Nutritional Implications for the Endangered Status of the Wild Gouldian Finch (*Erythrura gouldiae*).

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Background

The Gouldian Finch (*Erythrura gouldiae*) is a popular aviary bird throughout the world. However, the wild populations are in decline and, if this trend is not arrested, may eventually face extinction in the wild. Several theories have been postulated regarding influencing factors impacting on the wild population, one of which is nutritional ecology. Current management practices that may influence nutritional ecology of the species are evaluated and nutritional implications discussed.

Feeding Ecology of the Gouldian Finch

The Gouldian finch exploits the seasonal availability of grass seeds in open woodlands in the north of Australia. There are differing opinions on this bird's consumption of insects. In the dry season, Gouldian finches occupy home ranges of about 500 ha within woodland hills, feeding upon fallen seeds of *Sorghum intrans.* Patches of food are exploited by birds following fire. During the wet season the birds occupy the lowlands surrounding the hills, moving long distances and covering homing ranges of more than 200 ha. Germination of seed of *S. intrans* makes them difficult to find and the finches shift to feeding on ungerminated seeds trapped within rock crevices. Once these reserves disappear they shift their feeding to germinating seeds.

In early December perennial grass species such as *Alloteropsis semialata, Chrysopogon fallax* and *Triodia pungens* produce seed in lowland areas adjacent to the breeding sites. The finches feed on these grass species until late in the wet season when *S. intrans* and *H. triticeus* become available again. Finches have also been observed feeding on green leafy tissue, which provides a concentrated course of provitamin A carotenoids. During the dry season there is limited availability of green plant tissue, which is further exacerbated by grazing pressure from cattle. It is possible that intensive grazing from cattle minimises availability of green plant tissue, impacting provitamin A availability and antioxidant carotenoids.

Breeding commences in February towards the end of the wet season, continuing into the early months of the dry seasons. Data suggests that breeding and fledging rates are not compromised but survival of juveniles is in question. This suggests that the immune system of juveniles is compromised, leaving them susceptible to pathogenic invasion. This could be initiated at the embryonic, hatchling or fledgling stage and may be influenced by poor maternal nutrition.

Current Land Management Practices

There are concerns that land management practices are influencing species diversity, spatial distribution and availability of food plants. Fire management regimes promote annual fuel reduction burns during the dry season to minimise the risk of wildfire and promote green pickings for cattle. This system favours annual seeding species such as *Sorghum* spp, with the promotion of monocultures minimising nutritional value of the overall diet. There is a positive correlation between availability of *Triodia* spp and juvenile survival but *Triodia* and *Chrysopogon* species can take between 2-5 years to set seed. Changes in species diversity and spatial distribution of seed plants can influence health of the finches through changes in energy value and nutrient composition of food plants.

Changes in Energetic Potential of Sites

Taxonomic variation in energy value or size of seeds may influence intake requirements of birds. The energy value of a seed is generally calculated from the fat, digestible carbohydrate (starches and sugars) and protein components. Each nutrient category varies in both its digestibility and energy value. Birds generally require energy to sustain basal metabolism as well as any activities such as movement, food procurement, temperature regulation and disease resistance. Any variation in either the energy value of the seeds (taxonomic variation, seed size) or the activity of birds will influence energy requirements of the birds.

Seed Size

Altering the taxonomic composition of food plants in any given habitat can alter seed size available to birds. Even if nutrient composition is identical, the size of a seed can influence energy availability per seed harvested. Smaller seeds will require increased energy expenditure to procure the equivalent amount of energy. Ease of access (different species may be structurally less accessible) and spatial distribution of individual plants (different species may grow further apart) may increase energy required to harvest seeds. If birds can concentrate feeding efforts on plants in one area they minimise the energy expended in locating and harvesting seeds. If grazing or firing regimes increase spatial separation of individual food plants, they may increase energy requirements of birds, especially if the structure of the vegetation benefits predators, increasing birds' awareness of predation threats and influencing feeding practices. If there are variations in the number of seeds/seed heads brought about by taxonomic variation or habitat management practices, the energy value of individual species may vary. Differences in spatial variation of seed heads could influence energetics of harvesting.

Nutrient Composition of Seeds and Forbs

One of the biggest threats to the survival of juveniles is a compromised immune system. The maternal diet has an important impact on the first two weeks post hatch, with chick size, vigour, early feeding behaviour and immune status all dependent on nutritional intake of the hen. There are a number of nutritional factors that can impact on the immune system:

Protein and Amino Acids

Amino acid composition of plant proteins varies taxonomically with at least one essential amino acid generally deficient in each species. Animals compensate for these deficiencies by feeding on a variety of species. Since amino acids cannot be stored, birds require a variety of seed species at

any one time and practices that promote the development of monocultures may jeopardise this biodiversity. Amino acids are important during the vulnerable moult period and deficiencies could influence moulting efficiency and feather development.

