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Seasonal variation in prevalence and identification of ectoparasites in chickens (*Gallus domesticus*) in Maiduguri, Borno State, Nigeria

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ABSTRACT

Aim: The main purpose of the study was to investigate the seasonal variation, prevalence, and species composition of ectoparasites infesting chickens (*Gallus domesticus*) in Maiduguri, Borno State, Nigeria.
Method and materials: A total of 1,685 chickens from live bird markets and poultry farms were examined across the rainy, cold dry and hot dry seasons. Physical examination and laboratory identification techniques were employed to detect and classify ectoparasites.
Results: An overall prevalence of 75.73% (1,276/1,685) was recorded, with significantly higher infestations during the rainy season (29.38%) compared to cold dry (24.57%) and hot dry (22.61%) periods ($\chi^2 = 65.29$, $p < 0.0001$). Ten ectoparasite species were identified, dominated by lice (*Menacanthus stramineus*: 22.61%; *Gonoides gigas*: 10.74%), mites (*Cnemidocoptes mutans*: 8.72%), ticks (*Argas persicus*: 3.68%), and fleas (*Echidnophaga gallinacea*: 0.89%). Mixed infestations involving multiple taxa occurred in 2.4% of birds. Anatomical localization varied by species, with *M. stramineus* concentrated around the vent and breast, while mites and ticks showed predilection for scaly legs and skin folds. Ectoparasite prevalence was significantly higher in adult (40.95%) and female chickens (87.29%), with chicks being least affected (4.99%). Village chickens had a significantly higher infestation burden (45.46%) compared to exotic breeds (30.27%) ($\chi^2 = 230.8$, $p < 0.0001$). Seasonal trends showed species-specific variation, with *M. stramineus* peaking in the hot dry season, while *C. mutans* was more frequent in the cold dry season.
Conclusion: It was concluded that occurrence of mixed infestations, although relatively low (2.4%), further complicates control efforts due to potential additive or synergistic pathogenic effects. Importantly, species such as *Cnemidocoptes mutans*, *Ornithonyssus bursa*, and *Argas persicus* all of which possess zoonotic or severe pathological potential were identified with significant prevalence across seasons and host categories.

Keywords: Ectoparasites, Species composition, *Gallus domesticus*, Prevalence, Seasonal Variation.

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Introduction

Chickens (*Gallus domesticus*) are vital components of agricultural systems worldwide, serving as significant contributors to the global supply of meat and eggs (Tenza *et al*., 2024). Beyond their economic importance, chickens play an essential role in rural livelihoods, food security, and poverty alleviation, particularly in developing countries (Hedman *et al*., 2020; Manyelo *et al*., 2020). However, their health and productivity are continually jeopardized by various pathogens and parasites (Mesa-Pineda *et al*., 2021; Makouloutou-Nzassi *et al*., 2024). Among these, ectoparasites pose a formidable challenge, resulting in reduced production efficiency, compromised welfare, and significant economic losses for poultry farmers (Odenu *et al*., 2016; Lawal *et al*., 2017; Refisa and Rebuma, 2024).

Ectoparasites affecting chickens include a broad range of organisms such as mites, lice, fleas, and ticks. These parasites inflict direct harm on their hosts through blood-feeding, tissue damage, and irritation, and they also act as vectors for

various pathogens, exacerbating the spread of infectious diseases within poultry flocks (Muhammad *et al*., 2021; Luka *et al*., 2022; Refisa and Rebuma, 2024). The consequences of ectoparasite infestations extend beyond individual birds, leading to reduced flock productivity, lower egg quality, and compromised meat production, thereby causing substantial economic repercussions for the poultry industry (Grace *et al*., 2024).

In Nigeria, one of Africa's largest poultry markets, managing poultry health remains a persistent challenge due to the country's diverse ecological and climatic conditions (Ugo *et al*., 2020). Seasonal variations play a significant role in modulating ectoparasite prevalence and infestation intensity. Changes in temperature, humidity, and rainfall patterns influence ectoparasite survival, reproduction, and dispersal, while seasonal host behaviors, such as molting and changes in flock size, further impact ectoparasite dynamics (Benedek *et al*., 2024; Wang *et al*., 2024). Studies have demonstrated the importance of understanding these seasonal patterns to develop tailored intervention strategies aimed at minimizing infestation risks and optimizing poultry health (Fabiyi, 1980a,b; Fabiyi *et al*., 2017).

