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RESEARCH ARTICLE

Consistent Intra-Individual Seed Preferences, Yet No Dietary Conservatism in a Granivorous Songbird

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ABSTRACT

Birds, as most other animals, face challenges in finding food in ever-changing habitats where food availability can vary greatly. Given the fluctuating quantities and varieties of accessible food sources, the ability to explore and exploit alternative, perhaps completely new, food sources would be of great benefit. Despite the benefits of such generalist strategies, there is often foraging specialization, which may allow greater efficiency in accessing and processing a specific food source, and it helps reduce competition. However, how specialization arises and whether it implies that specialists avoid novel foods (dietary conservatism), even though these new foods may provide benefits, is poorly studied. This study therefore examines whether domestic canaries are consistent in their seed choice and whether they tend to avoid a novel seed type, in this case, white millet. To this end, food preferences were investigated in a series of individual-based seed preference tests. Most individuals exhibited consistent seed preference patterns over time. Seed choice appeared a repeatable behavior, and seeds picked are hence not chosen at random. Subsequently, when exposed to a novel seed type (white millet), individuals did not show any dietary conservatism. On the contrary, individuals familiar with white millet picked a significantly lower amount of that seed than individuals who were not familiar with the seed. This suggests that individuals with more experience with this seed type may have learned that its foraging is not very efficient. Taken together, our results show that being consistent in dietary choices does not necessarily relate to dietary conservatism.

1 | Introduction

In ever-changing environments, food can be a limited resource and its accessibility can differ, not only from year to year, but also with season or even from day to day (Benkman and Pulliam 1988, Brooks et al. 1999, Cutting et al. 2016). Given the fluctuating quantities and varieties of accessible food sources, the ability to switch to an alternative, perhaps a completely new food source, would be of great benefit (Lima 1985, 1994; McMahon et al. 2014). However, while such generalist strategies could be beneficial in fluctuating environments, individual specialization in certain food sources is a common occurrence in many species (Bolnick et al. 2011; Futuyma and Moreno 1988). Specialists have strong preferences, tend to become more efficient in exploiting a certain food type, and relying on this strategy works well in predictable environments when the availability of the preferred food type is stable (Bolnick et al. 2003; Wakefield et al. 2015). Consequently, specialist individuals may avoid novel foods (dietary conservatism), even though these new foods may provide benefits (McMahon et al. 2014).

Granivorous songbirds have been a popular subject for studying dietary preferences due to the variety of seeds their diet consists of (Radtke 2011; Soobramoney and Perrin 2007). Furthermore, seed-eating songbirds cannot digest the hard seed shells but first need to dehusk the seeds before being able to consume these.

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Dehusking particular seeds efficiently requires a specific beak size and morphology, as well as certain beak movements and bite force (Diaz 1994; Herrel et al. 2005; Johansen et al. 2014; van der Meij and Bout 2006). This, however, implies that because of the differences in beak shapes and associated beak kinematics, for some species a certain type of seed can be more time and energy consuming to open than other seed types (Kear 1962; Titulaer et al. 2018). Because of the variety in seed types (such as in size, shape, hardness, ...), there is considerable variation in beak shapes among birds to deal with seed husking. One well-known example is Darwin's finches (Grant et al. 1976; Herrel et al. 2005), which evolved strikingly different beaks, each adapted to the specific food niche they are exploiting.

Beak shapes and seed handling skills not only differ among species but can also strongly differ among individuals within a species (Andries et al. 2024), which is thought to relate to individual specialization, as a mechanism to reduce intraspecific competition over food (Bolnick et al. 2002). Yet less is known about how individual preferences arise to ultimately lead to individual specialization. One potentially relevant set of mechanisms are neophobia and dietary conservatism. Neophobia refers to the initial, short-term avoidance of novel objects or stimuli, including food items (Marples and Kelly 1999). Relatedly, dietary conservatism describes the tendency of individuals to persistently avoid novel food sources even after initial exposure (Doherty and Cowie 1994; McMahon et al. 2014). Thus, neophobia may represent a proximate mechanism underlying dietary conservatism, with the former emphasizing avoidance of novelty itself and the latter the longer-term persistence of familiar foraging choices. This tendency for dietary conservatism could also lead to differences in specialization among individuals: some birds may consistently stick to familiar food types while others are more willing to explore new resources. Individuals may balance the costs and benefits of feeding differently, either due to differences in morphology (Andries et al. 2025), personality (McMahon and Marples 2017; Milligan et al. 2017), social aspects (McMahon et al. 2024) or innate and acquired (or learned) preferences (Doherty and Cowie 1994) in prioritizing different aspects of seed choice (e.g., seed size vs. shape vs. color). These traits can reinforce differences in diet choice, with certain individuals becoming specialized on particular seeds. In this way, dietary conservatism may act as a behavioral mechanism that promotes individual consistency in resource use, complementing morphological differences like beak shape.

