Improvements in health and productivity of large psittacines fed organic formulated diets low in vitamin A.

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Abstract

Health and productivity of large psittacines were evaluated at two professional breeding aviaries. In experiment 1, productivity of blue and gold macaws (*Ara araruana*) increased from 0.9-6 chicks per pair (n=7 pairs), when transferred from an unsupplemented seed-based diet to organic formulated products low in vitamin A. This was evidenced with increased egg production (35 to 69, n=7 pairs), increased fertility (29% to72%) increased number of hatchlings (20% to 64%) and chicks reared (17% to 62%), with a decrease in embryonic mortality (9% to 4%). In experiment 2, the nutrient compositions of seven diets were compared among formulated commercial products and correlated with breeding success, with efficacies of organic and nonorganic products evaluated. Breeding success increased from 0.87 chicks per pair (n=150 breeding pairs) to in excess of 3 chicks per pair when birds were transferred to diets composed of organic ingredients. The organic products provided lower levels of vitamin A (0.63-5.68 IU kg^{-1} vs. 8.33-17 IU kg^{-1}) copper (6-10 mg kg^{-1} vs. 10-17 mg kg^{-1}), iron (121-132 mg kg^{-1} vs. 140-233 mg kg^{-1}) and zinc (43-85 mg kg^{-1} vs. 128-130 mg kg^{-1}). Higher levels of fat (11-18% vs. 6.7-8%) and selenium (0.6-0.8 mg kg^{-1} vs. 0.3 mg kg^{-1}) were detected in the organic products. Nutritional implications for the health and breeding success of these birds are discussed.

Introduction

Inadequate nutrition compromises the health and productivity of birds, increasing costs of commercial production from a lack of income producing young and a constant economic drain from expenses involved in veterinary attention and intensive hand-rearing of chicks that are in poor health or rejected by parents. Minimising problems associated with nutritional inadequacy in adult birds improves the health and viability of chicks produced as well as breeding longevity of hens. Traditional avicultural diets consisting primarily of seed/nuts, fruit and vegetables are not conducive to the production of large clutches or healthy offspring, yet these diets still feature largely for companion psittacines. Seed-based diets are deficient in key nutrients such as calcium, essential amino acids and the fat-soluble vitamins A and E, with chronic illness and poor productivity prevalent in birds maintained on these diets (Angel, 1995).

While the advent of commercially formulated diets provides a convenient vehicle for present nutritionally balanced diets, skepticism associated with formulated diets (Green 2001; Cravens 2002) is not without foundation (Carpino 1997) as many of these products are manufactured with nutritionally inferior by-products, artificial preservatives, colors and flavors and varying amounts of vitamins. Excesses of vitamin A in conjunction with deficiencies in vitamin E are common, with reports of vitamin A toxicosis for cockatiels (Koutsos and Klasing, 2002), cockatoos (Schoemaker et al, 1997), conures (Bourke, 1996) macaws (Schoemaker et al, 1997) and lorikeets (McDonald, 2002). High rates of infertility, poor hatching, weak, non-thriving chicks (with a high percentage of gram negative bacterial problems), yeast excesses, bent legs, crop emptying problems and high chick mortality have all been associated with nutritionally imbalanced formulated diets (G Harrison 2003). In addition, behavioural problems, including a failure of parents to incubate eggs, result in decreased hatchability, decreased parent-raising if the eggs hatch, and an increase in the time spent hand-rearing and hand-feeding chicks, with high breeder mortality (Meade, 1998).

Anecdotal studies indicate that diets formulated from organic ingredients (HBD products) improve health and productivity of birds that have been maintained on either seed-based diets or poorly formulated diets composed of nonorganic ingredients. However, it is not clear whether these improvements are correlated with the organic nature of the products or nutrient composition. To evaluate the efficacy of formulated bird foods composed of organic ingredients, health and productivity of large psittacines maintained at two different commercial aviaries were assessed, with key nutritional differences discussed.

Methods

Aviary 1, UK

Seven breeding pairs of blue and gold macaws (*Ara ararauna*) were maintained on nonorganic seed-based diets. Birds were transferred to HBD Adult Lifetime (ALC) prior to the breeding season and HBD High Potency (HPC) during the breeding season. Nutrient composition was not evaluated in this study, with comparisons confined to breeding outcomes and health aspects.

