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Prevalence of Intestinal Parasites in Ornamental Cage Birds in Sebha City, Southern Libya: A Cross-Sectional Coproscopic Survey

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ABSTRACT

Ornamental (cage) bird keeping has expanded into a commercial trade across Libya, yet the parasitic burden carried by these birds remains poorly characterized. The aim of this study was to determine the prevalence of intestinal parasites among ornamental birds in Sebha City, southern Libya, and to generate locally relevant evidence for breeders and pet-shop operators. This cross-sectional study examined 101 faecal samples collected between September and December 2022 from ornamental birds representing nine taxonomically distinct groups, including the domestic canary (*Serinus canaria domestica*), the budgerigar (*Melopsittacus undulatus*), lovebirds (*Agapornis* spp.), the cockatiel (*Nymphicus hollandicus*), and the zebra finch (*Taeniopygia guttata*). Samples were processed by formalin-ether sedimentation and examined by light microscopy. Overall, 36 of 101 birds (35.6%, 95% CI 27.0-45.4%) were positive for at least one intestinal parasite. *Eimeria* spp. oocysts were the most common finding (22.8%), followed by *Ascaridia* sp. ova (7.9%), mixed *Eimeria-Ascaridia* infection (3.0%), and *Entamoeba* sp. cysts (2.0%). Prevalence varied among taxonomic groups; the comparison of canaries, budgerigars, and all other groups combined approached statistical significance ($\chi^2 = 5.86$, df = 2, p = 0.053). No significant association was found between infection and sex, food source, or water source. These findings indicate that intestinal parasitism is common among ornamental birds traded in southern Libya and support targeted parasitological screening, improved husbandry education, and broader surveillance.

معدل انتشار الطفيليات المعوية في طيور الزينة المرباة في الأقفاص بمدينة سبها، جنوب ليبيا: دراسة مسحية مقطعية لفحص البراز.

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الكلمات المفتاحية:
طيور الزينة
الطفيليات المعوية
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ليبيا

الملخص

تُعد تربية طيور الزينة نشاطاً متزايداً في ليبيا، إلا أن بيانات الطفيليات المعوية ما تزال محدودة .هدفت هذه الدراسة المقطعية إلى تحديد معدل انتشار الطفيليات المعوية بين طيور الزينة في مدينة سبها، جنوب ليبيا . فُحصت 101 عينة برازية جُمعت بين سبتمبر وديسمبر 2022 باستخدام تقنية الترسيب بالفورمالين-إيثر والمجهر الضوئي .كانت 36 من أصل 101 عينة(35.6%) ؛ فاصل الثقة (95%: 27.0-45.4%) إيجابية لطفيلي معوي واحد على الأقل .كانت *Eimeria* spp. الأكثر شيوعاً(22.8%) ، تلتها(7.9%) *Ascaridia* sp. ، والعدوى المختلطة(3.0%) *Eimeria-Ascaridia* ، وأكياس *Entamoeba* sp. (2.0%). اقترب الاختلاف بين المجموعات التصنيفية من الدلالة الإحصائية($\chi^2 = 5.86$ ، p = 0.053)، ولم ترتبط الإصابة بالجنس أو مصدر الغذاء أو مصدر المياه.

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Introduction

Keeping ornamental birds, including canaries, budgerigars, lovebirds, cockatiels, small psittacines, and finches, has developed from a hobby into an active commercial trade, with birds often moving through breeders, dealers, and hobbyists before reaching private cages [1]. Such movement can facilitate the circulation of intestinal nematodes and enteric protozoa, including subclinical infections that may remain unnoticed until health or productivity declines [2]. Recent literature has also emphasized the welfare and sustainability implications of keeping birds as companion animals [3], while current European pet-population reports confirm that birds remain a substantial companion-animal category [4]. Many pet-parrot species remain genetically undercharacterized despite their popularity [5]. More broadly, domestication involves heritable and developmental adaptation to human-controlled environments [6]; among cage birds, the domestic canary is a well-established model for investigating avian domestication and genomic change [7]. Internal parasitic infections can be clinically important in young or heavily infected birds [8], and some enteric protozoa, including *Giardia duodenalis* and *Cryptosporidium* spp., have zoonotic relevance [9]. In Libya, parasitological data for companion birds are limited largely to a coproscopic survey of domestic pigeons in Tripoli [10]. Surveys from Alexandria [11] and Dhaka [12] report substantial but geographically variable prevalence, so their findings cannot be directly extrapolated to southern Libya. The present study therefore aimed to determine the prevalence of intestinal parasitic infection among ornamental birds kept in Sebha and to provide locally relevant evidence that can inform breeders, pet shops, and owners about parasitic risk.

