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Foraging opportunity and increased physical complexity both prevent and reduce psychogenic feather picking by young Amazon parrots

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Abstract

Although many authors have suggested that the quality of the cage environment contributes to the development and performance of psychogenic feather picking by parrots, there is little scientific evidence for this relationship. In chickens, there is an established relationship between absence of foraging opportunity and the performance of a similar behavior, feather pecking. Thus, we assessed whether providing environmental enrichments designed to facilitate foraging behaviors would prevent or reduce the development of feather picking behavior by parrots, as evidenced by superior feather condition. Two groups of eight parrots were parent-reared to weaning and then housed singly in either enriched or unenriched cages for 48 weeks. In the enriched condition, a unique combination of one foraging and one physical enrichment was presented to each parrot weekly. In both groups, feather condition was quantified using a 10-point scale. The provision of enrichments led to an improvement in feather condition over 48 weeks in the enriched group, while feather scores in the control group decreased significantly (repeated measures GLM: $F_{1,46} = 5.59$; $P = 0.022$) during this same period, indicating that feather picking behavior had developed in this group. In the second part of this study, the control group was transferred to the enriched treatment for a period of 16 weeks. During this period re-feathering occurred and feather scores improved significantly, indicating that feather picking behavior had decreased (repeated measures GLM: $F_{1,53} = 35.57$, $P < 0.0005$). In conclusion, our results show that enriching the environment by providing appropriate foraging substrates and increasing physical complexity can significantly modify both the development and the performance of feather picking behavior by parrots. Possible mechanisms are discussed.

Keywords: Environmental enrichment; Parrots; Psittacine; Foraging behavior; Feather picking; Feather pecking

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1. Introduction

It has been estimated that 1 in 10 captive parrots perform self-directed psychogenic feather picking behavior (Grindlinger, 1991). Psychogenic feather picking behavior develops or persists in the absence of medical causes, and observational evidence suggests that it may be associated with a number of management factors such as inadequate diet, social isolation, and lack of environmental stimulation (e.g. Mertens, 1997). Feather picking resembles an exaggerated form of preening in which the feathers are chewed and/or removed rather than simply groomed. In some cases, feather picking can lead to medical problems such as skin and tissue damage, hypothermia, infection or hemorrhage. Thus, psychogenic feather picking can be considered to be a sign of compromised welfare due to the physical problems it may cause as well as the psychological distress it may reflect.

Although there have been few systematic studies of feather picking behavior in psittacines, there has been a significant amount of research on feather pecking, a similar behavior commonly performed by domestic fowl (Mench and Keeling, 2001). In chickens feather pecking is generally directed at other birds, while in parrots picking is generally self-directed, but this difference may simply reflect differences in management. Chickens are generally socially housed, while parrots are often caged alone. When parrots are housed in social groups, feather picking can also be directed at cage-mates or nestlings.

Feather pecking by chickens is strongly associated with the performance of foraging behavior (e.g. Nicol et al., 2001; Klein et al., 2000; Huber-Eicher and Wechsler, 1997, 1998; Blokhuis, 1986). In chickens, normal foraging behavior consists of pecks directed at both edible and inedible substrates (Blokhuis, 1986), but if chickens are housed such that ground pecking is prevented, then pecks may instead be directed at the feathers of conspecifics (Blokhuis, 1986; Huber-Eicher and Wechsler, 1997). Provision of non-nutritive foraging material such as long straw and polystyrene blocks is effective in both preventing and reducing feather pecking behavior by chicks (Huber-Eicher and Wechsler, 1997). In addition, hens provided with foraging material show significantly lower rates of feather pecking than those kept without foraging material (Wechsler and Huber-Eicher, 1997). Thus, feather pecking is considered by many to be re-directed foraging behavior (e.g. Hoffmeyer, 1969; Blokhuis, 1989; Huber-Eicher and Wechsler, 1997, Wechsler and Huber-Eicher, 1997). The degree to which individual chickens feather peck, however, is influenced by genetic background, environmental circumstances, and the bird's physiological state with respect to stress (Hughes, 1982; Savory, 1995; El-lethey et al., 2000, 2001; Kjaer and Mench, in press). These factors may influence both the performance and development of feather pecking. Nevertheless, there is general consensus that lack of appropriate foraging opportunity is a major contributor to feather pecking behavior by chickens.

Given the putative role of foraging behavior in the development of feather pecking by chickens, it is possible that a similar relationship exists between foraging behavior and feather picking in parrots. We examined the relationship between the captive environment and feather picking in parrots by assessing the effect of foraging opportunity and increased physical complexity on feather picking behavior.

Foraging is one of the most severely constrained classes of behavior in captive parrots. In the wild, Puerto Rican Amazons (*Amazona vittata*) spend approximately 4–6 h per day foraging (Snyder et al., 1987). Birds regularly travel several miles between feeding sites, and once they arrive engage in a rich suite of local search, food selection, and food manipulation behaviors (Snyder et al., 1987). In contrast, most parrots in captivity do not travel between feeding sites, do not have to select different foods to balance their diet, and have little opportunity to manipulate objects to obtain food. Thus, captive Orange-winged Amazon parrots (*Amazona amazonica*) spend only 30–72 min a day in feeding behaviors when fed a pelleted diet (Oviatt and Millam, 1997). Many captive feeding methods allow minimal environmental interaction and greatly reduce the amount of work and energetic cost involved in feeding activities. Because of the importance of these behaviors in the repertoire of wild parrots, it is possible that parrots, like chickens (Blokhuis, 1986), are highly motivated to search for, access, and process food items.