Aviary 2, Florida USA

150 breeding pairs comprising eight psittacine species were maintained on a variety of commercial bird pellets composed of nonorganic ingredients for a period exceeding 15 years, before being transferred to commercial products composed of organic ingredients (HBD Adult Lifetime and HBD High Potency) in 1994. The species studied include: African grey parrots (*Psittacus erithacus*), Amazons (*Amazona* spp), cockatoos (*Cactua galerita, C. moluccensis, C. galerita triton*), eclectus parrots (*Eclectus roratus*) and macaws (*Ara* and *Anodorhynchus* spp). Nutrient composition data was obtained directly from independent laboratory analyses (HBD products) and comparisons made with

manufacturers' values for three nonorganic products that had previously been used at this commercial aviary (Mazuri Parrot Maintenance, Pretty Bird African Special and Kaytee Exact Rainbow Breeder). Proportions of fruit, seeds and nuts outlined in Table 1 remained constant, with the composition of the fruit/vegetable mix including apple, banana, cantaloupe, mango, pineapple, yellow corn, carrot and sweet potato, the greens mix composed of collards, beet greens, mustard greens, broccoli, French beans and okra, and the seed mix comprising predominantly sunflower seeds. Due to the higher nutritional demands of the hyacinth macaws, these birds were maintained on breeding diets all year round once transferred to the organic products (HBD HPC).

Results

Aviary 1

Anecdotal reports from the breeder indicate that productivity increased significantly when transferred from a seed-based diet to the organic formulated diet, with a decrease in productivity when birds were returned to a seed-based diet during the non-breeding season. Breeder records were evaluated for seven of these breeding pairs. Productivity increased from an average of 0.9 chicks per pair when fed a seed-based diet to an average of six chicks per pair when maintained on the HBD products. Egg production increased from 35 to 69 (n=7 pairs), with improvements in fertility (29% to72%), number of hatchlings (20% to 64%) and number of chicks reared (17% to 62%), and a decrease in embryonic mortality (9% to 4%) all correlated with maintenance on the organic products, Figure 1.

Aviary 2

When birds were transferred to the organic products, breeding success increased from an average of 0.87 chicks per pair (n = 150 pairs) to in excess of three chicks per pair, with a reduction in embryonic death, poor chick development and adult aggression, and improvement in parental care, eliminating the need to hand-rear chicks. Nutrient data was incomplete for all nonorganic products so comparisons are limited to values for proximates, minerals and the fat-soluble vitamins A and E, Table 2. Despite variations in proportions of formulated products in the various diets, Table 1, discussion is confined to the nutrient composition of the commercially formulated products and not over dietary content for ease of comparison.

Crude protein content was marginally higher in the organic products (17-21% vs. 14-18%), with higher fat content in the organic breeding diet (18% vs. 6.7-8%). Vitamin A content was higher in the nonorganic products (8.33-17 IU g^{-1} DM) when compared to the organic maintenance (0.63 IU g^{-1} DM) or the organic breeding (5.68 IU g^{-1}) product, with highest levels of vitamin E detected in the organic breeding product (220 mg kg^{-1}, HBD HPC). Calcium:phosphorus ratios of all products exceeded 1:1 with higher copper, iron and zinc levels detected in the nonorganic products and higher levels of selenium in the organic products.

Discussion

Formulated diets for companion birds have been available for a number of years but there are still few studies of the efficacy of these products, with dietary requirements of poultry (NRC, 1994) remaining the reference standards for many of these products. However, granivorous birds do not provide adequate physiological models for all avians, with malnutrition diagnosed in many companion bird species maintained on commercially formulated diets. A number of these illnesses are correlated with deviations in concentrations of fat-soluble vitamins from those recommended for poultry, even though there is no evidence that companion birds have higher dietary requirements for vitamins A and D.