In this study we investigated dietary conservatism, and how it is linked with seed preferences in individuals of a captive population of the Domestic Canary (*Serinus canaria*). This granivorous songbird specializes in feeding on small seeds, showing strong and persistent seed preferences that may vary among individuals (Andries et al. 2024; Doherty and Cowie 1994). These characteristics make canaries a suitable model for studying how specialist feeders with a limited propensity for dietary exploration cope with changing food availability. First, consistency of individual seed preferences was measured by repeated choice experiments with seed species from the usual seed mix offered to these captive canaries. Subsequently, a different group of canaries underwent similar seed choice experiments, yet this time supplemented with one novel seed type, white millet. More specifically, we compared seed choices of individual birds when they first have access to a novel seed type with those of individuals that already had short- and long-term experience with this seed. We predicted that canaries with a strong seed preference avoid novel seed types because of an association of specialization and dietary conservatism. However, with increased experience with the new seed type, this pattern may fade away so that individuals may nevertheless incorporate novel seed types into their daily diet.

2 | Materials and Methods

2.1 | Study Species

For this study, 80 canaries (*Serinus canaria*) (40 males and 40 females) that belonged to a captive population at the University of Antwerp were used. The birds used for the experiments were randomly selected and were between one and four years old. Throughout most of the year, canaries are housed in single-sex aviaries at room temperature (19°C–24°C) with a 12 h/12 h day-night cycle. A canary seed mix (Van Camp, Belgium) and water were always accessible to them. During the experiment, all experimental birds were kept in individual cages (50 × 64 × 40 cm, GEHU cages, The Netherlands), again with food and water ad libitum. Canaries were moved to different individual cages without food (water still ad libitum) at least 4 h before each trial, forcing a minimum hunger level to stimulate seed consumption when trialed. The study subjects were weighed prior to each test to assess their overall health condition. The test set-up consisted of a square glass box (50 × 50 × 50 cm). The top of the glass box was covered by a metal grating to prevent the study subjects from leaving the glass box during the experiment. The floor was covered with sand and shell grit. The front and the back of the box were covered with paper to minimize the effects of light reflection and improve video quality. The front paper had a square cut out for the camera position. All experiments were filmed with a Sony RX1000M4 camera (Figure 1A). Ethical approval for the experiments was granted by the Ethical Committee for Animal Testing of the University of Antwerp (approval number: 2021-35).

2.2 | Experimental Setup

2.2.1 | Consistency Test

Seed preferences were assessed three times every other day for each of the 20 individual males and 20 individual females. During the experiments, subjects were filmed whilst feeding from a tray on the ground for 10 min. The tray contained six different seed types of varying size, shape, and color: canary seed, hemp seed, flaxseed, bird's rapeseed, nigerseed, and peeled oat (Figure 1B and Table 1). All seeds were part of the birds' daily diet. The tray contained 50 seeds of each type to avoid that choices are influenced by shortage of a given seed type. While this set-up is not very reflective of a natural situation, we consider this suitable for the purpose of this study. We are specifically interested in seed choice, rather than the entire process of foraging (which includes food search and acquisition), and it is expected that birds have knowledge of the full range of seeds present. Hence, our tray serves as a shortcut to minimize variation associated

