Feeding Trial Evaluating Mazuri® Nestling Meal Compared to FoNS© as a Diet for Nestling and Fledgling Passerines in a Rehabilitation Setting

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Abstract: Formula for Nestling Songbirds (FoNS©) is a diet commonly fed to nestling and fledging passerines in rehabilitation settings. The authors evaluated a new formulation, Mazuri® Nestling Meal (MNM), as a potential commercial alternative to FoNS©. The objective was to evaluate the adequacy of MNM compared to FoNS© in birds presented to Tri-State Bird Rescue & Research between 10 June and 10 August 2009. Clutchmates were randomly assigned to FoNS© (control group) or MNM (experimental group) and fed on the same schedule to satiety. Birds received species-appropriate dietary supplementation. Birds were discharged from the study when they moved outside, died, or were removed by a clinician due to health status. The primary endpoint was rate of weight gain, as determined by the percent of admission body weight gained per day. The mean of the control population (n=27) was compared with the experimental population (n=27) using the Student's *t*-test, with statistical significance set at $p<0.05$. The mean percentage body weight gain per day for the control group was 4.57 (95% CI 2.825-6.310). The mean percentage body weight gain per day for the experimental group was 3.89 (95% CI 2.145-5.631). The difference between populations was not statistically significant as indicated by $p=0.58$. The control group had one death. The experimental group had three deaths and three birds removed by clinician (two subsequently euthanized). With the exception of one inconclusive result, necropsies performed by the overseeing clinician determined cause of death to be unrelated to diet. The statistical analysis and additional qualitative data suggests that MNM is equivalent to FoNS© and an acceptable alternative.

Key words: Songbirds, diet, FoNS©, Mazuri®

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INTRODUCTION

The diet fed to nestling and fledgling songbirds in a rehabilitation setting plays a critical role in their ability to survive and thrive. Diets that do not meet the needs of these young animals can lead to skeletal deformities, slow growth, poor feather quality, inability to be released, or death. However, the field of avian nutrition is still in its infancy and much of the information available about the nutrient requirements of both companion and wild birds is based largely on guesswork and trial and error methodology (Brue 1994). As a result, the diets used for nestling and fledgling songbirds in rehabilitation centers are works-in-progress that are changed or tweaked frequently in an effort to produce the healthiest birds possible with the best chance of survival.

Formula for Nestling Songbirds (FoNS©) is a diet currently syringe-fed to nestling and fledgling songbirds at many rehabilitation centers. The recipe was first published in 2002 (Winn) and has been through several revisions as ingredient availability and nutritional knowledge have evolved. In 2006, the 2004 version of FoNS© was tested in a split clutch study against three facility-specific diets designed at the Wildlife Rescue Association of BC (WRA) in Burnaby, Canada. FoNS© was shown to be as effective as the in-house diets for generalists and seedeaters and far superior to the in-house diet for insectivores (Sheldon and Drake 2008; Finke and Winn 2009). The most recent version of the FoNS© formula was tested at eight rehabilitation centers during the summer of 2007 on a total of about 2,500 birds. Positive reports from the participant centers led to publication of the revised recipe in 2008 (Winn and Finke).

While FoNS© is widely considered an appropriate and effective diet for raising wild songbird babies, it

has several drawbacks. The formula is not commercially available and must be mixed by each center that uses it. Volunteer and staff resources are expended on diet preparation. FoNS© often is made in large quantities and frozen for storage. Such storage uses freezer space and requires that rehabilitators estimate daily usage in advance to allow adequate time for the diet to thaw. The cat kibble that serves as the base for the diet must be pre–soaked, making it difficult to mix FoNS© quickly in the event of a shortage. In addition, some centers make ingredient substitutions that alter the nutritional analysis and effectiveness of the formula.

The Mazuri® branch of PMI Nutrition® (St. Louis, MO) created a syringe–feeding diet for nestling and fledgling songbirds aimed at eliminating some of the challenges of FoNS© while maintaining the survival, health, growth, and feather quality achieved by FoNS©. The company sought to create a diet that could be manufactured commercially as a nutritionally complete powder to which rehabilitators add only water. A commercially available formula could discourage substitutions and alterations to nutrient content at the rehabilitation center level. The ease of diet mixing allows volunteer and staff resources to be directed elsewhere. Furthermore, the quick preparation allows diet to be made 'as needed' and eliminates the need to freeze and thaw large quantities.