Despite the well-documented impact of ectoparasites on poultry production, there remains limited research on their seasonal variation in Nigeria, particularly in the northeastern region. Existing studies have often focused on prevalence of specific ectoparasite species, offering little perception into seasonal dynamics across different ecological zones. This lack of comprehensive data emphasizes the need for a thorough investigation into the prevalence, species diversity, and seasonal variations of ectoparasites in chickens in North-eastern Nigeria.

Maiduguri, located in the semi-arid northeastern region of Nigeria, is characterized by distinct seasonal patterns, including cold, dry harmattan conditions during the dry season and wet, humid weather during the rainy season (Bello *et al*., 2023; Abaje, 2023). These climatic conditions significantly influence the prevalence and distribution of ectoparasites, making Maiduguri an ideal setting for studying their seasonal dynamics in chickens. This study was aimed to address this knowledge gap by determining the prevalence, species diversity, and seasonal variation of ectoparasite infestations in chickens and assess the risk factors associated with ectoparasite infestations in chickens Maiduguri, Borno State, Nigeria.

Materials and Methods

Maiduguri is the largest city and capital of Borno State, it is located between longitude 11° 46´ to 11° 54´ North and latitude 13° 06´ to 13° 14´ East (Fig 1). The relief is relatively flat with a vast undulating plain that slopes gently toward Lake Chad. It has an average altitude of about 300 meters above sea level. The climate is characterized by a long dry season ranging from October to May and a short wet season raging from June to September. Temperatures in Maiduguri fluctuate greatly between seasons. During the dry season, daytime temperatures can rise as high as 40°C (104°F), while nighttime temperatures in the harmattan period can drop significantly to around 12-15°C (54-59°F). In the wet season, temperatures range between 25°C and 35°C (77°F - 95°F), providing a cooler but more humid environment (Bello *et al*., 2023).

Study Design and Sampling: A cross-sectional study was conducted between February and November 2024 to determine the seasonal variation in prevalence and identification of ectoparasites in chickens (*Gallus domesticus*) in Maiduguri, Borno State, Nigeria. Sampling was performed across three distinct seasons: rainy (June–October), cold dry (November–February), and hot dry (March–May)—to capture seasonal variations.

To ensure comprehensive coverage and minimize bias, the study area was stratified into representative locations, including live bird markets (Monday Market, Tashan Bama, Gidan Madara, and Custom Markets) and poultry farms within residential areas (Mairi, GRA, Gwange, and University of Maiduguri Staff Quarters). Stratification facilitated the inclusion of diverse poultry management systems and ectoparasite exposure levels.

Sample Size Determination: The study employed a non-probabilistic sampling approach, where sample selection was based on convenience, purposiveness, availability of chickens, and the willingness of poultry owners to permit sample collection. Given the nature of the study and the absence of prior prevalence data specific to Maiduguri, sample size determination did not follow a formal statistical formula. Instead, the sample size was guided by logistical feasibility, accessibility, and the need to obtain a sufficiently large dataset for meaningful seasonal comparisons.

A total of 1,685 chickens including both sexes (male and female), different breeds (exotic and village), and various age groups (adults, growers and chicks)were examined over the study period, distributed as follows: 566 chickens during rainy season, 553 during cold dry season, and 566 during the hot dry season. The distribution was maintained to ensure balanced seasonal representation while considering fluctuations in poultry availability and market dynamics. The chosen sampling strategy allowed for a robust assessment of seasonal ectoparasite prevalence while accommodating practical constraints in the field.

Age and Sex Determination of Chickens: The sampled chickens were categorized into three age groups based on estimated age: chicks (less than 2 months old), growers (3 to 4 months old), and adults (above 5 months old). Age classification was determined through a combination of farm records (where available), physical assessment of body size and feather development, and discussions with poultry farmers and vendors.

Sex determination was performed by examining the comb and wattle development, with males characterized by larger and more prominent combs and wattles, while females had relatively smaller, less pronounced features. Chicks that could not be accurately sexed due to the underdevelopment of secondary sexual characteristics were categorized as unclassified.