2. Materials and Methods

2.1 Study Area

The study was conducted in Sebha, the principal city of the Fezzan region in south-western Libya, situated between latitudes 27.00°N and 27.9°N and longitudes 14.12°E and 14.37°E [13]. Sebha lies approximately 800 km south of Tripoli within a hot, arid desert climate with cold winters, and functions as the largest urban centre and the principal commercial and service hub of southern Libya [13,14].

2.2 Study Population and Sample

Faecal samples were collected from ornamental birds kept by private breeders, pet shops, and commercial bird traders in Sebha between 1 September 2022 and 1 December 2022. For each bird, an accompanying questionnaire recorded sex, diet source (locally sourced grain versus commercially formulated feed), and water source (municipal tap water versus desalinated water). Random sampling yielded 101 individual faecal specimens representing several ornamental species and colour varieties sold under local trade names. Because identical trade names were used inconsistently across colour morphs and, occasionally, related species, each bird was reclassified for analysis to genus or species level using standard ornithological and avicultural nomenclature, so that no individual remained taxonomically unclassified. Colloquial breed and colour-variety names, including the canary varieties marketed as Abyssinian, Arabic, Tunisian, European, Agate, Mosaic, Gloster, and Timbrado and the budgerigar varieties marketed as Arabic, English, Australian, and Rainbow, were treated as breeds or colour mutations within a single parent species rather than as distinct taxa. A cluster of local trade names applied to small hook-billed parrots was resolved to the lovebird genus *Agapornis*, consistent with regional avicultural usage identifying this trade group as comprising *Agapornis fischeri*, *A. roseicollis*, and *A. personatus*. The same genus-level classification was applied to a small number of birds recorded only under a generic "parrot" label or an unverified regional colour/origin descriptor because these entries co-occurred in the same trade batches and questionnaire records as confirmed *Agapornis* birds and no better-supported classification was available. One bird recorded under a descriptor corresponding to a southern African geographic origin was classified as the Cape parrot, *Poicephalus robustus*. The final taxonomic composition is presented in Table 1 and Figure 1.

2.3 Sample Examination

Faecal samples were processed by the formalin-ether sedimentation technique to concentrate parasite eggs, larvae, and protozoan cysts and were examined by light microscopy for helminth ova and protozoan stages. Materials used were medical gauze; polypropylene centrifuge tubes (Corning Inc., Corning, NY, USA); a bench-top centrifuge (Hettich Zentrifugen, Tuttlingen, Germany); 10% buffered formalin (Sigma-Aldrich, St. Louis, MO, USA); diethyl ether (Sigma-Aldrich, St. Louis, MO, USA); capped test tubes; Lugol's iodine solution (Sigma-Aldrich, St. Louis, MO, USA); a binocular light microscope (Olympus CX23, Olympus Corporation, Tokyo, Japan); and a glass stirring rod [15]. Approximately 2 g of faeces was emulsified in 10 mL of normal saline and mixed thoroughly. The suspension was filtered through gauze into a conical centrifuge tube and centrifuged at 2,000 rpm for at least 10 minutes, yielding approximately 0.75 mL of sediment. The supernatant was discarded, and the sediment was washed twice with normal saline by repeated centrifugation until the supernatant was clear. Ten millilitres of 10% formalin was then added to the final sediment, mixed, and left for 5 minutes; 1-2 mL of diethyl ether was subsequently added, the tube was capped and shaken vigorously, and the mixture was centrifuged at 1,500 rpm for 10 minutes. This produced four layers: an upper ether layer, a debris plug, a formalin layer, and sediment at the base. The upper three layers were decanted, the remaining sediment was resuspended in a small volume of residual fluid, and a drop of the suspension was examined with saline and Lugol's iodine under a coverslip [16]. Because identification followed fixation and concentration, *Entamoeba*-positive findings were reported as cystic forms; motile trophozoites were not assessed. Structures morphologically consistent with avian ascarid ova were classified as *Ascaridia* sp., rather than *Ascaris*, which is restricted to mammalian hosts.

2.4 Statistical Analysis

Descriptive statistics (frequencies and percentages) were calculated for all demographic, husbandry, and parasitological variables. Binomial proportions and 95% confidence intervals were calculated using the Wilson score method, which is preferable to the normal approximation for small subgroups. Associations between infection status and categorical variables (sex, food source, water source, and taxonomic group) were evaluated using the chi-square test of independence; Fisher's exact test was also reported for the 2 × 2 husbandry comparisons because of modest cell counts in some subgroups. A p-value < 0.05 was considered statistically significant. Unadjusted odds ratios with 95% confidence intervals were calculated for the three binary husbandry variables. The analyses were univariable; no multivariable model was fitted, so independent risk factors could not be estimated. All calculations were performed in Python using SciPy on the study dataset; no simulated data were introduced.