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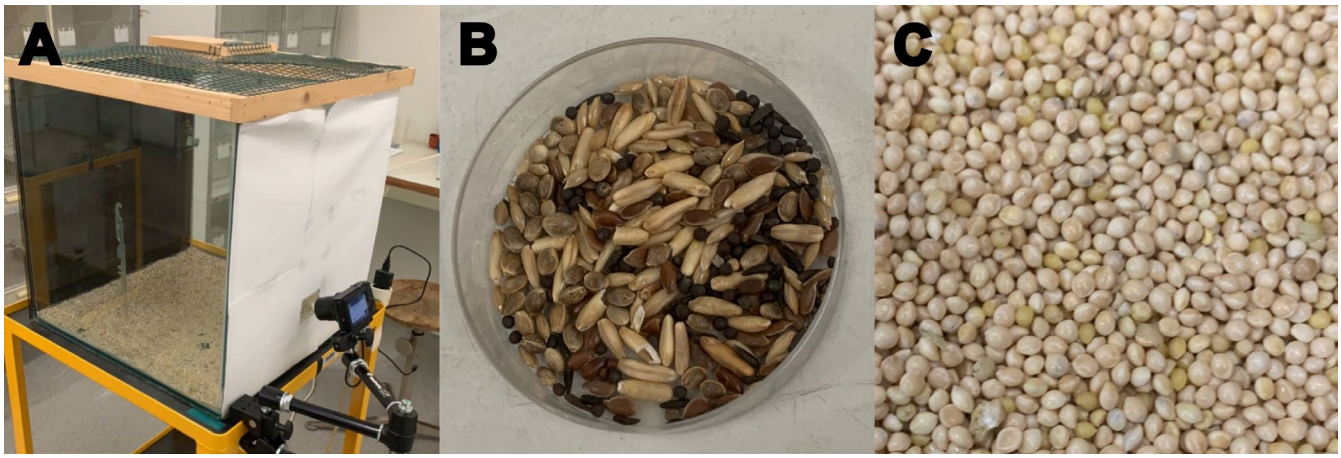


FIGURE 1 | Experimental setup. (A) Image of the test set-up with camera attached to the front. (B) Food tray containing the six different seed types from the normal diet as presented to the birds. (C) The newly introduced white millet seed.

TABLE 1 | Seed types used in this study with description of approximate size, shape, color, energy content (based on nutrition data from U.S. Department of Agriculture 2019).

Seed	Approx. size (mm) length × width	Shape	Color	Approx. energy contents of 1 seed (cal)
Canary seed *Phalaris canariensis*	4.70 × 1.80	Spindle-shaped	Light brown	28
Hemp *Cannabis sativa*	4.20 × 2.90	Oblate spheroid	Dark brown	83
Flaxseed *Linum usitatissimum*	4.80 × 2.30	Discoid	Brown	40
Bird's rapeseed *Brassica rapa subsp. oleifera*	2.00 × 1.80	Spheroid	Black	23
Nigerseed *Guizotia abyssinica*	3.90 × 1.10	Lanceolate	Black	16
Oat (peeled) *Avena sativa*	7.10 × 2.30	Cylindrical Spindle-shaped	Light brown	114
White millet *Panicum milliaceum*	**2.60 × 2.10**	**Spheroid Weakly ovoid**	**White**	**26**

Note: The novel seed (i.e., not part of their usual diet) is indicated in bold (table modified from Andries et al. 2024).

with search time and encounter rate. After presenting the tray, the individual was left alone in the room to avoid distractions and stress during the actual test. Multiple individuals that were tested on the same day were filmed in a randomized order.

After the experiments, footage of the camera was used to count how many seeds of each type were picked by an individual. Both occurrences where the seed was successfully extracted from its shell and where the seed was dropped after a failed attempt were counted. However, taking into account that granivorous birds commonly do not give up a seed after a failed husking attempt (Greig-Smith 1987), occasions where a bird picked up the exact same seed after a failed attempt were not counted as a newly picked seed. Occasions where a bird picked up and dropped a seed without displaying effort to husk were not counted either.

2.2.2 | Novel Seed Test

To test for the incorporation of a novel seed species into their diets, individual canaries were presented with a new food item, white millet. Another 40 canaries (different from the Consistency test) were randomly assigned to one of three experimental groups: "Short-term control" (5 males and 5 females), "Long-term control" (5 males and 5 females), and "Millet" (10 males and 10 females; Table 2). At the start of the experiment, the Millet group received an adjusted daily diet. This daily diet consisted of their standard daily diet (the six different seed types described above), supplemented with the as of yet unknown seed type, white millet (Figure 1C and Table 1). Both control groups were kept on their standard diet throughout the entire experiment. All individuals were tested twice, after 1 day and

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TABLE 2 | Summary of the differences between each group within the novel seed test.