Hypovitaminosis A is prevalent in birds maintained on seed-based diets, characterised by growth defects, poor feathering and facial hyperkeratosis, impaired function of epithelial tissue increasing pathogen invasion and keratinisation of reproductive tissue, as well as compromised immune function (Koutsos and Klasing, 2002). Failure of spermatogenesis and a decline in sexual activity, increased time between clutches, reduced hatchability, increased embryonic mortality, decreased survival time of progeny, decreased testis size and failure of spermatogenesis have also been reported, many of which are associated with failure to maintain healthy epithelium (McDowell, 2000). Vitamin supplementation is regularly prescribed for birds maintained on seed-based diets to minimize incidence of malnutrition.

While there is no evidence that dietary requirements of vitamin A are higher for companion birds than those of poultry, many commercial products provide vitamin A in excess of recommendations for either poultry (1,500 IU $kg^{-1;}$ NRC, 1994) or cockatiels (Koutsos and Klasing, 2,000 IU kg^{-1} 2002), Table 3. Dietary excesses of vitamin A weaken the membranes of cells of epithelial tissue, increasing access to pathogens and infections and can influence fertility. While hyperkeratosis is commonly associated with dietary deficiencies of vitamin A, similar symptoms result from dietary excesses of vitamin A, resulting in a loss of function of associated tissues and compromised immune system. Pancreatitis (Koutsos and Klasing, 2002; McDonald, 2002a) and iron storage disease (McDonald, 2002b) have also been correlated with dietary excesses of vitamin A, as have changes in vocalisation patterns (Koutsos and Klasing, 2002).

While the author does not question the benefits of diets composed of organic ingredients, it is likely that the improvements in health and productivity of birds in these studies are correlated with improvements in dietary vitamin A content. Deficiencies in vitamin A and E from the seed-based diet at aviary 1 can be correlated with decreased productivity and survivorship of hatchlings. Conversely, poor fertility and fledgling survivorship at aviary 2 may be correlated with dietary excesses of vitamin A, with vitamin A content of the nonorganic products exceeding levels reported to be toxic for cockatiels (10,000 IU kg^{-1}; Koutsos and Klasing, 2002). Although vitamin A content of the organic maintenance product falls below these recommendations, supplementation with fresh produce provides additional vitamin A in the form of carotenoids, with sufficient conversion from β-carotene (2.4 mg kg^{-1}) reported in cockatiels in the absence of dietary vitamin A (Koutsos and Klasing, 2002). Higher productivity at aviary 1 (0.87 to in excess of 3 chicks per pair) on diets lower in vitamin A reflects similar results reported by Stoodley (1998) of 3.25 chicks per pair (n=120 pairs) after a period of four years on the HBD diets. The high incidence in chicks of bent beaks and legs and general poor health at aviary 2 was diminished when the birds were transferred to the organic formulated diets, reducing veterinary expenditure significantly. Excesses of vitamin A have also been implicated in high infertility and hatchling mortality as well as compromised immune function and increased incidence of pancreatitis in lorikeets (McDonald, 2002a).

Behavioural abnormalities have been correlated with pesticide contamination as well as dietary excesses of vitamin A. Parental aggression was reported in many breeders at aviary 2 resulting in large amounts of time dedicated to hand-rearing chicks. When transferred to the organic formulated diets, parental aggression was reduced, increasing the number of chicks that were parent reared until at least 10-12 weeks of age (Meade, 1998). Improved nest cleanliness has been correlated with a reduction in dietary vitamin A in lorikeets (McDonald, 2002a) as well as changes in vocalisation patterns of cockatiels (Koutsos and Klasing, 2002), which may influence parental response to begging behaviour of chicks.

Dietary vitamin E levels reported by manufacturers appears to be adequate but inadequate packaging can result in degradation prior to products being opened. Actual vitamin E levels in a single sample of Prestige Nutribird P15 is approximately 1/3 that stated by the manufacturer (McDonald unpublished data). The triple laminate packaging of the organic formulated products preserves levels of vitamin E more efficiently and vitamin E deficiencies may also be implicated in poor productivity and health of chicks in these studies. Dietary excesses of vitamin A in conjunction with deficiencies of vitamin E can increase susceptibility of spermatozoa to lipid peroxidation, impacting on fertility. Dietary excess of vitamin A can also compete with uptake of carotenoids that act as potent antioxidants, possibly influencing the antioxidant systems of developing embryos and hatchlings.