PMI Nutrition® recruited Tri–State Bird Rescue & Research (TSBRR), a wild bird rehabilitation center in Newark, DE, to test the Mazuri® diet, referred to as Mazuri® Nestling Meal (MNM), compared to the 2008 version of FoNS©, the syringe–feeding diet already in use at TSBRR. Weight, feather length, feather quality, fecal quality, morbidity, and mortality were monitored to evaluate the nutritional adequacy of the MNM compared to FoNS® and determine viability of MNM as a commercial nestling and fledgling hand–feeding formula.

Materials and Methods

The study population was drawn from clutches of at least two nestling or fledgling passerines (any species) presented to TSBRR between 10 June 2009 and 10 August 2009. Birds were admitted to the center by a clinic supervisor who performed a standard admission exam and provided any treatment needed. All birds received only Pedialyte® (Abbott Laboratories, Columbus, OH) during the admission period. Clutches that appeared relatively healthy with equivalent health statuses among clutchmates were enrolled in the study. Clutchmates were randomly assigned to the control group receiving FoNS© or the experimental group receiving MNM.

Clutchmates were housed together in the same nest cup and incubator, basket, screen cage, or playpen depending on age. To ensure birds received the proper diet in the mixed housing, color–coded leg tags and non–permanent beak markings were given to make identification of diet group possible without handling. All cages containing study birds were clearly marked. Only members of the research team or clinic staff familiar with the study feeding protocols fed study birds.

FoNS© was prepared and frozen by TSBRR volunteers according to the recipe as published in 2008 (Winn and Finke). Researchers thawed the FoNS© as needed, keeping the diet refrigerated once thawed. The active culture plain yogurt called for in the recipe was added before freezing, and the Avi–Era™ bird vitamins (LaFeber Company, Cornell, IL) were added after thawing. Fresh FoNS© from the refrigerator was placed on the feeding trays at the beginning of each four– to five–hour shift. MNM was mixed at a ratio of 1 part powder to 1.5 parts water and stirred with a hand blender (Proctor–Silex®, Hamilton Beach Brands, Inc., Washington, NC). MNM was mixed fresh at the beginning of every shift. MNM was never mixed in advance or refrigerated prior to use.

The research team or the clinic supervisors fed study birds according to standard TSBRR protocols for baby birds. Birds were fed at intervals ranging from 20 minutes to two times per day, with interval length dependent on age. Feeding intervals increased incrementally about every three days. Clutchmates in the two groups were fed at the same times and on the same intervals throughout the study. Birds were syringe fed only the diet (FoNS© or MNM) to which they were randomly assigned. However, both groups received the same species–appropriate dietary supplementations including gut–loaded mealworms, crickets, fruit, soaked cat kibble, egg yolk, and seeds. The researchers fed the control and experimental diets with 1–cc syringes, 1–cc syringes with cannula tips, or 3–cc syringes. Syringe choice was based on the size of the bird. The MNM formulation used in the study clogged the tips of standard syringes; consequently, a high–speed rotary tool (Dremel®, Robert Bosch Tool Corporation, Racine, WI) was used to slightly widen the tips of syringes used to feed MNM (a subsequent re–formulation of the MNM diet passes through normal syringes without a problem but was not available in time for use in this study). Birds were fed to satiety unless members of a species known to overeat (e.g., house finches, *Carpodacus mexicanus*). These species were fed until crops were full based on observation by the feeder.