Group	Individuals and sex	Diet	Trial after 1 day	Trial after 1 week
Short term control	5 M & 5 F	Six known seed types	Six known seed types + white millet	Six known seed types + white millet
Long term control	5 M & 5 F	Six known seed types	Six known seed types	Six known seed types + white millet
Millet	10 M & 10 F	Six known seed types + white millet	Six known seed types + white millet	Six known seed types + white millet

Note: Shown are the number of individuals with their sex, the type of diet each group receives prior to, and between both trials, and the seeds given to each group during the trials.

after 1 week. Trials were conducted exactly as described above (see Consistency Test), except for the addition of the novel white millet seed to the tray during the trials. See Table 2 for an overview of the seed mixture given to each experimental group during each trial. The "long term control" group was created to maintain the novelty of millet seeds after 1 week, and the first-day trial was conducted to standardize the testing process. Hence, this group did not receive white millet seeds in the first trial. After the experiments, camera footage was again used to manually count how many seeds of each type were picked per individual, as described in the Consistency test.

2.3 | Statistical Analysis

2.3.1 | Consistency Test

To assess how consistent individuals are in their seed preferences across the different feeding trials, the repeatability for each seed (proportion of the seed relative to the total number of seeds selected per trial) was calculated in R (version 4.1.0) using the package "rptR" (Stoffel et al. 2017). The repeatability statistic is a bootstrapped intraclass correlation coefficient based on variance partitioning. More specifically, it represents the proportion of between-individual variation relative to the total variation in the sample (Bell et al. 2009). Since previous research demonstrated among-individual differences in seed preferences in canaries (Andries et al. 2024), repeatability offers an appropriate measure to assess whether such individual differences are stable across repeated observations. Repeatability also assumes that repeated measures within individuals are independent. Since we tested seed preferences using the birds' usual diet and trials were conducted in a relatively short timeframe (1 week; see "Experimental Setup"), we do not expect learning effects or other changes in seed preferences (e.g., related to development or aging) to be relevant. Each seed was present in sufficient quantities, so that choice should not have been influenced by shortage of certain seed types (see 'Experimental Setup'). Consequently, results for each seed type can also be considered independent.

Repeatabilities were estimated assuming a binomial distribution, which is appropriate for proportional response variables. 1000 iterations were used for parametric bootstrapping to estimate standard errors and confidence intervals. Model assumptions were assessed through simulation-based residual diagnostics using the "DHARMa" package (Hartig 2026). While most models showed adequate fit, some exhibited deviations from expected residual patterns. To ensure robustness of statistical inference, we additionally obtained *p*-values using 1000 permutation tests per model. Herein, the association between response values and individual identity was randomly shuffled to generate a null distribution of repeatability estimates against which the observed values were compared (Stoffel et al. 2017). The experimental set-up was sex-balanced to avoid possible confounding (and for practical considerations). However, our objective is to estimate the repeatability of seed preferences at the individual level, not to model sex-specific differences; hence, sex was not included in any analyses.

2.3.2 | Novel Seed Test

To test whether and under which conditions canaries chose for the novel seed (white millet), a generalized linear mixed effects model with a binomial distribution (logit link function) in R (version 4.1.0) was used, with proportion of millet seeds picked (= amount of white millet seeds chosen as proportion of the total number of seeds chosen during the respective trial) as dependent variable and the experimental groups as independent categorical variable. Individual identity was added as random effect to account for repeated measures. Similarly to the models of the Consistency Tests, this model was also checked for assumptions using the DHARMa package's simulation-based residual diagnostics (Hartig 2026). The packages "lme4" (Bates et al. 2015) and "lmerTest" (Kuznetsova et al. 2017) were used for constructing the linear mixed model. To facilitate interpretation of the effects of a diet supplemented with white millet on white millet preference, the "Millet 2" group (Millet group filmed after 1 week) was chosen as a reference group to compare all other groups to.

3 | Results

3.1 | Consistency Test

Based on a qualitative assessment of seed preferences, roughly four groups of preference patterns could be distinguished (Figure 2). 9 out of the 40 tested individuals fed on a relatively large number of different seed types (three or more), which we consider 'generalists' (Figure 2A). Their preferences were relatively consistent across trials but varied more in the seed types selected in lower quantities. 14 individuals almost exclusively

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selected two seed types (double-seed specialist; Figure 2B) and 13 individuals fed almost exclusively on a single seed type (single-seed specialist, Figure 2C). Both groups were overall very consistent in their preferences across trials. Finally, 4 individuals demonstrated more variable preferences across trials, with typically one trial showing notably different preferences from the other two trials (variable feeder, Figure 2D). Table 3 gives an overview of repeatability estimates per seed type.