3. Results

The sample comprised 101 ornamental birds. Species composition and species-level prevalence are summarized in Table 1 and Figure 1. The domestic canary (*Serinus canaria domestica*) was the largest group (n = 36) and had a prevalence of 44.4% (16/36; 95% CI 29.5-60.4%). Lovebirds (*Agapornis* spp.; n = 14) showed the highest prevalence among groups represented by more than one bird (57.1%; 8/14; 95% CI 32.6-78.6%), whereas the budgerigar (*Melopsittacus undulatus*; n = 32) had the lowest prevalence among the well-represented species (18.8%; 6/32; 95% CI 8.9-35.3%). Estimates for sparsely sampled species were imprecise, as reflected by their wide confidence intervals. Table 2 summarizes the demographic and husbandry characteristics of the sample. Infection prevalence was similar in males (35.0%) and females (36.6%). It was 32.2% among birds receiving locally sourced feed and 40.5% among those receiving commercial feed, and 38.4% among birds receiving tap water compared with 20.0% among those receiving desalinated water. These descriptive differences were evaluated inferentially in Table 4 and Figure 3.

Overall, 36 of 101 birds were positive for at least one intestinal parasite (35.6%; 95% CI 27.0-45.4%) (Table 3 and Figure 2). *Eimeria* spp. oocysts were the most frequent finding (22.8%), followed by *Ascaridia* sp. ova (7.9%), mixed *Eimeria-Ascaridia* infection (3.0%), and *Entamoeba* sp. cysts (2.0%). The three mixed infections demonstrate that not all positive birds carried a single parasitic finding. The association between taxonomic group (canary versus budgerigar versus all other groups combined) and infection status approached, but did not reach, the conventional significance threshold ($\chi^2 = 5.86$, df = 2, $p = 0.053$) (Table 4). No statistically significant association was

identified for sex, food source, or water source. The corresponding unadjusted odds ratios were also non-significant, with all 95% confidence intervals crossing 1.0 (Figure 3).

Table 1. Taxonomic classification and species-level prevalence of intestinal parasites among the ornamental birds examined (n = 101).

Common name	Scientific name	Family	n (%)	n positive	Prevalence % (95% CI)
Domestic canary	*Serinus canaria domestica*	Fringillidae	36 (35.6)	16	44.4 (29.5–60.4)
Budgerigar	*Melopsittacus undulatus*	Psittaculidae	32 (31.7)	6	18.8 (8.9–35.3)
Lovebird (Fischer's / rosy-faced / masked)	*Agapornis* spp.	Psittaculidae	14 (13.9)	8	57.1 (32.6–78.6)
Cockatiel	*Nymphicus hollandicus*	Cacatuidae	6 (5.9)	1	16.7 (3.0–56.4)
Zebra finch	*Taeniopygia guttata*	Estrildidae	4 (4.0)	2	50.0 (15.0–85.0)
Rose-ringed (ring-necked) parakeet	*Psittacula krameri*	Psittaculidae	4 (4.0)	1	25.0 (4.6–69.9)
Senegal parrot	*Poicephalus senegalus*	Psittacidae	3 (3.0)	1	33.3 (6.1–79.2)
Cape parrot	*Poicephalus robustus*	Psittacidae	1 (1.0)	1	100.0 (20.7–100.0)
Rainbow lorikeet	*Trichoglossus moluccanus*	Psittaculidae	1 (1.0)	0	0.0 (0.0–79.3)
Total	—	—	101 (100.0)	36	35.6 (27.0–45.4)

CI: Wilson score 95% confidence interval. Colour and breed variants (e.g., Abyssinian, Arabic, Tunisian, European, Agate, Mosaic, Gloster, and Timbrado canaries; Arabic, English, Australian, and Rainbow-mutation budgerigars) are grouped under the parent species. The lovebird group includes birds recorded under a generic 'parrot' label or an unverified colour/origin descriptor, resolved to *Agapornis* spp. on the basis of shared trade context (see Methods, Section 2.2).