If wild parrots are highly motivated to perform foraging behaviors, captive parrots are also likely to be highly motivated to perform these behaviors. This is the case because even though parrots are kept in a wide variety of captive situations, they cannot be considered to be domesticated animals. Domestication is a process of adaptation to the captive environment that includes both genetic changes occurring over generations and environmentally induced developmental events (such as taming) that occur within the lifetime of an individual (Price, 1984). The process of domestication affects behavioral development such that, in most cases, the capacity to perform the behaviors seen in the repertoire of wild counterparts remains, although the threshold for performance may be altered (Price, 1999). Since many of the parrots currently kept in captivity are either wild caught or belong to one of the first few generations of captive-born individuals, parrots can be considered to be in the early stages of the domestication process. It is therefore likely that captive parrots share both the behavioral capacities and the response thresholds of their wild counterparts. In terms of foraging behavior, this may mean that captive parrots are highly motivated to perform the behaviors associated with food procurement in the wild and that this motivation may persist despite the fact that captive feeding methods meet their nutritional needs. There is some evidence for contra-freeloading in captive parrots, indicating that they prefer to perform some amount of work for food even when “free” food is available (Coulton et al., 1997). The act of foraging may therefore be considered a behavioral need for parrots, and the absence of foraging opportunity may result in frustration and redirection of foraging-like activities toward the feathers.

In the current study, which was one component of a larger study examining the relationship between environmental complexity and behavioral development in parrots, we provided enrichments designed to facilitate foraging behaviors along with physical enrichments designed to increase the complexity of the cage to one group of young parrots while housing a second group without these enrichments. Our hypothesis was that parrots in the enriched condition would develop significantly less feather picking behavior, as evidenced by superior feather condition, relative to parrots in the unenriched cages. To our knowledge, this is the first experiment to follow the development of feather picking behavior in parrots and relate this development to environmental conditions. In the second part of the study we provided similar enrichments to the parrots that were formerly in the unenriched condition to test the hypothesis that feather picking behavior could be reduced by enrichment. The only other published study of the effects of enrichment on reduction of feather picking in psittacines is a study of crimson-bellied conures, in which it was found that provision of enrichments resulted in stabilization, but not improvement, of feather condition (van Hoek and King, 1997). However, this study was conducted with parrots from three different zoos, so all environmental elements could not be controlled. Thus, our study was the first to systematically evaluate the role of the environment in both the development and the reduction of feather picking behavior in parrots.

2. Methods

2.1. Subjects and caging

Subjects were 16 (7M, 9F) Orange-winged Amazon parrots (*A. amazonica*) hatched in the animal colony at the University of California, Davis, from wild-caught pairs imported from Guyana in 1987. All subjects were parent-raised to weaning (18 weeks) in 2 m × 1 m × 2 m suspended welded wire cages. At 18 weeks of age, the parrots were moved to individual cages in another room. Individual housing was necessary in order to avoid confounding physical and foraging enrichment with social enrichment. All cages measured 0.75 m × 0.75 m × 1 m and were suspended 1 m above the ground. Each cage contained one wooden perch at a height of 1.75 m above the ground, a metal ‘‘L’’ shaped feeder, and a nipple drinker. Water and pellets (Roudybush low-fat maintenance pellets, Roudybush Inc. Sacramento, CA) were available ad libitum. Other food items (fruits, vegetables, seeds and nuts) were presented daily in limited quantities. Parrots in both treatment groups received the same amounts of these additional food items; only the manner of presentation differed, since enriched birds received the items in their foraging enrichment devices (see Section 2.2). Lights went on at 08:00 and off at 19:00, but there was a window that allowed in some natural light, creating seasonal dawn and dusk periods.

We created treatment groups by dividing the parrots into two groups of eight, balanced for sex and parentage. Each group was then randomly assigned to either the control or the enriched condition. The control group had four males and four females and the enriched group had three males and five females. The control and the enriched cages were spaced in the room so as to control for position effects. Visual barriers were installed between cages so that each parrot only had visual contact with the parrot in the adjacent cage; adjacent cages were assigned to the same treatment. Vocal contact was possible between all birds in the room. After 2 days of habituation to the new surroundings the enrichment protocol was implemented in the enriched cages.

2.2. Enrichment protocol and observations

Two categories of enrichments were used: physical and foraging. Examples of the enrichments used are given in Table 1. Physical enrichments were chosen to increase the physical complexity of the cage. They provided alternate perching sites, climbing or swinging opportunities, or movable objects that could be manipulated with the beak and/or feet. Foraging enrichments were chosen to provide an opportunity for the parrots to perform some amount of work in order to retrieve foods such as seeds, fruits, vegetables and nuts. These enrichments required that the parrots chew through barriers, manipulate objects through holes, sort through inedible material, or open containers to obtain food items.