The researchers weighed the birds on a designated scale at admission and every morning before the first feeding until dismissal from the study. When birds were handled for weighing each morning, the researchers also did a cursory examination to assess general health status, body condition, feather quality, and presence of any morbidity. Any abnormalities, concerns, or feather issues were recorded in the bird's chart. Right wing chord and right outermost tail feather length were measured using composite digital calipers (Cen–Tech®, Harbor Freight Tools, Camarillo, CA) at admission, every Tuesday thereafter, and at dismissal from the study. Occasionally, admission and dismissal feather measurements were missed for some clutches. Spread wing pictures were taken every Sunday, Tuesday, and Thursday for all birds and at admission and dismissal for most clutches (Figure 1). Fecal quality and abnormalities were recorded at each feeding. Fecal observations could be attributed to specific birds during the nestling period because each bird produced a fecal sac during the feeding process. Therefore, differences between the diets could be examined more accurately during this time. Once fledged, fecal production was not usually witnessed. This resulted in difficulty distinguishing droppings from individual birds. Consequently, observations were generally recorded on a cage–by–cage basis. Incidences of constipation and crop stasis were recorded on feeding data sheets when the conditions occurred.

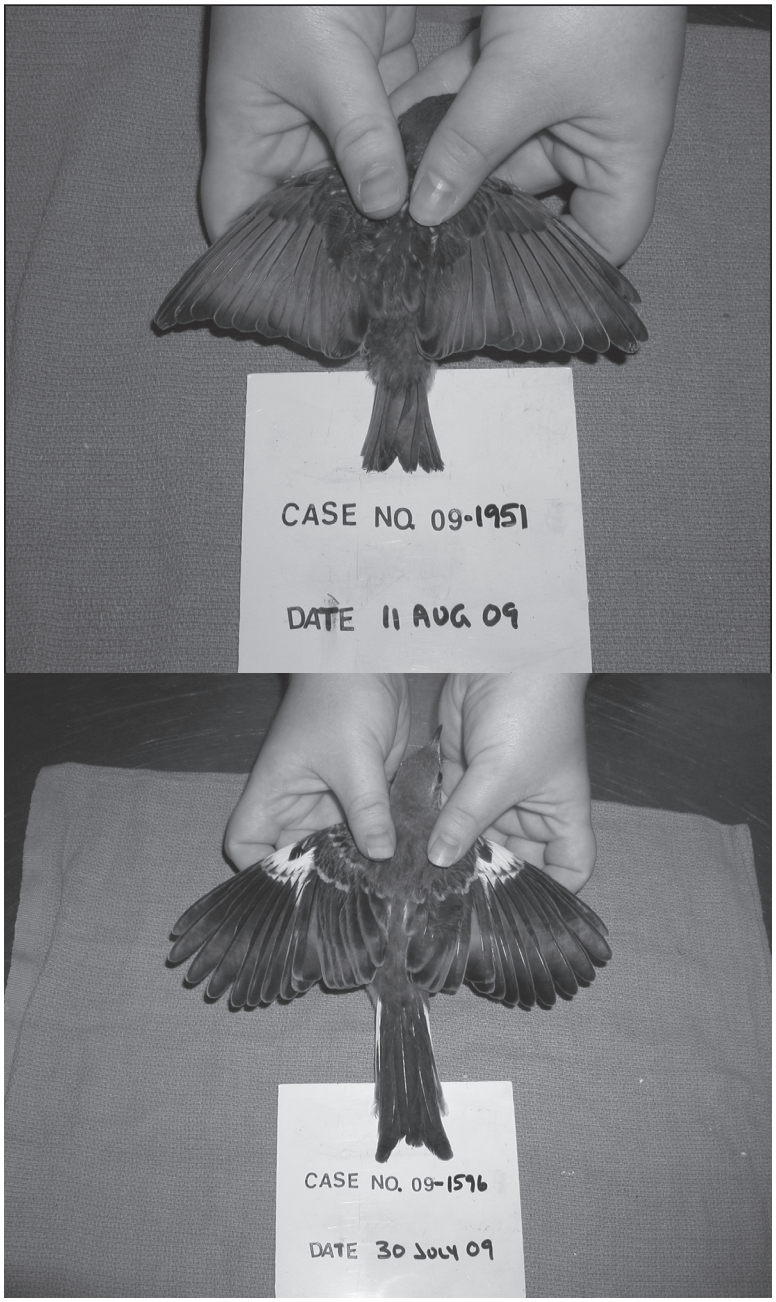

Figure 1. Technique used to photograph study birds. Top: Eastern bluebird (Sialia sialis) *from control group. Bottom: Northern mockingbird* (Mimus polyglottos) *from experimental group. (TSBRR staff photo)*