There were a number of differences in mineral content of the various commercial products but few of these are implicated in the significant differences in health and productivity. Dietary requirements for copper have yet to be established for psittacines so it is difficult to evaluate whether the lower copper content of the organic diets is beneficial. All diets contained high levels of iron, exceeding recommendations to minimise incidence of iron storage disease in birds (Johnson, 1999; Dorrestein et al, 2000; Schoemaker and Beynan, 2001) but high levels of dietary iron has also been detected in wild foods of the toucan (Otten et al, 2001). Given the levels of iron in products in this study, it is unlikely that differences in health and productivity are directly correlated to dietary iron levels. The iron content of the HBD products has since been reduced to less than 80 mg kg^{-1}.

Selenium levels of the organic products exceeded those of the nonorganic products. While selenium toxicity has been reported in aquatic birds (Spallholz and Hoffman, 2002; Hoffman, 2002; Ohlendorf et al 1990), dietary requirements have not yet been established for psittacines. Maximum weight gain has been reported in poultry chicks fed 0.5 mg kg^{-1} selenium when combined with 300 mg kg^{-1} vitamin E (Swain et al 2000) and selenium content of the products in this study did not exceed levels of toxicity reported for domesticated species of 5-20 mg kg^{-1} (Klasing, 1998). Selenium, as part of the enzyme glutathione peroxidase (GHS-Px) plays an integral role in protecting cells from lipid peroxidation and may be important for birds that are maintained on diets high in polyunsaturated fatty acids, especially those of the *n*-3 family that are particularly susceptible to lipid peroxidation. Tissues of the heart (Rani and Lalitha, 1996), liver (Surai, 2000) and reproductive tissues (Surai et al 1998) are particularly susceptible to lipid peroxidation and may be affected during embryonic development. Selenium supplementation of hens has a stimulatory effect on GSH-Px activity and improves the efficacy of the antioxidant system throughout embryonic development and early postnatal development of offspring (Surai, 2000). Increasing levels of GSH-Px in the seminal plasma of spermatozoa, testes and liver along with higher levels of α-tocopherol(as seen in the organic breeding diet), improve the antioxidant systems of spermatozoa, which are particularly susceptible to peroxidation due to the high proportion of the phospholipid fatty acids arachidonic acid (20:4n6) and docosatetraenoic acid (22:4n6) (Surai et al 1998). It is possible that the higher selenium content of the organic diets enhanced sperm viability due to increased GSH-Px activity increasing fertility.

Zinc toxicity has been diagnosed in a number of psittacines that have ingested zinc coated toys or aviary wire (Donely, 1992). Dietary zinc requirements have not been established for psittacines but concentrations in the nonorganic products in this study all exceeded recommendations of 40 mg kg^{-1} for poultry (NRC, 1994). High levels of zinc can impair enteric absorption and/or transport of vitamin E as a consequence of zinc-induced pancreatic insufficiency, a major cause of reduced tissue concentrations of α-tocopherol (Lü and Combs, Jr, 1988). Although most negative effects of excess dietary zinc are observed at levels higher than detected in any of the diets in this study, lower levels of plasma tocopherol are correlated with higher levels of zinc (100-200 mg zinc kg^{-1}), equating to levels identified in some of the nonorganic diets. Given the sensitivity of psittacines to zinc toxicity, high levels of dietary zinc may have compromised vitamin E availability and should be viewed with caution.

Conclusion

Comparisons among organic and nonorganic commercial bird foods indicate that the improved health and productivity of birds maintained on the organic diets may be related to the lower levels of vitamin A and zinc, with the higher levels of selenium and vitamin

E possibly enhancing the antioxidant systems of these birds. The increased quantity and quality of offspring, decreased time spent preparing food and feeding birds, decreased food wastage, decreased veterinary expenditure and increased longevity of breeding pairs, all increase the economic viability of using products that are nutritionally balanced. In addition, pet shops paid a 10% premium for babies produced at aviary 2, an acknowledgment of the exceptional health of the offspring from the aviary in this study. It is unclear whether the organic nature of the products in these two studies or superior nutritional quality support higher production and greater health in psittacines but it is evident that the provision of nutritionally balanced formulated diets can improve the health and productivity of aviary birds.