Lipids and Fatty Acids

The fatty acid composition of seeds varies taxonomically and the ratio of the essential *n*-3 to *n*-6 fatty acids can influence a number of physiological processes including inflammatory responses. Seeds that are lying on the ground may be nutritionally inferior to those available directly from plants, especially with regard to the fatty acids. As lipids break down, antioxidants such as vitamin E are depleted and it is likely that these seeds are deficient in vitamin E as well as providing rancid fats of poor nutritional quality that also promote the production of harmful free radicals that may damage intestinal structure and inhibit uptake of nutrients

Carbohydrates

The chemical structure of carbohydrates influences digestibility and may vary taxonomically and temporally. Green seeds may have more digestible carbohydrates than seeds that have been lying on the ground for an extended period of time. Some oligosaccharide carbohydrates may also be advantageous in promoting beneficial microbial gut flora that can boost the immune system and facilitate fighting off infection from parasites and bacteria.

Vitamin A and Carotenoids

Although vitamin A is a critical fat-soluble vitamin, there is **NO** vitamin A in plant products with provitamin A provided by a limited number of carotenoids. There are few carotenoids in seeds with high concentrations in green leafy tissue. There is some conjecture as to whether the gouldian finch feeds on green plant tissue as this would provide a valuable source of provitamin A carotenoids. Birds convert carotenoids to vitamin A on an 'as needs' basis, thus avoiding any potential for toxicity. Any excess carotenoids are then used for feather pigmentation or as antioxidants, protecting cellular membranes and boosting the immune system. During the dry season there is limited availability of green plant tissue, which is further exacerbated by grazing pressure from cattle. It is possible that intensive grazing from cattle minimises availability of green plant tissue, impacting provitamin A availability and antioxidant carotenoids.

Vitamin E

Vitamin E is one of the most potent antioxidants. It is necessary to protect seed lipids from degradation during lipid peroxidation as well as fatty acid constituents of cellular membranes. Vitamin E is also essential for the immune system. Seeds that are high in polyunsaturated fatty acids often have high concentrations of vitamin E but these fatty acids are also highly susceptible to lipid peroxidation so, over time, the vitamin E will be depleted. Fatty acids of the *n*-3 family are also more susceptible to lipid peroxidation than those of the *n*-6 family and taxonomic variation in fatty acid composition may influence vitamin E stability. Green seeds are also likely to be higher in vitamin E than those that are on the ground for an extended period of time.

Carotenoids and Feather Pigmentation

The feather colours of the gouldian finch are vivid and varied. Studies of other passerines indicate a correlation between parasitic loads and general health of birds with intensity of feather pigmentation. There is some suggestion of variation in intensity of feather colour among the

different wild populations, which may be attributed to differences in health. Finches generally metabolise carotenoids before anchoring them as feather pigments and any influences on enzymatic systems may impact feather pigmentation and/or colour intensity. Differences in expression of feather pigmentation may provide indicators of individual bird health.

Antioxidants

The main antioxidants are vitamins C and E, selenium and various carotenoids. Green tissue may provide sources of carotenoids and, while seeds often provide good levels of vitamin E, those that have been lying on the ground throughout the dry season for any period of time will be depleted of this vitamin as it combats lipid peroxidation of fatty acids. Many birds have the capacity to synthesise vitamin C from dietary precursors but this has not been verified in the Gouldian finch. Individual antioxidants interact with other antioxidants in the body as well as with pro-oxidants (iron, high PUFA, mycotoxins), with a deficiency of vitamin C not only influencing the antioxidant potential of the diet but also restricting recycling of vitamin E, thus increasing dietary requirement for vitamin E. Levels of antioxidants required for disease resistance in juveniles may be in excess of those required for production and general health of adults.

Summary

There are a number of nutritional implications for the compromised health status of juveniles. This may be due to poor maternal nutrition or inadequate nutrition at the nestling/fledgling stage. Management practices such as controlled burns that promote green pickings for cattle and minimise the risk of wildfire, may alter spatial distribution of seeding species and biodiversity of food plants. Development of monocultures of *Sorghum* spp may be inappropriate given the positive correlation between juvenile survivorship and presence of seeds of *Triodia* spp. Differences in intensity of feather colour among populations may also be indicative of nutritional adequacy of the various sites. It is clear that the topic of habitat management for optimisation of nutritional adequacy of sites warrants further consideration.

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