Birds were discharged from the study in one of three ways: the bird died; the bird was removed from the study by a clinician due to poor health status (including weight loss, feather problems, failure to thrive, or other concerns); or, the bird was moved to an outdoor cage in preparation for release. The overseeing veterinarian performed necropsies on birds that died or were euthanized. Incidences of morbidity and mortality in study birds during the pre–release outdoor period were recorded. Weights, photographs, and wing chord and tail measurements were taken at release for most study birds. All study birds were given permanent metal bands issued by the US Bird Banding Lab before release.

The statistical analysis plan focused on the primary endpoint of percentage of admission weight gained per day. This measure was chosen as the best way to analyze weight gain while controlling for the fact that different clutches entered the study at different ages and remained in the study for differing numbers of days. This approach also attempted to control the variability introduced by inclusion of many species with a wide range of normal adult weights. The mean percent weight gained per day for the control and experimental groups were compared using the Student's *t*–test with 95 percent confidence intervals, with statistical significance set at $P<0.05$. A second analysis was performed with the exclusion of birds that died within

Table 1. Number of Birds in each Group by Species.

Common Name	Genus and Species	Control Group (FoNS©)	Experimental Group (MNM)
American robin	*Turdus migratorius*	3	3
Northern mockingbird	*Mimus polyglottos*	5	5
Song sparrow	*Melospiza melodia*	1	2
Barn swallow	*Hirundo rustica*	4	3
Eastern bluebird	*Sialia sialis*	4	3
Northern cardinal	*Cardinalis cardinalis*	1	1
Brown-headed cowbird	*Molothrus ater*	1	1
House finch	*Carpodacus mexicanus*	1	2
House wren	*Troglodytes aedon*	1	1
Carolina wren	*Thryothorus ludovicianus*	6	6
		Total = 27	**Total = 27**

Table 2. Deaths and Necropsy Findings.

Control Group (FoNS©)		
Bird ID	**Days from Admission to Death**	**Necropsy Findings by Overseeing Veterinarian**
American robin 1249	2	Free blood in abdomen and trauma suggestive of a fall from nest. Death unlikely to be related to diet
Experimental Group (MNM)		
Bird ID	**Days from Admission to Death**	**Necropsy Findings by Overseeing Veterinarian**
Northern mockingbird 1226	1	Intestines distended with fluid. Caudal half of both liver lobes are dark. Cause of death not determined.
Eastern bluebird 1252	2	Facial edema and erythema on left side of head and neck. Lungs and trachea filled with blood. Trauma, either prior to arrival or at TSBRR was cause of death. Diet not a factor in death.
Carolina wren 1588	2	Body partially autolyzed; bile imbibition. Consolidation of lateral margins of both lungs. Cause of death not determined, but unlikely related to diet.

48 hours of randomization. Similar analyses were performed for mean percent wing chord length gained per day and mean percent right outermost tail feather length gained per day. Birds for which two wing and tail measurements were not available due to early death or study removal were excluded from these calculations. In clutches for which admission or dismissal data was not available, the analysis was performed for the period from the first to last measurements available. For birds admitted with no tail feathers in pin, a baseline measurement of one millimeter was assigned instead of zero to ensure only real numbers resulted from the calculations.

Results

Fifty–four birds, 27 in the control group and 27 in the experimental group, were admitted to the study. The birds came from 20 different clutches and included 10 species (Table 1).

The control group experienced one death and the experimental group experienced three deaths. All four deaths occurred within two days of admission to the

Table 3. Birds Removed from Study by Clinician with Final Outcomes and Necropsy Findings when Applicable.