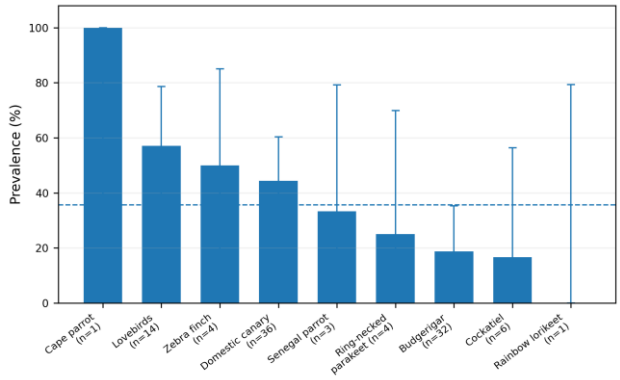


Figure 1. Species-level prevalence of intestinal parasitic infection with 95% Wilson confidence intervals. Sample sizes are shown for each taxonomic group; wide intervals in sparsely sampled groups indicate substantial uncertainty.

Table 2. Demographic and husbandry characteristics of the sample and associated intestinal parasite prevalence (n = 101).

Variable	Category	n (%)	n positive	Prevalence %
Sex	Male	60 (59.4)	21	35.0
	Female	41 (40.6)	15	36.6
Food source	Local	59 (58.4)	19	32.2
	Commercial	42 (41.6)	17	40.5
Water source	Tap water	86 (85.1)	33	38.4
	Desalinated water	15 (14.9)	3	20.0

Statistical comparisons and unadjusted odds ratios for the recorded husbandry variables are reported in Table 4 and Figure 3.

Table 3. Overall and parasite-specific prevalence of intestinal parasites among examined ornamental birds (n = 101).

Finding	n	% of sample	95% CI
Negative	65	64.4	54.6–73.0
Eimeria	23	22.8	15.7–31.9
Ascaridia sp.	8	7.9	4.1–14.9
Entamoeba sp. cysts	2	2.0	0.5–6.9
Mixed (*Eimeria* + *Ascaridia* sp.)	3	3.0	1.0–8.4
Total positive	36	35.6	27.0–45.4
Total examined	101	100.0	—

CI: Wilson score 95% confidence interval.

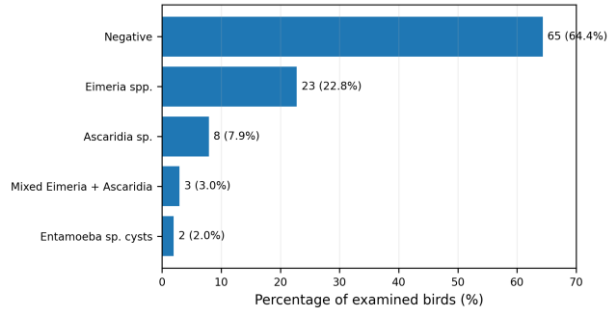


Figure 2. Distribution of parasitological findings among examined ornamental birds (n = 101). Counts and percentages are shown; mixed infection denotes concurrent *Eimeria* and *Ascaridia* findings.

Table 4. Association between selected factors and intestinal parasitic infection.

Factor/comparison	OR (95% CI)	χ^2 (df); p [Fisher]
Taxonomic group Canary vs budgerigar vs others	—	5.86 (2); 0.053 [—]
Sex Male vs female	0.93 (0.41-2.14)	0.00 (1); 1.000 [1.000]
Food source Local vs commercial	0.70 (0.31-1.59)	0.42 (1); 0.519 [0.408]
Water source Tap vs desalinated	2.49 (0.65-9.49)	1.16 (1); 0.281 [0.245]

OR: unadjusted odds ratio. CI: confidence interval. Fisher's exact p-values are shown in brackets for the three 2 × 2 husbandry comparisons; Fisher's exact test was not applied to the three-level taxonomic comparison.

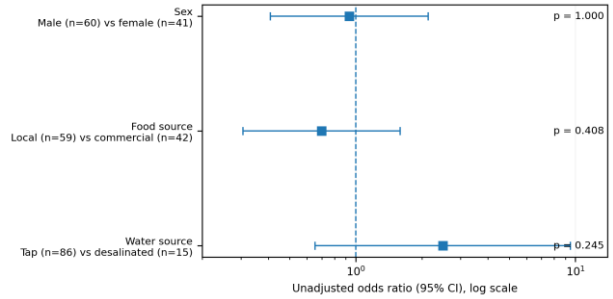


Figure 3. Association between husbandry risk factors and intestinal parasitic infection. Squares represent unadjusted odds ratios and horizontal lines show 95% confidence intervals; Fisher's exact p-values are displayed. All confidence intervals cross 1.0.