Table 1
Descriptions of some of the enrichment items used in the experiment

Enrichment item	Description
Foraging enrichments (all filled with both edible and inedible items)	
T-shirt bags[a]	Sack of cotton cloth hung on a rope from the top of the cage
Fruit cage[b]	Cylindrical metal cage (height 15 cm, diameter 7 cm) hung with a chain from the top of the cage
Toy box	Plastic cube (25 cm^3) with holes and doors of various sizes and shapes hung from the top of the cage
Treat basket	Enclosed woven basket hung from the top of the cage
Physical enrichments	
Boing[b]	2.5 cm diameter cotton rope wound around a spiral spring (0.75 m long) hung from the top of the cage
Diamonds[b]	Two plastic diamonds (0.5 m long) connected end to end and hung from the top of the cage
Spring[b]	Flexible plastic coil (0.75 m long) connected horizontally to opposite ends of the cage
Bridge[b]	Swinging ladder (0.75 m long) made of wood and rope connected horizontally to opposite ends of the cage

[a] Bird Brain Toys.
[b] Birds and Branches.

Foraging enrichments were refilled daily at 09:00. Twenty-four different enrichments (12 foraging and 12 physical) were used over the course of the entire study and 8 different enrichments (4 foraging, 4 physical) were chosen for each of the three 16-week periods. All parrots in the enriched condition received one foraging and one physical enrichment in one of 16 possible combinations each week for 16 weeks. The order in which the combinations were presented was balanced using a Latin square design. We controlled for the time that the caretaker had contact with the parrots while enrichments were rearranged and refilled by spending an equal amount of time refilling feed cups in the control birds' cages.

To avoid observer effects on behavior, we conducted all observations via videotape. To monitor enrichment use, birds in the enriched condition were observed three times weekly. To account for changes in enrichment use relative to the length of time since the foraging enrichments had been re-filled, observations were scheduled at 09:30 and 12:00 h (either 30 min or 3 h after the foraging enrichments were refilled). Each observation lasted 20 min during which time all occurrences of physical contact, excluding incidental contact, with enrichments were recorded using Hewlett-Packard HP 48 G+ graphing calculators programmed for data collection. We calculated the mean percentage of active time (time not sleeping or resting) each parrot spent interacting with each category of enrichments during each 16-week period.

2.3. Veterinary exams

We consulted an avian veterinarian to rule out possible medical causes for feather picking behavior such as dermatitis, parasites, or infection. Physical exams were conducted monthly, and blood work (CBC and chemistry panel) and bacteriological assessment (of choanal swab samples) were completed prior to and immediately after the study. No evidence for a medical cause of feather picking was detected in any of our subjects. We did not test for psittacine beak and feather disease (PBFD) because the birds were part of a biosecure closed flock with no history of PBFD.

2.4. Plumage scoring

Based on experience with other parrots in our colony we knew that feather picking was difficult to evaluate behaviorally. In a pilot study we collected hundreds of hours of videotape of parrots in an attempt to observe feather picking behavior. Episodes of feather picking were rarely seen on videotape and the amount of feather picking we did tape was not representative of the feather damage we observed. Because we often found evidence (feathers beneath the cages) of feather picking in the mornings we believe that feather picking may have occurred almost exclusively in the dark hours.

Since the parrots were housed singly in relatively large cages, cage abrasion was probably only responsible for minor fraying of tail and wing feathers. Additional damage to feathers and feather removal was therefore likely to have been self-inflicted. Thus, we used plumage condition as an indirect measurement of feather picking behavior. We developed a 10-point scoring system to quantify plumage condition (Table 2). This system involved scoring the feather condition on five separate body areas (chest/flank, back, legs, tail and wings) and then combining these sub-scores for an overall score. Similar scoring systems have been used for chickens (e.g. Tauson et al., 1984), but to our knowledge ours is the first such system developed specifically for parrots. We developed this scoring system by surveying our research colony of Orange-winged Amazons ($n = 76$) and determining the prevalent patterns of feather loss and damage. In the current study, two blind, independent scorers evaluated each parrot monthly. Inter-rater reliability was assessed using Pearson product moment correlation coefficients after each feather-scoring session.

2.5. Enrichment of the control group

After three 16-week periods the parrots from the enriched group were removed from the study and the control group began receiving enrichments. The enrichment protocol described earlier was repeated and plumage scoring continued with this group of parrots. This phase of the study lasted for 16 weeks.

2.6. Statistical methods

The plumage score data were analyzed using repeated measures GLM. The assumptions of parametric methods (normality of error, homogeneity of variance and linearity) were confirmed from plots of coefficients versus fitted values and suitable transformations were applied where required. All analyses were performed using MiniTab (2000) software. The probability level accepted for significance was $P < 0.05$.

For the comparison of feather scores between parrots in the control and enriched groups over the first three 16-week periods of the study, both feather score and time data were log transformed to preserve homogeneity of variance. Log transformations were also used on feather score and time data for the analysis of trends in feather score before and after enrichment of the control group.