Control Group (FoNS©)			
(no birds terminated by clinician in this group)			
Experimental Group (MNM)			
Bird ID	**Reason for Termination**	**Final Outcome**	**Necropsy Findings by Overseeing Veterinarian**
Barn swallow 1192	Development of neurologic signs on day 4	Euthanized on day 4	Pectoral muscle damage. White flocculent material in lungs. Death unlikely to be related to diet.
Northern mockingbird 1228	Decreasing weight, inability to process food, swallowing problems developed day 2 and continued past termination on day 3	Euthanized on day 4	No fat reserves. Coccidia oocysts found in intestinal mucosa. 3-5mm firm white areas throughout the liver parenchyma. Coccidiosis and hepatitis of probable bacterial or parasitic origin. Death unlikely to be related to diet.
Carolina wren 1364	Development of severe respiratory problems on day 14 likely due to aspiration	Recovered and survived to release	Not applicable

Table 4. Occurrences of Morbidity by Type.

Type of Morbidity	**Incidence in Control Group (FoNS©)**	**Incidence in Experimental Group (MNM)**
Avian poxvirus	3	1
Fractures	2	0
Parasites	3	4
Respiratory disease or difficulty	3	6
Hernia	1	0
Subcutaneous emphysema	0	1
Foot conformation	0	1 (corrected by splinting)
Splay leg	0	1 (corrected by hobbling)
Total Morbidities	**13**	**15**

study. Deaths and necropsy findings are outlined in Table 2. Necropsy findings for the control bird and two of the experimental birds concluded that cause of death was unlikely to be related to diet. The necropsy of the remaining experimental group bird, Northern mockingbird (*Mimus polyglottos)* #1226, was inconclusive. Diet was neither implicated nor ruled out as a contributor to death.

The control group had no birds removed from the study by a clinician due to health status, while the experimental group had three birds removed. Causes and outcomes of removal are summarized for each bird in Table 3. Barn swallow (*Hirundo rustico)* #1192 developed neurologic signs on day four in the study. The bird was removed from the study and euthanized the same day. Necropsy revealed massive damage to the right pectoral muscle and flocculent material in the lungs. The veterinarian determined cause of death to be unrelated to diet. Northern mockingbird #1228 presented with weight loss, difficulty swallowing, and an inability to process food on day two in the study. Problems continued into day three when the bird was removed from the study. No improvement was seen with additional supportive care, and the bird was euthanized on day four. Necropsy revealed hepatitis and coccidiosis. The veterinarian determined cause

of death to be unrelated to diet. Carolina wren #1364 was removed from the study on day fourteen due to severe respiratory disease likely resulting from aspiration of diet. The bird subsequently received specialized attention from clinic supervisors, recovered, and was eventually released.

Analysis of the percent weight gained per day for the control group yielded a mean of 4.57 (95% confidence interval [CI] for the mean of 2.850 to 6.310). The mean percent weight gain per day for the experimental group was 3.89 (95% CI, mean of 2.145 to 5.631). The p–value was calculated to be 0.58, indicating that the difference in the means was not statistically significant. The analysis was repeated with exclusion of birds that died within two days of admission (one bird in the control group and three in the experimental group). This exclusion yielded tighter means. The mean for the control group was 4.74 (95% CI of 3.005 to 6.482). The mean for the experimental group was 4.55 (95% CI of 2.745 through 6.364). The p–value for the second analysis was 0.88.

Analysis of the percent wing chord length gained per day for the control group yielded a mean of 8.03 (95% CI of 5.144 to 10.910). The mean for the experimental group was 10.7 (95% CI of 7.484 to 13.900). The resulting p–value was 0.22. The mean percentage of right outermost tail feather length gained per day for the control group was 84.0 (95% CI of 45.91 to 122.10). The mean for the experimental group was 117 (95% of 74.15 to 158.90). The p–value was 0.26. Based on these p–values, no statistically significant differences in the mean feather growth of the two populations were found.

*Figure 2. Increased yellow pigmentation of the gape flanges and oral mucosa of birds fed MNM compare to birds fed FoNS©. Top: Carolina wrens (*Thryothorus ludovicianus*) fed MNM gaping on the left and center with a FoNS© fed clutchmate gaping on the right. Bottom: Northern mockingbird (*Mimus polyglottos*) fed MNM in the upper left with a FoNS© fed clutchmate in the lower right.*

Researchers, clinic staff, and veterinarians found feather quality to be good and equivalent for birds fed FoNS© and MNM. One Northern mockingbird receiving FoNS© developed a stress bar across the tail feathers. One barn swallow receiving MNM developed a single stress spot, slightly wider than a stress bar, mid–shaft on left primary feather number ten. Both of these abnormalities may have resulted from stress incidents prior to admission to the study. No other feather problems or abnormalities were noted for either group.