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Species	African Grey	Amazon	Cockatoo (*C. galerita*)	Cockatoo (*C. moluccensis/ C. galerita triton*)	Eclectus	Macaw (*Ara spp*)	Macaw (*Anodorhynchus spp*)
Pellets	40 (69)	40 (74)	45 (76)	70 (83)	35 (60)	40 (58)	40 (54)
Seeds	10 (17)	6 (11)	6 (10)	6 (7)	15 (26)	15 (22)	15 (20)
Almonds	0.5 (0.9)	0.5 (0.9)	0.5 (0.9)	0.5 (0.6)	0.5 (0.9)	0.5 (0.7)	3 (4)
Peanuts	0.5 (0.9)	0.5 (0.9)	0.5 (0.9)	0.5 (0.6)	0.5 (0.9)	0.5 (0.7)	3 (4)
Fruits	3.5 (6)	3.5 (7)	3.5 (6)	3.5 (4)	3.5 (6)	6.5 (9)	6.5 (9)
Vegetables	3.5 (6)	3.5 (7)	3.5 (6)	3.5 (4)	3.5 (6)	6.5 (9)	6.5 (9)
Total (g)	58	54	59	84	58	69	74

Table 1. Composition of diets fed to psittacines at aviary 1. Figures in parentheses indicate percent total diet (as fed). All quantities are expressed in g (as fed).

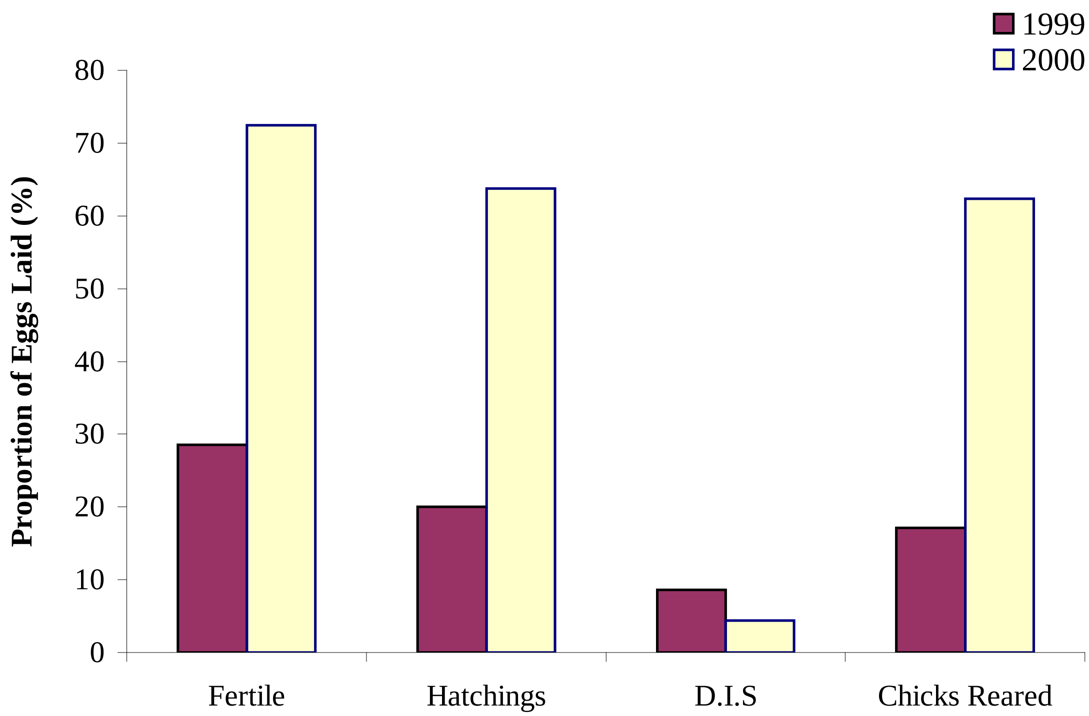

Figure 1. **Breeding Results for Blue and Gold Macaws at Beck's Bird Barn Expressed as a Percentage of Eggs Laid (n = 7 pairs)**

Table 2. Nutrient composition of various commercial parrot foods. ¯ indicates no data available.