Table 2
Feather-scoring system

Score	Description
(a) Scoring system used for chest/flank, back and legs	
0	All or most feathers removed, down removed and skin exposed, evidence of skin or tissue injury
0.25	All or most feathers removed, down removed and skin exposed, no evidence of skin or tissue injury
0.5	All or most feathers removed, some down removed, patches of skin exposed
0.75	All or most feathers removed, down exposed and intact or feathers removed from more than half of the area, some down removed, patches of skin exposed
1.0	Feathers removed from less than half of the area, some down removed and skin exposed
1.25	Feathers removed from more than half of the area, down exposed and intact
1.5	Feathers removed from less than half of the area, down exposed and intact
1.75	Feathers intact with fraying or breakage
2.0	Feathers intact with little or no fraying or breakage
(b) Scoring system used for wings	
0	All or most primaries, secondaries and coverts removed, down removed, skin exposed, evidence of skin or tissue injury
0.5	All or most primaries, secondaries and coverts removed, down removed, skin exposed, no evidence of injury
1.0	More than half of coverts removed, down exposed and intact or more than half of primaries and secondaries removed, down exposed and intact
1.5	Fewer than half of coverts removed, down exposed and intact or fewer than half of primaries and secondaries removed, down exposed and intact or primaries and secondaries intact with significant breakage and fraying
2.0	Feathers intact with little or no fraying or breakage
(c) Scoring system used for tail	
0	All or most tail feathers removed or broken
1	Some tail feathers removed or broken or significant fraying of tail feathers
2	Feathers intact with little or no fraying or breakage

To compare trends in feather score over time in the two treatment groups we constructed a model that tested the main effects of individual (nested within sex and treatment), sex, treatment, and time as well as the interactions of sex $\times$ treatment and treatment $\times$ time. Time was a covariate in the model.

To compare the change in feather score of the control group over time during the first 48 weeks (unenriched) and the last 16 weeks (enriched) of the study, time was re-encoded as number of weeks the parrot had been exposed to each treatment (weeks-in-treatment) to allow us to compare the slopes in a repeated measures GLM. The model tested the main effects of individual (nested within sex and treatment), sex, treatment (unenriched or enriched) and weeks-in-treatment as well as the interactions of sex $\times$ treatment and treatment $\times$ weeks-in-treatment. A significant treatment $\times$ weeks-in-treatment interaction would indicate that the rates of change in feather score (slopes) were different in the two treatments. A post hoc *t*-test was used to compare the slopes in absolute terms. Because of a slight ceiling effect in these data that could not be resolved, a binomial test was used as a secondary analysis to confirm the results of the GLM. In this analysis, the number of parrots that maintained or showed improvement in feather score during the unenriched period was used as the background probability. We then counted the number of parrots that improved their feather score during the enriched period and calculated the probability of this occurring given the background probability of maintenance or improvement in the unenriched condition.

3. Results

3.1. Response to enrichment

All parrots in the enriched group interacted with all the enrichments. They would usually approach the objects 1–20 min after presentation, and then proceed to investigate them with their beaks and feet. The physical enrichments elicited balancing, swinging and climbing behaviors, while the foraging enrichments elicited chewing, object manipulation, sorting inedible material and food selection behaviors. The physical enrichments were often used to access the foraging enrichments.

Use of both enrichment types remained stable during the first two 16-week periods and declined during the third 16-week period (repeated measures GLM: $F_{2,35} = 7.56$; $P = 0.002$; Fig. 1). In all periods, foraging enrichments were used more than physical enrichments (repeated measures GLM: $F_{1,35} = 44.34$; $P < 0.0005$; Fig. 1).

3.2. Inter-rater reliability of feather scoring

Inter-rater reliability was maintained at 0.76 or above, which exceeds the threshold for statistical significance ($P = 0.05$) at both sample sizes ($N = 16$ in weeks 4–48; $N = 8$ in weeks 48–64).

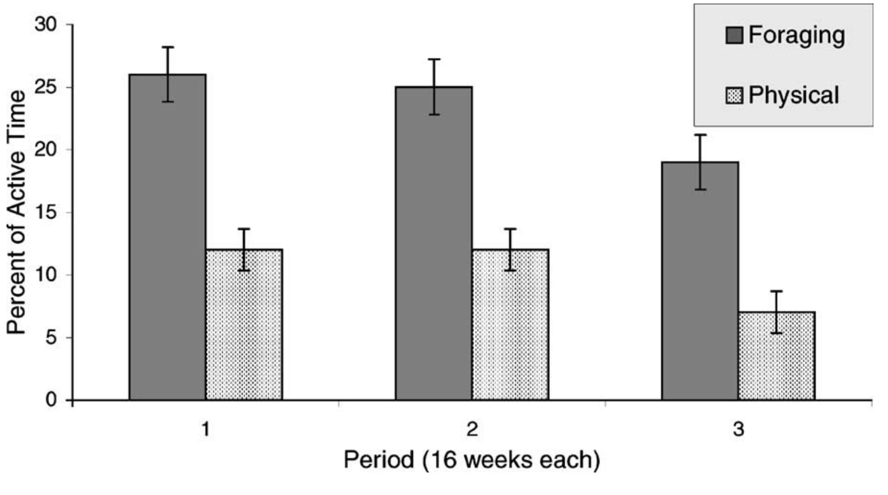

Fig. 1. Mean (±S.E.) enrichment use during the three 16-week enrichment periods. In all periods, foraging enrichments were used significantly ($P < 0.0005$) more than physical enrichments.