Qualitative observations of fecal quality did not differ greatly between the groups. The feces of the birds fed MNM tended to be slightly more orange in color but of similar consistency to the feces of birds fed FoNS©. Instances of abnormal feces, constipation, and crop stasis occurred with similar frequency for each diet according to researcher observations during feedings. Researchers noted more vibrant yellow pigmentation of the gape flanges and oral mucosa of Carolina wrens, house wrens (*Troglodytes aedon*),

Mazuri® Nestling Meal Ingredients

Hydrolyzed soy protein concentrate, dried whole egg, spray dried cooked chicken, menhaden fishmeal, cornstarch, soybean oil, brewers dried yeast, DL–methionine, calcium carbonate, menadione dimethylpyrimidinol bisulfite (vitamin K), lecithin, xanthan gum, taurine, choline chloride, pyridoxine hydrochloride, l–ascorbyl–2–polyphosphate (vitamin C), dried aspergillus niger fermentation extract, irradiated dried yeast, dried enterococcus faecium fermentation product, dried lactobacillus acidophilus fermentation product, primilac (lactobacillus culture), biotin, mixed tocopherols, dl–alpha tocopheryl acetate, folic acid, glycine, manganese sulfate, thiamin mononitrate, calcium pantothenate, riboflavin, zinc sulfate, nicotinic acid, d–alpha tocopheryl acetate, tagetes.

Guaranteed Analysis

Crude protein not less than	45.0%
Crude fat not less than	22.0%
Crude fiber not more than	2.0%
Calcium not more than	1.4%
Phosphorus not more than	0.90%
Metabolizable Energy*, kcal/kg	3,750

* Metabolizable energy is determined based on data gathered in domesticated poultry.

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Eastern bluebirds (*Sialia sialis*), Northern mockingbirds, barn swallows, and American robins (*Turdus migratorius*) fed MNM when compared to clutchmates fed FoNS© (Figure 2).

[***Editor's Note:*** Because the black and white photographs in this publication do not show variations in the mouth color well, the color photographs that clearly show differences are posted on the NWRA website and may be accessed at: <http://www.nwrawildlife.org/photos/MazuriDietComparison.pdf>.]

The most common morbidity observed in the study was respiratory disease or difficulty, which affected six birds from the experimental group and three birds from the control group. The next most common morbidity was parasitic infection, which affected four MNM birds and three FoNS© birds. Pox occurred in three birds in the control group and one bird in the experimental group. Two birds fed FoNS© suffered fractures, and no fractures occurred in birds fed MNM while enrolled in the study. All other morbidities occurred in only a single bird (Table 4).

Post–study outcomes were tracked for all study graduates. Carolina wren #1367 of the control group suffered a humeral fracture three days after being discharged from the study and moved to an outside cage. The bird was subsequently euthanized. Carolina wren #1586 of the experimental group was found dead the morning following discharge from the study and the move to an outdoor cage. Brown–headed cowbird (*Molothrus ater*) #1328 of the experimental group had a calloused beak fracture on admission. The bird thrived and grew normally during the study, but mal–alignment of the bird's beak due to the old fracture led to euthanasia rather than release of the bird at the conclusion of the study period. All other study graduates survived to release.

Discussion

Based on the quantitative and qualitative data collected over the course of the study, the researchers concluded that Mazuri® Nestling Meal could serve as a commercial alternative to Formula for Nestling Songbirds©.

The higher numbers of mortalities and birds removed by clinician in the experimental group compared to the control group were initially worrisome. However, all mortalities in both groups occurred within two days of admission and two of three removals

by clinician in the MNM group occurred within four days. The early timing of these negative outcomes and the necropsy findings suggest conditions unrelated to diet to be the cause of death in all but one of these cases. Unfortunately, these conditions, which should have precluded these birds from inclusion in the study, likely were present but clinically unobservable at admission. Northern mockingbird #1226 was the only death for which diet could not be ruled out; however, diet also was not clearly implicated in this case. The difference in numbers of negative outcomes between the two groups may have been attributable to small sample size rather than concrete differences in the performance of the diets. It is the researchers' belief that with a larger sample size the numbers of negative outcomes would be similar between groups.