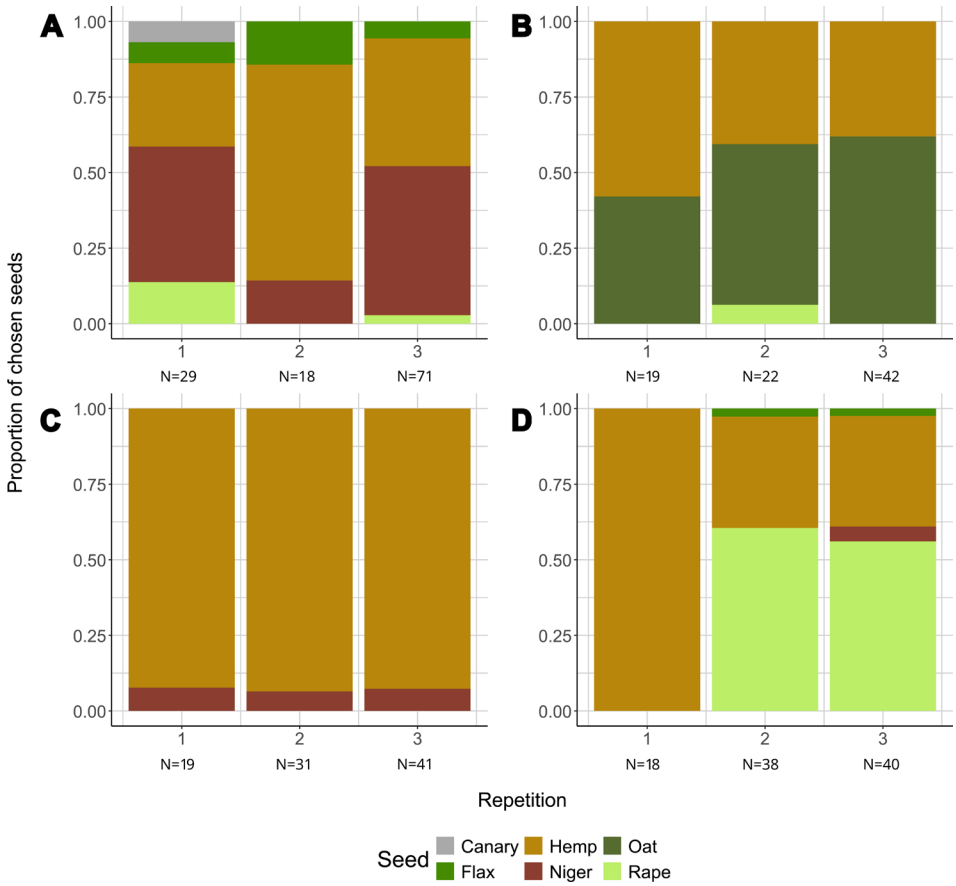


FIGURE 2 | Examples of the food preferences of four different individuals across the repeated food choice experiments, each representing a distinct preference pattern (A = generalist, B = double-seed specialist, C = single-seed specialist, D = variable feeder). Repetition refers to the trial number, in chronological order. The proportion of each seed is calculated from the total number of seeds picked (N) in the respective trial.

TABLE 3 | Repeatability estimates in preference per seed type, along with standard errors (SE), 95% confidence intervals (CI) and *p*-values (indicate whether repeatability is significantly different from 0).

Seed type	Repeatability (± SE) [95% CI]	Bootstrap *p* value	Permutation *p* value	Average preference
Canary	0.021 (±0.010) [0, 0.042]	0.329	0.591	0.018
Hemp	0.273 (±0.074) [0.127, 0.408]	< 0.001	0.013	0.693
Flax	0.059 (±0.037) [0, 0.130]	0.019	0.057	0.040
Rape	0.056 (±0.030) [0.003, 0.122]	0.003	0.065	0.053
Niger	0.284 (±0.062) [0.140, 0.384]	< 0.001	0.005	0.169
Oat	0.202 (±0.147) [0, 0.543]	0.049	0.127	0.027

Note: Estimates are based on both bootstrapping and permutation methods, reported on the original scale. Additionally, average preference per seed type (as proportion of all seeds chosen) is also included.