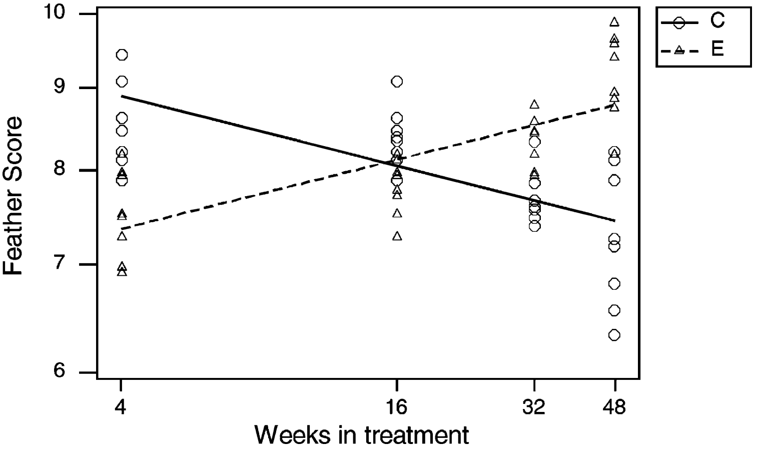

Fig. 2. Residual plots of feather score in the control (C) and enriched (E) groups over the 48 weeks of the study. Data are presented on log-transformed axes. Feather condition improved with time in the enriched group but worsened in the control group. The difference between these slopes was significant at $P < 0.0005$.

3.3. Comparisons of feather score in the control and enriched groups

At the start of the study, the mean feather scores of the enriched and control groups were 8.56 and 8.87 points, respectively. The feather damage seen at the beginning of the study may have been due to either self-picking or parental picking. Feather score changed significantly over time in both groups but the direction of the change was different. The enriched birds improved with time, while the control birds worsened. Thus, in the enriched group, the least-squares mean feather score improved from weeks 4 to 48 by 1.41 points, whereas in the control group the LSM score decreased by 1.45 points during this same time period. The slopes of these lines were significantly different (repeated measures GLM: treatment × weeks-in-treatment $F_{1,46} = 48.62$; $P < 0.0005$; Fig. 2).

3.4. Enrichment of the control group

All parrots in the original control group began interacting with the enrichments within 2 days of introduction. Although some parrots avoided the enrichments for the first several hours, by the day 2 interactions with the physical enrichments were prolonged and vigorous and by the following day most of the parrots had figured out how to successfully utilize the foraging enrichments. Use of foraging enrichments remained relatively stable across the 16 weeks, while use of physical enrichments declined with time. In all periods, foraging enrichments were used significantly more than physical enrichments (repeated measures GLM: $F_{1,49} = 12.87$, $P = 0.001$; Fig. 3).

3.5. Change in feather score after enrichment

Although feather condition was not scored until 1 month after introduction of enrichments, we first observed re-feathering after only 2 weeks. Feather scores improved

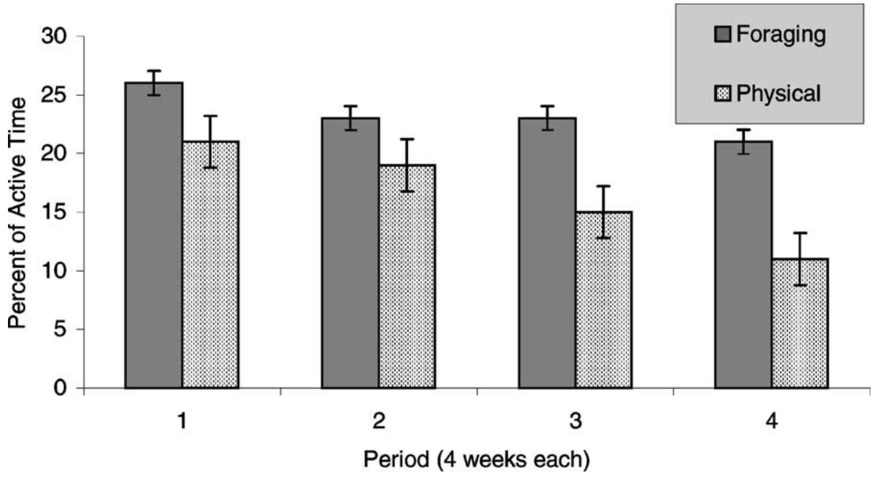

Fig. 3. Mean (±S.E.) enrichment use by the original control group during four 4-week enrichment periods. In all periods, foraging enrichments were used significantly ($P = 0.001$) more than physical enrichments.

significantly as a result of enrichment (repeated measures GLM: $F_{1,53} = 35.57$, $P < 0.0005$; Fig. 4). During the unenriched period, two of the eight parrots maintained their feather score while the other six had a decrease in feather score. Six of the eight parrots showed an improvement in feather score during the enriched period. The probability of six or more parrots maintaining or improving during the enriched period, given that two maintained their scores during the control period, was 0.00423 (Binomial test),