While the mean percent weight gain per day was slightly higher in the control group and the mean percentages of wing chord and tail feather growth per day were somewhat higher in the experimental group, the differences between the means were not statistically significant. It should be noted that small sample size decreased the power of the analyses, as it is often difficult to achieve statistical significance with small samples. Nonetheless, the closeness of the means for weight gain and feather growth between the two groups led researchers to conclude that MNM was equivalent to FoNS© in terms of ability to support healthy growth. The presence of healthy feathers and the lack of any major feather abnormalities in both groups allowed the researchers to conclude that the diets were also equivalent with regards to feather quality.

The observations of a more orange color to the feces and a more vibrant yellow pigmentation to the gape flanges and oral mucosa of birds in the experimental group were clinically insignificant. The scientists who created Mazuri Nestling Meal for PMI Nutrition® theorized that these pigmentations likely resulted from marigold extract in the diet. Marigold is a source of lutein that imparts yellow pigmentation in birds.

The incidence of morbidities was similar between the two groups. However, the morbidities that occurred most frequently differed based on diet. The higher occurrence of respiratory disease in the experimental population may have been due to the fact that the MNM was fed using syringes with widened tips. The slight increase in tip diameter may have led to administration of larger quantities of food at once or administration of diet too shallow in the mouth, resulting in a higher incidence of diet aspiration and subsequent respiratory issues. If this were the case, a study using the new formulation of MNM that can be fed through unaltered syringes would lead to a decrease in the occurrence of respiratory disease in birds fed the experimental diet.

Fractures occurred more frequently in birds fed FoNS© than those fed MNM. No fractures occurred in the experimental group from admission to release from the center. Two fractures occurred in the control group during the study period and one occurred during the post–study pre–release period. This data suggests, but does not prove, that MNM may be superior to FoNS© with regards to bone strength. The numbers are too small to easily distinguish the effects of dietary differences from chance.

In late July of the study period, the researchers decided, based on initial positive observations, that MNM was an acceptable diet for raising healthy nestling and fledgling songbirds. As a result, the entire non–study passerine baby bird population at TSBRR was fed MNM instead of FoNS© for the remainder of the season. American goldfinches (*Spinis tristis*) were fed a fifty–fifty mix of MNM and Zupreem® Embrace® Plus (Premium Nutritional Products, Inc., Mission, KS) instead of the fifty–fifty mix of FoNS© and Exact® (Kaytee Products, Inc, Chilton, WI) normally fed to this species at TSBRR. During this time, many of the birds were fed a revised version of MNM that easily passed though standard syringe tips. The new formulation was the same as that used for the study birds except all the ingredients were ground more finely, and the original poultry meal was substituted with a more finely ground version. No significant diet related health issues occurred in the non–study baby bird population switched to MNM diet. Staffers reported an increased incidence of fecal abnormalities following the switch, but these observations were complicated by the high prevalence of parasitic infection in the baby bird population at the center during this period. Within the randomized study population, there were similar incidences of fecal abnormality in the MNM experimental group and the FoNS© control group.

Concerns have been raised by some rehabilitators that the MNM product is a soy–based diet (see sidebar listing ingredients). The article *On the Use of Soy Protein in Diets for Juvenile Birds* by Drs. Duerr and Klasing (page 24) addresses this concern and provides an explanation of protein metabolism in young songbirds. In the course of this study, the authors saw no problems associated with use of the diet, and believe that the hydrolyzed protein as used in the MNM product provides an excellent, affordable source of protein.

The quantitative and qualitative observations made by this split clutch study led the researchers to conclude that Mazuri® Nestling Meal would be an acceptable alternative to FoNS© for nestling and fledgling passerines. Furthermore, the MNM product would simplify the diet preparation process for rehabilitators if produced commercially as the finely ground, revised form.

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