4. Discussion

This study identified intestinal parasitic infection in 35.6% of ornamental birds examined in Sebha, indicating that parasitism is common within the local cage-bird trade. The estimate is similar to the 35.6% reported among pet and zoo birds in Italy [9] and the 34.8% overall positivity reported in an Iranian avian survey [2], while lying between estimates from ornamental birds in Alexandria (31%) [11] and game and pet birds in Dhaka (45%) [12]. Domestic pigeons examined in Tripoli showed a higher combined helminth prevalence (56%) [10]. Differences among surveys should be interpreted in light of host composition, husbandry, diagnostic methods, and local exposure patterns rather than as direct evidence of geographic differences in susceptibility.

Eimeria spp. dominated the parasite spectrum in the present sample, accounting for most parasite-positive findings. Avian coccidia are

favoured by husbandry conditions that permit oocyst accumulation, sporulation, and re-ingestion, including contaminated cage floors and shared feed or water vessels. The lower *Eimeria*/coccidian prevalence reported in Iran and Italy [2,9] may therefore reflect differences in husbandry or host composition; however, because the present questionnaire captured only sex, food source, and water source, this explanation remains an inference rather than a tested causal conclusion.

Ascaridia sp. ova were identified less frequently than *Eimeria* spp. oocysts (7.9% versus 22.8%). Higher ascarid prevalence has been reported in pigeons in Tripoli and game birds in Dhaka [10,12], and *Ascaris*-type ova were also reported among ornamental birds in Alexandria [11]. The lower value in Sebha may reflect reduced contact of cage-reared granivorous birds with contaminated substrate, although intermittent helminth egg shedding and differences in host populations and sampling design may also contribute.

Prevalence varied across taxonomic groups, but several groups were represented by very small samples and consequently had wide confidence intervals. For example, the single Cape parrot was positive, whereas the lovebird group (n = 14) had a prevalence of 57.1% with a 95% CI of 32.6-78.6%. The comparison among canaries, budgerigars, and all other groups combined approached statistical significance ($p = 0.053$), but this does not establish a species-specific effect. Observed differences may reflect host susceptibility, feeding behaviour, husbandry, or other unmeasured exposures, and larger species-stratified samples are required to distinguish among these explanations.

None of the three recorded husbandry variables—sex, food source, or water source—was significantly associated with infection. This is consistent with the absence of a sex effect in the Dhaka survey [12]. Nevertheless, the present analysis was univariable, and the questionnaire did not capture potentially important determinants such as stocking density, cage-floor hygiene, duration of ownership, clinical status, or recent antiparasitic treatment. Consequently, the absence of statistical significance should not be interpreted as evidence that husbandry is unimportant.

The findings should be interpreted within several limitations. The cross-sectional, single-city design limits temporal and geographic generalizability, and the sampling frame was restricted to birds accessible through participating breeders, pet shops, and traders. Several taxonomic groups had small sample sizes, producing wide confidence intervals and unstable extreme prevalence estimates. Parasite identification relied exclusively on morphology-based light microscopy after concentration, without molecular confirmation, which may permit misclassification of morphologically similar taxa and precludes confident species-level assignment within genera such as *Eimeria* and *Ascaridia*. *Entamoeba*-positive samples were therefore reported conservatively as cystic forms rather than trophozoites. In addition, no multivariable model was fitted, so independent predictors of infection could not be established. Future studies should use larger multicentre and multi-season samples, record a broader set of husbandry and clinical variables, and incorporate molecular confirmation and targeted screening for zoonotic protozoa such as Giardia and *Cryptosporidium*.

Despite these constraints, the study provides baseline data for an under-investigated component of animal health in southern Libya. The broad confidence intervals displayed in Figure 1 are informative rather than merely graphical variability: they directly reflect the limited precision available for sparsely sampled species and support cautious interpretation of between-species comparisons.

5. Conclusion

Intestinal parasitic infection was detected in just over one-third of the ornamental birds examined in Sebha, with *Eimeria* spp. as the dominant finding. Canaries and lovebirds showed numerically higher prevalence than budgerigars and cockatiels, but subgroup uncertainty prevents definitive species-level conclusions. No significant association was identified between infection and sex, food source, or water source. At the national level, these data provide an initial baseline for ornamental-bird parasitism in southern Libya and support the inclusion of cage birds in broader veterinary surveillance and future One Health research. Molecular parasite characterization and expanded regional sampling are priorities for subsequent work.

6. Recommendations

Periodic faecal screening should be encouraged in breeding facilities, pet shops, and newly acquired ornamental birds, together with routine cage hygiene, regular cleaning of feeders and drinkers, prompt isolation of clinically unwell birds, and quarantine of new arrivals before introduction into established collections. Breeder education should emphasize husbandry practices that reduce faecal-oral transmission. Future multicentre studies should incorporate molecular identification and specifically evaluate zoonotic parasites at the human-bird interface.

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