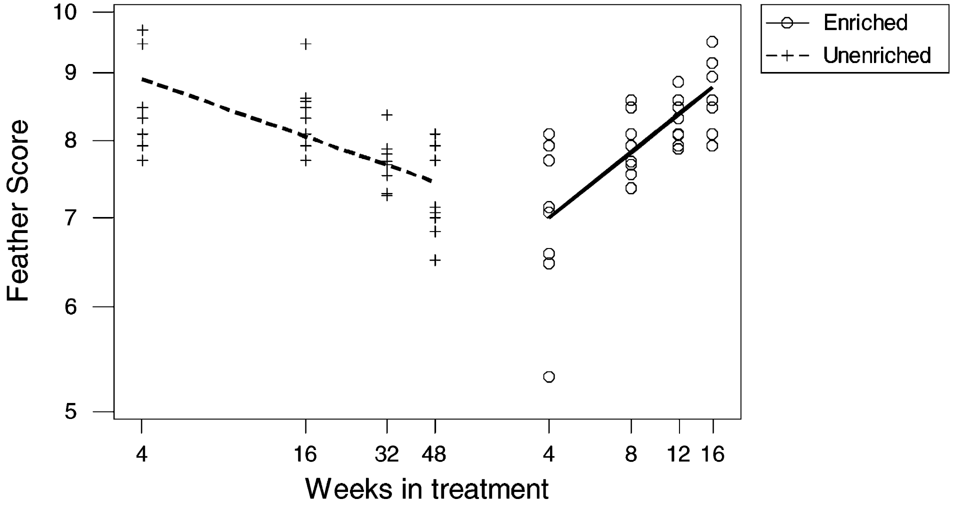

Fig. 4. Residual plots of feather score of the control group during the unenriched (U) and enriched (E) periods. Data are presented on log-transformed axes. Feather condition worsened in the control group during the unenriched period, but improved significantly ($P < 0.0005$) during the enriched period.

thus confirming the results of the GLM. The rate of change in feather score was significantly different between periods both with respect to direction of change (repeated measures GLM: $F_{1,53} = 48.08$, $P < 0.0005$) and absolute value of change (paired *t*-test: $t_{53} = 4.39$, $P < 0.0005$). Thus, feather score improved during the enriched period at a rate faster than the rate of decline during the unenriched period.

4. Discussion

Psychogenic feather picking is one of the most challenging behavioral problems common to captive parrots. Although it has been repeatedly suggested that the environment plays a role in the development and performance of this behavior (e.g. Ryan, 1985; Davis, 1991; King, 1993; Mertens, 1997; van Hoek and King, 1997), ours represents the first systematic study of this relationship. As predicted, enrichments designed to facilitate foraging behaviors and increase the physical complexity of the cage successfully prevented deterioration in feather condition over the course of 48 weeks and significantly improved feather condition over the course of 16 weeks. Since we introduced foraging and physical enrichments together, rather than separately, it is difficult to tell the relative importance of each type of enrichment from our study. It is possible that the combination of physical and foraging enrichments is necessary for the preventative and reversal effects on feather picking we observed. However, since the foraging enrichments were used for significantly greater periods of time than the physical enrichments, our data certainly demonstrate a link between foraging opportunity and the development and performance of feather picking in parrots.

In this sense, our data are in agreement with the findings of Huber-Eicher and Wechsler (1997), who found that foraging opportunity significantly reduced the development of feather pecking by chickens. In their study, chicks that had access to straw as a foraging substrate from an early age did not develop high rates of feather pecking. In addition, the quality and availability of foraging material influences the development of feather pecking in chickens (Huber-Eicher and Wechsler, 1998). Thus, the longer foraging materials are available and the more foraging behavior they stimulate, the more effective they are in reducing feather pecking development. In our study, parrots in the enriched condition worked for access to supplemental food items an average of 19–26% of active time and in the process used behavioral skills such as chewing, sorting, and manipulating objects. By contrast, parrots in the control condition had no access to these materials during the unenriched period and could not perform these behaviors. As a result, they may have redirected foraging attempts toward their own plumage. Thus, the quality and availability of the enrichments we used likely contributed to their effectiveness in modifying feather picking behavior.

While foraging opportunity clearly plays an important role in the development and performance of feather picking in parrots, as with chickens it is likely that additional factors also play a role. In parrots, one possible contributing factor is neurological development. Although it was beyond the scope of this study to directly address this link, it is possible that the difference in behavioral opportunity between the control and the enriched environments may have caused dissimilar brain development in the two groups, contributing to the development of feather picking in the control group. Feather picking has been likened to the human mental disorders obsessive–compulsive disorder (OCD) (Grindlinger and Ramsay, 1994) and tricotillomania (Bordnick et al., 1994; Stein and Dodman, 1994). In humans, the performance of OCDs is related to dysfunction in the brain areas responsible for the selection and sequencing of behavior (Norman and Shallice, 1986; Turner, 1997). Given the similarities in performance, and the fact that the avian brain possesses analogous, if not homologous, structures to those implicated in the performance of human OCD (Reiner et al., 1998), it has been suggested that a similar neural disorder may underlie feather picking in parrots (Grindlinger and Ramsay, 1994). If this is the case, then the wider range of behavioral opportunities presented to the enriched birds, through engendering a more flexible behavioral repertoire, may have in some way protected the enriched parrots from the pathological changes in behavior sequencing mechanisms that underlie feather picking. Additional data, including evidence for neural dysfunction in feather picking parrots as well as a relationship between behavioral diversity and the development of this dysfunction, is needed before this explanation can be confirmed. However, the link between feather picking and compromised neural development is supported by results from recent research we conducted on stereotypic behaviors. In these experiments, we found a strong relationship between lack of behavioral opportunity and the development of stereotypic behaviors in parrots (Meehan et al., submitted) as well as evidence for underlying neural compromise correlated with stereotypy (Garner et al., submitted). We are not suggesting that the neural mechanisms involved in the stereotypy and feather picking are identical, or that the behaviors are equivalent. However, this evidence does suggest that environmentally induced neural dysfunction may underlie certain forms of abnormal repeated behavior, including feather picking.