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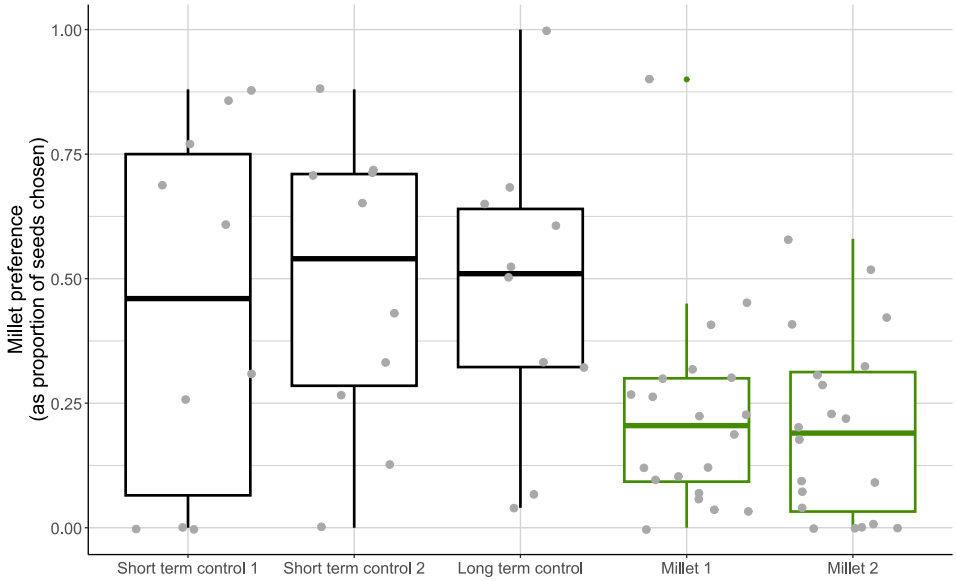


FIGURE 3 | Distribution of the proportion of Millet seed picked per experimental group. The "Short term control" group was tested after 1 day (Short term control 1) and 1 week (Short term control 2). The "Long term control" group was only tested after 1 week (since these individuals only had access to millet seeds after 1 week). The 'Millet' group was tested after 1 day (Millet 1) and after 1 week (Millet 2). The centre line of the boxplot indicates the median value (50th percentile), while the outer line of the boxes contains the 25th and 75th percentiles. The black whiskers mark the 5th and 95th percentiles, values beyond these upper and lower bounds are considered outlier values. Raw data per individual are shown as gray dots.

TABLE 4 | Summary statistics of the logistic regression, with "Millet 2" as reference group for comparison with the other experimental groups.

Group	Estimate	Error	*z* value	*p* value
Short term control 1	1.222	0.607	2.014	0.044*
Short term control 2	1.317	0.600	2.196	0.028*
Long term control	1.552	0.597	2.601	0.009*
Millet 1	0.116	0.149	0.780	0.435

Note: The table shows estimated differences in millet preference between 'Millet 2' and each experimental group (estimate), standard errors, *z*-values and *p*-values. Estimates and errors are on logit scale (log-odds, dimensionless), expressing differences in probability of choosing millet seeds. Positive values indicate a higher preference than the reference group. Significant *p*-values are indicated with an asterisk.

3.2 | Novel Seed Test

Individuals of all control groups had similar feeding preferences with respect to millet regardless of the time point of the test (after 1 day or after 1 week). Individuals of the control groups generally picked a higher proportion of the millet seed than individuals of the "Millet" groups (Figure 3). Comparing the control groups with 'Millet 2' shows a significant difference in the proportion of millet seeds picked for all three control groups ("short term control 1": $p = 0.044$, "short term control 2": $p = 0.028$ and "long term control": $p = 0.009$) (Table 4). There was no significant difference in the preference for millet in the 'Millet' group between feeding after 1 day and after 1 week ("Millet 1": $p = 0.435$) (Table 4).

4 | Discussion

Dietary conservatism, the tendency of animals to avoid new food sources even when the fear of novelty is overcome (McMahon et al. 2014), may be a mechanism through which food specialists have more difficulty adapting to changing food availabilities (Bolnick et al. 2003; Wakefield et al. 2015). In this study, we tested whether the domestic canary, serving as a model for a seed specialist with persistent individual preferences (Doherty and Cowie 1994), exhibits dietary conservatism when offered a new seed type in its diet: white millet. We can confirm that individual canaries do show different time-persistent seed preferences among known seeds. However, contrary to our predictions, canaries did not persistently avoid the novel seed type. Rather, the opposite pattern was observed where individuals with less experience with white millet picked more of the seed than individuals with more experience.

