but a higher survival of those birds released, is preferable to a feeding programme which produces the converse effect. Starving birds are very prone to predation, and serve only to attract and concentrate predators. This, in turn, raises the threat of predation to those released birds which are surviving in that environment.

Poultry breeders minimize aggression and select for docility because it raises profits. In raising birds for release one should not try to eliminate aggressiveness and dominance but, rather, minimize its appearance and intensity by managing the captive environment, lowering bird density and providing escape cover. While some loss of birds due to aggression at this stage is inevitable, it is a small price to pay for retaining the fundamental behaviours which contribute to fitness.

Summary

Raising captive species of birds on commercial, concentrated feeds prior to release in wild environments may preclude the success of such reintroductions. Interactions must occur between the components of a diet, foraging behaviours and the morphological development of the alimentary tract of young birds. It is vital to precondition the digestive system to the types of wild foods each bird will encounter in its wild habitat in order for reintroduction programmes to succeed. Commercial type rations, while producing rapid and efficient body growth, may not condition the digestive system to the bulky, more fibrous, and less digestible foods birds will encounter after release. They certainly do not encourage optimal foraging behaviours and reinforce specific appetitive behaviours. Herbivorous species which consume appreciable amounts of secondary compounds with their food should be given these compounds so that the enzyme system involved with metabolizing them can be activated before release to the wild.

Zusammenfassung

Die Fütterung von Vögeln mit handelsüblichem Futter vor ihrer Freilassung in die Natur ist nicht zu befürworten. Handelsübliche Futtermischungen wurden entwickelt, um maximales Wachstum mit besonderer Betonung des Muskelwachstums zu erzielen. Sie sind im

allgemeinen sehr gut verdaulich und enthalten hohe Nährstoffkonzentrationen; daher entwickelt sich der Darm nur unzureichend. Vögel, die nur handelsübliche Futtermischungen erhalten, werden außerdem kaum in der Lage sein, natürliche Nahrungsquellen zu erkennen. Die Nahrung freilebender Pflanzenfresser ist für gewöhnlich weniger gut verdaulich und hat einen geringen Nährstoffgehalt. So ist in den meisten Fällen ein vielseitiges Nahrungsangebot für das Überleben entscheidend. Um die Ernährung zu sichern, müssen viel mehr Ballaststoffe aufgenommen werden als in kommerziellen Futtermischungen enthalten sind. Die Anatomie des Verdauungstraktes ist an die natürliche Nahrungswahl angepaßt und verändert sich als plastisches System mit der Eigenschaft der aufgenommenen Nahrung. Bei der Aufzucht zur Freilassung ist die Beachtung der Wechselwirkung zwischen Eigenschaften der Nahrung, der Entwicklung des Verdauungssystems und den Komponenten des Verhaltens beim Nahrungserswerb von größter Wichtigkeit. Jungvögel müssen daher auch mit Futterrationen geringen Nährstoffgehaltes gefüttert werden, um in Freiheit reelle Überlebenschancen zu haben. Vögel, die mit Wildfutter aufgezogen werden, lernen dadurch auch, Nahrungsquellen nach ihrem Nährwert zu unterscheiden. Dieser Aspekt im Verhalten ist für das Überleben in Freiheit ebenso wichtig wie ein ausreichend entwickelter Darm. Freilebende Pflanzenfresser sind einem großen Spektrum von Mykotoxinen ausgesetzt, die vom Körper metabolisiert werden müssen. Enzymketten müssen dafür aktiviert werden. Die Fütterung von Naturfutter vor der Freilassung schafft daher auch die nötigen Bedingungen für den Stoffwechsel, mit diesen zusätzlichen Belastungen fertig zu werden. Man sollte also magere, die effizient ihre Nahrung suchen können, nicht große oder fette Individuen aufziehen. Handelsübliche Futtermischungen einzusetzen, ist zwar ökonomisch wesentlich günstiger; will man jedoch freilebende Populationen aufbauen, dürfen Kosten und Arbeitsaufwand nicht die allein entscheidenden Faktoren sein. Die Entscheidung, ob entsprechende Maßnahmen ökonomisch und ökologisch sinnvoll waren, wird allein von der Lebenserwartung der ausgesetzten Vögel in Freiheit bestimmt, nicht durch die Zahl von freigelassenen Individuen mit scheinbar guter Kondition.

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