Attempts to reverse feather picking behavior in parrots have had varying degrees of success (e.g. Iglauer and Rasim, 1993, Grindlinger and Ramsay, 1994; Mertens, 1997; van Hoek and King, 1997). In the present study, re-feathering occurred soon after enrichment of the control parrots began, and continued at a rate greater than that at which damage had occurred over the previous 48 weeks. In order for improvements in feather quality to happen this rapidly, a dramatic and nearly immediate decrease in feather picking behavior must have taken place. In chickens, provision of straw to chicks that had developed high rates of feather pecking led to a decrease in this behavior (Huber-Eicher and Wechsler, 1997). In addition, foraging behavior was inversely related to the rate of feather pecking, indicating that foraging material may have caused the chicks to abandon feather pecking in favor of foraging behaviors (Huber-Eicher and Wechsler, 1997). Our study provides indirect evidence for a similar relationship between foraging behavior and feather picking, since feather quality improved rapidly after foraging enrichments were available. Although we did not quantify feather picking behaviors directly, it is possible that a switch from feather picking to foraging behavior could have occurred rapidly, since the parrots used foraging enrichments within 3 days of introduction. However, we cannot determine if the switch might be due to behavioral competition (i.e. less time spent feather picking because more time is spent interacting with the enrichments), or because a specific behavioral need (i.e. the need to perform foraging behaviors) was satisfied by the enrichments and therefore was no longer re-directed towards the feathers.

Finally, the rapid change in feather condition we observed could potentially have been influenced by changes in underlying neural systems, provided that these systems are flexible and that damage incurred during deprivation was not permanent. Treatment of birds that feather pick with psychoactive drugs such as fluoxetine, clomipramine and haloperidol can result in a rapid (2 weeks to 1 month) improvement in feather quality (Mertens, 1997; Grindlinger and Ramsay, 1994; Iglauer and Rasim, 1993) indicating that neurobiological changes may occur quickly. However, improvements with drug treatment are transient (e.g. Mertens, 1997), require continuous use for sustained effects (e.g. Iglauer and Rasim, 1993), and may be associated with side effects such as drowsiness, regurgitation, ataxia, temporary hyperactivity, lethargy, frequent sneezing, and vocabulary loss (Iglauer and Rasim, 1993; Grindlinger and Ramsay, 1994; Mertens, 1997). Thus, if there is a neural disorder associated with feather picking, treatment with environmental enrichment, which in our study resulted in sustained, significant improvement of feather score, appears to be preferable to treatment with psychoactive drugs. It is important to note that although the parrots in our study were young, they had been performing feather picking for up to 11 months prior to enrichment. Thus, while the efficacy of enrichment in reducing feather picking behavior may have been greater because of the age of the parrots in our study, we have nevertheless shown that even well-established feather picking is sensitive to changes in the environment.

This study demonstrates that the cage environment plays an important role in the development of feather picking and may contribute to many cases of this behavior. More specifically, it appears that provision of enrichments that allow the parrots to utilize foraging skills to access food may fulfill a behavioral need to forage, and thus reduce the probability that foraging attempts will be re-directed at the plumage. In addition, it is possible that enrichment contributes to the prevention of feather picking by eliciting a diverse behavioral repertoire and supporting normal neural development. Based on the results of this study as well as others that demonstrate a reduction of stereotypy and fearfulness as a result of these enrichment techniques (Meehan et al., submitted; Meehan and Mench, 2002), we strongly recommend that all populations of captive parrots be provided with a varied enrichment protocol designed to elicit foraging behaviors and environmental interaction.

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References

Blokhuis, H.J., 1986. Feather pecking in poultry: its relation with ground pecking. Appl. Anim. Behav. Sci. 16, 63–67.

Blokhuis, H.J., 1989. The Development and Causation of Feather Pecking in the Domestic Fowl. Ph.D. Thesis, Agricultural University, Wageningen, The Netherlands.

Bordnick, P.S., Thayer, B.A., Ritchie, W., 1994. Feather picking disorder and trichotollomania: an avian model of human psychopathology. J. Behav. Ther. Exp. Psychiatry 25, 189–196.

Coulton, L.E., Warran, N.K., Young, R.J., 1997. Effects of foraging enrichment on the behavior of parrots. Anim. Welfare 6, 357–363.

Davis, C.S., 1991. Parrot psychology and behavior problems. Veterinary Clin. North Am. Small Anim. Pract. 21, 1281–1288.

El-lethey, H., Aerni, V., Jungi, T.W., Wechsler, B., 2000. Stress and feather pecking in laying hens in relation to housing conditions. Br. Poult. Sci. 41, 22–28.

El-lethey, H., Jungi, T.W., Huber-Eicher, B., 2001. Effects of feeding corticosterone and housing conditions on feather pecking in laying hens (*Gallus gallus domesticus*). Physiol. Behav. 73, 243–251.

Garner, J.P., Meehan, C.L., Mench, J.A., submitted. Cage-induced stereotypy in parrots and brain dysfunction: parallels to schizophrenia and autism.

Grindlinger, H., 1991. Compulsive feather picking in birds. Arch. Gen. Psychiatry 48, 857.