4.1 | Consistency in Seed Preferences

Canaries were generally highly consistent in their feeding preferences over time with repeatability values ranging between 0.2 and 0.4, which can be considered moderate to high (common for behavioral traits, see Bell et al. 2009). There were differences among seed types, however. Hemp seed and nigerseed were picked regularly in high proportions by many individuals (69,3% and 16,9% of all seeds chosen on average respectively, see Table 3), and in a very consistent way. Oat on the other hand, was only picked by a few individuals (resulting in a low average preference of 2.7%, see Table 3), but these were relatively consistent. Canary seed, which is the most common seed type in the standard canary seed mix, flaxseed and to a lesser extent rapeseed were least preferred (Table 3), often not taken at all, which

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made it difficult to calculate repeatabilities (Stoffel et al. 2017), as taking one more or less can make a considerable difference so that the repeatability for these seeds was very low.

Why some seed types are preferred over other likely relates to shape, size and nutritional value. Hemp seed was one of the most popular seeds chosen by the birds (Table 3), despite the fact that these seeds are relatively difficult to husk for canaries (Andries et al. 2023; van der Meij and Bout 2006). A preference for hemp seeds has already been found by earlier studies (Andries et al. 2024; Kear 1962) and has been linked to their high energetic content (Table 1). In contrast, the moderately popular nigerseed (Table 3) is very low in terms of energy contents, but canaries have been found to husk nigerseeds faster than most other seeds (Kear 1962). Flaxseed, which has somewhat higher nutritional value (Table 1), requires longer handling times to dehusk (Kear 1962), and was consumed less frequently (Table 3). These patterns are consistent with a trade-off between energetic gains and handling time costs, which has been proposed as a general mechanism of shaping seed choice in granivorous birds (Marone et al. 2022; Radtke 2011; Titulaer et al. 2018). Only a few individuals consistently consumed oat seeds (Table 3). Oats are nutritious but very high in carbohydrates and low in fat, while hemp for example is very high in fat and low in carbohydrates (U.S. Department of Agriculture 2019). Some studies report that birds tend to prefer seeds that are high in fat over seeds that are high in carbohydrates (Molokwu et al. 2011; Thompson et al. 1987), likely because fats supply more energy over time in comparison to carbohydrates which supplies more energy on short term (Bender 2014). On the other hand, many bird species also choose seeds with high carbohydrate contents (Brzęk et al. 2010; Ríos et al. 2012; Zwarts et al. 2023), hence specific nutritional contents of seeds might not be a very good predictor of preference in granivorous birds. The canaries in this study exploited multiple seed types, mostly preferring those that are more energy-efficient to consume, more specifically high in energetic value and/or easy to dehusk. Thus, seeds are not chosen at random, but despite common selection criteria, individuals nevertheless differ in their preferences, possibly linked to individual differences in morphology (Andries et al. 2025), personality (Milligan et al. 2017) and/or development (such as learned preferences, see Doherty and Cowie 1994).

Another curiosity apparent from this study is that canaries primarily chose forb seeds (hemp and nigerseed), while avoiding canary seed, which is a grass seed. This is an interesting result given that many granivorous bird species belonging to various families are highly graminivorous (i.e., preferring grass seeds of the Poaceae family) in most of the world (Camín et al. 2015; Marone et al. 2017; Soobramoney and Perrin 2007; Whelan et al. 2015; Zwarts et al. 2023) Why some European songbirds appear to consume more forb seeds than grass seeds (Andries et al. 2024; Valera et al. 2005; Wilson et al. 1999; this study) is an intriguing, and still unsolved ecological question related to the search for synthesis and integration in granivory studies worldwide.

4.2 | Dietary Conservatism and Preferences for a New Seed Type

Individuals familiar with white millet picked a significantly lower amount of white millet than individuals that were not familiar with it (Figure 3). This contrasts our hypothesis, since we expected that individuals would avoid novel food items, and that such dietary conservatism would only fade over time. When an individual could only consume the novel seed during the experiments, significantly more of this seed was consumed than when individuals are free to consume this novel seed. White millet is a round seed of moderate size and has a bright white color (Table 1). Birds tend to have a preference for round objects (Keating 1989), so they might expect white millet to be easily dehusked, and the bright white color might also draw attention (Slaby and Slaby 1977). Birds also commonly select seeds based on size, as larger seeds are typically more energetically efficient but take longer to dehusk (Titulaer et al. 2018; van der Meij and Bout 2006). Millet, being larger than rapeseed but smaller than hemp (Table 1), might therefore have an ideal intermediate size for canaries. Hence, based on the seed's external properties, millet seems like an ideal seed for these birds.