Grindlinger, H., Ramsay, E.C., 1994. Use of clomipramine in the treatment of obsessive compulsive behavior in psittacine birds. J. Assoc. Avian Veterinarians 8, 9–15.

Hoffmeyer, I., 1969. Feather pecking in pheasants: an ethological approach to the problem. Dan. Rev. Game Biol. 6, 1–36.

Huber-Eicher, B., Wechsler, B., 1997. Feather pecking in domestic chicks: its relation to dustbathing and foraging. Anim. Behav. 54, 757–768.

Huber-Eicher, B., Wechsler, B., 1998. The effect of quality and availability of foraging materials on feather pecking in laying hen chicks. Anim. Behav. 55, 861–873.

Hughes, B.O., 1982. Feather pecking and cannibalism in domestic fowls. In: Bessei, W. (Ed.), Disturbed Behavior in Farm Animals, Verlag Eugen Ulmer, Stuttgart, pp. 138–146.

Iglauer, F., Rasim, R., 1993. Treatment of psychogenic feather picking in psittacine birds with a dopamine antagonist. J. Small Anim. Pract. 34, 564–566.

King, C.E., 1993. Environmental enrichment: is it for the birds? Zoo Biol. 12, 509–512.

Kjaer, J.B., Mench, J.A., in press, Behavioral problems associated with selection for increased production. In: Muir, W., Aggrey, S. (Eds.), Poultry Breeding and Biotechnology. CAB International, Wallingford, Oxon, UK.

Klein, T., Zeltner, E., Huber-Eicher, B., 2000. Are genetic differences in foraging behavior of laying hen chicks paralleled by hybrid-specific differences in feather pecking? Appl. Anim. Behav. Sci. 70, 143–155.

Meehan, C.L., Mench, J.A., 2002. Environmental enrichment affects the fear and exploratory responses to novelty of young Amazon parrots. Appl. Anim. Behav. Sci. 79, 75–88.

Meehan, C.L., Garner, J.P., Mench, J.A., submitted. The effects of environmental enrichment on cage stereotypy in Orange-winged Amazon parrots (*Amazona amazonica)*: insights into developmental processes.

Mench, J.A., Keeling, L.J., 2001. The social behavior of domestic birds. In: Keeling, L.J., Gonyou, H.W. (Eds.), Social Behavior in Farm Animals. CAB International, Wallingford, Oxon, UK, pp. 177–211.

Mertens, P.A., 1997. Pharmacological treatment of feather picking in pet birds. In: Mills, D.S., Heath, S.E. (Eds.), Proceedings of the First International Conference on Veterinary Behavioral Medicine, UFAW, Potters Bar, UK, pp. 209–213.

Nicol, C.J., Lindberg, A.C., Phillips, A.J., Pope, S.J., Wilkins, L.J., Green, L.E., 2001. Influence of prior exposure to wood shavings on feather pecking, dustbathing and foraging in adult laying hens. Appl. Anim. Behav. Sci. 73, 141–155.

Norman, D.A., Shallice, T., 1986. Attention to action: willed and automatic control of behavior. In: Davidson, R.J., Schwartz, G.E., Shapiro, D. (Eds.), Consciousness and Self-Regulation: Advances in Research and Theory. Plenum Press, New York, USA, pp. 1–18.

Oviatt, L.A., Millam, J.R., 1997. Breeding behavior of captive Orange-winged Amazon parrots. Exotic Bird Rep. 9, 6–7.

Price, E.O., 1984. Behavioral aspects of animal domestication. Q. Rev. Biol. 59, 1–32.

Price, E.O., 1999. Behavioral development in animals undergoing domestication. Appl. Anim. Behav. Sci. 65, 245–271.

Reiner, A., Medina, L., Veenman, C.L., 1998. Structural and functional evolution of the basal ganglia in vertebrates. Brain Res. Rev. 28, 235–285.

Ryan, T.P., 1985. Feather picking in caged birds. Mod. Veterinary Pract. 66, 187–189.

Savory, C.J., 1995. Feather pecking and cannibalism. World Poult. Sci. J. 51, 215–219.

Snyder, N.F.R., Wiley, J.W., Kepler, C.B., 1987. The Parrots of Luquillo: Natural History and Conservation of the Peurto Rican Parrot. The Western Foundation of Vertebrate Zoology, Los Angeles, CA, USA.

Stein, D.D., Dodman, N.H., 1994. Behavioral disorders in veterinary practice: relevance to psychiatry. Compr. Psychiatry 35, 275–285.

Tauson, R., Ambrosen, T., Elwinger, K., 1984. Evaluation of procedures for scoring the integument of laying hens—independent scoring of plumage condition. Acta Argic. Scand. 34, 400–408.

Turner, M., 1997. Towards an executive dysfunction account of repetitive behavior in autism. In: Autism as an Executive Disorder. Oxford University Press, New York, USA, pp. 57–100.

van Hoek, C.S., King, C.E., 1997. Causation and influence of environmental enrichment on feather picking of the crimson-bellied conure (*Pyrrhura perlata perlata*). Zoo Biol. 16, 161–172.

Wechsler, B., Huber-Eicher, B., 1997. The effect of foraging material and perch height on feather pecking and feather damage in laying hens. Appl. Anim. Behav. Sci. 58, 131–141.