However, based on observations in this study, husking millet seeds seemed to be time-consuming for the canaries (though Kear (1962) did report that canaries husk millet seeds as fast as the easily dehusked canary seeds, though this might be related to experience). Millet seeds also have similar energetic contents as rapeseeds (Table 1), which were not strongly preferred, so millet seeds might not provide sufficient nutrients given the effort it takes to dehusk them (Radtke 2011; Titulaer et al. 2018). Consequently, individuals with more experience with millet seeds might have learned that it is not very energy efficient to feed on this seed. The fact that the control groups had similar preferences for millet regardless of the different timepoints indicates that 10 min (duration of the experiment at each timepoint) is not sufficient to gain this knowledge. Meanwhile, since the millet group both after 1 day and 1 week showed little preference for millet seed, 1 day of exposure appears sufficient to learn about the relatively poor cost–benefit ratio of millet. However, millet seeds (and similar seed species) appear to be highly preferred by several other granivorous bird species (Marone and Camín 2022; Whelan et al. 2015; Zwarts et al. 2023). Hence, it remains unclear what exactly causes canaries to end up avoiding millet seeds, or perhaps what makes our captive canaries particularly inefficient at consuming these seeds.

It must be said that there is not necessarily a straight correlation between specialization and dietary conservatism, however. Many generalist bird species also exhibit high levels of neophobia and dietary conservatism, such as house sparrows and shiny cowbirds (Echeverría et al. 2006), ravens (Heinrich 1988), and new world blackbirds (Mettke-Hoffmann et al. 2013), among others. These patterns have previously been explained by the "dangerous niche hypothesis", which predicts that species that encounter more potentially dangerous environments, objects, or food sources will exhibit high levels of neophobia and dietary conservatism (Barnett 1958; Greenberg 2003). In light of this hypothesis, our model system of captive canaries might facilitate the opposite pattern. Our canaries were kept in a very stable and safe environment, lacking exposure to dangerous (toxic) food sources, which might encourage them to explore new types of food, explaining the high levels of preference for the novel white millet seed among the control groups. This, however, does not explain their reluctance to incorporate white millet into their

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long-term diets. One possibility is that birds raised on a consistent diet may sample novel foods more readily due to safe conditions but tend to revert to familiar food sources once the effects of novelty diminish.

5 | Conclusions

While we found persistent seed preference that varies among individuals, we did not find dietary conservatism in canaries. This suggests that even food specialists retain some flexibility in their food preferences, which could become important in the face of changing food availability. However, even though canaries do not hesitate to consume novel food, they appear to be reluctant to incorporate novel food into the diet after some level of familiarity has been gained. It could be interesting to gain more detailed information on the processes of how, why, and when such dietary preferences could be overcome. This could relate to consistency and/or preference magnitude, but even though we could categorize individuals in four distinct groups according to those aspects, sample sizes were as of yet too limited for testing. Taken together, by studying dietary wariness we can gain deeper insights into the complexity of food choices and the ability to adapt diets to nutritional requirements in changing environments.

Author Contributions

Tim Andries: conceptualization, writing – review and editing, methodology, validation, visualization, software, formal analysis, data curation, supervision, writing – original draft. **Sam Van Wassenbergh:** writing – review and editing, resources, project administration, funding acquisition. **Stan Romijn:** conceptualization, investigation, methodology, writing – original draft, writing – review and editing, visualization, data curation, formal analysis. **Wendt Müller:** conceptualization, writing – review and editing, resources, project administration, supervision, formal analysis, validation.

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Ethics Statement

Ethical approval for all animal experiments was granted by the Ethical Committee for Animal Testing of the University of Antwerp (approval number: 2021-35).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data and code are available from the Dryad Digital Repository (https://doi.org/10.5061/dryad.jsxksn0s2, private reviewer link: http://datadryad.org/share/LINK_NOT_FOR_PUBLICATION/C2LfsADAqUZMr23lql3L1u8dRqipzr_oFZdfZaEowi8). All data are extracted from video recordings which are not publicly available due to their excessive combined file size. These videos can be accessed upon request by contacting the corresponding author.

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