Physical Examination and Ectoparasites Collection: Chickens were physically examined for ectoparasites by parting the feathers after dusting them with Sevin® powder (1-naphthyl-N-methyl carbamate). Key body regions, including the head, neck, wings, and vent, were inspected separately to determine the predilection sites of each species. Leg scrapings were also collected for microscopic examination of mites. Ectoparasites were retrieved using forceps and magnifying lenses and preserved in 70% ethanol for further analysis.

Laboratory Identification: Specimens collected during study were transported in labeled containers to Department of Veterinary Parasitology and Entomology, University of Maiduguri. In laboratory, ectoparasites were initially sorted by genera and mounted on slides using Hoyer's medium or lactophenol. It was examined under a stereomicroscope at 7x–42x magnification with specimens isolated using a paintbrush or fine forceps.

For species-level identification, morphological features such as body segmentation, setae patterns, mouthparts, and leg morphology were analyzed. Taxonomic keys (Amber *et al*., 2023) were employed to assist identification. Using a light microscope, detailed examinations were conducted at 40x–100x magnification. Lice were identified following the descriptions and keys of Emerson (1962) and Soulsby (1982), mites and fleas were identified according to Arends (2003), and ticks were identified based on Walker *et al*. (2003). Ticks were cleared in lactophenol before identification.

Only birds that had not received pesticide treatment in the six months preceding the study were included.

Photographic Documentation: High-resolution images of ectoparasites were captured using digital microscopy for documentation and publication purposes.

Data analysis: Data generated from the study were analyzed with statistical package for social sciences version 21 (SPSS, 2012). Chi- square was used to test for significant differences between variables. Differences were considered significant at a probability level of $p < 0.05$.

Results and Discussion

Out of 1,685 chickens examined for ectoparasitic infestation in Maiduguri, Borno State, a total of 1,276 birds were found to be infested, representing an overall prevalence of 75.73%(95% CI: 73.63–77.72). Ectoparasites identified were categorized by genus and species and further grouped based on whether infestation was due to a single parasite species or a mixture of species (Table 1). Among chickens with single infestations *Menacanthus stramineus* (a louse species) was most frequently encountered ectoparasite, detected in 381 chickens (22.61%, 95% CI: 20.68–24.67). It was followed by *Gonoides gigas* (10.74%, 95% CI: 9.35–12.31), *Lipeurus caponis* (10.27%, 95% CI: 8.91–11.81) and *Cnemidocoptes mutans* (8.72%, 95% CI: 7.47–10.16). Other lice species such as *Menopon gallinae*, *Goniocotes gallinae*, and *Lipeurus caponis* had prevalence rates of 5.34%, 5.52% and 10.27%, respectively. Mites and ticks were also detected, although at lower rates. *Ornithonyssus bursa* (tropical fowl mite) infested 4.87% of chickens (95% CI: 3.94–6.00) while *Argas persicus* (fowl tick) was observed in 3.68% (95% CI: 2.88–4.69). Flea infestations were rare with *Echidnophaga gallinacea* (0.89%, 95% CI: 0.54–1.46) and *Ctenocephalides spp.* (0.65%, 95% CI: 0.36–1.16) accounting for lowest prevalence.

Table 1. Prevalence of Ectoparasites species in Chickens (*Gallus domesticus*) in Maiduguri, Borno State, Nigeria, Categorized by Genus and Species

Nature of Infestation	Genus	Species of Ectoparasites Encountered	Number of Chickens Infested (N = 1685)	Prevalence (%)	95% CI (LL - UL)
Single	*Menacanthus* (Lice)	*Menacanthus stramineus*	381	22.61	20.68 – 24.67
	Lipeurus (Lice)	*Lipeurus caponis*	173	10.27	8.91 – 11.81
	Gonoides (Lice)	*Gonoides gigas*	181	10.74	9.35 – 12.31
	Ornithonyssus (Mite)	*Ornithonyssus bursa*	82	4.87	3.94 – 6.00
	Cnemidocoptes (Mite)	*Cnemidocoptes mutans*	147	8.72	7.47 – 10.16
	Menopon (Lice)	*Menopon gallinae*	90	5.34	4.36 – 6.52
	Goniocotes (Lice)	*Goniocotes gallinae*	93	5.52	4.53 – 6.72
	Argas (Tick)	*Argas persicus*	62	3.68	2.88 – 4.69
	Echidnophaga (Flea)	*Echidnophaga gallinacean*	15	0.89	0.54 – 1.46
	Ctenocephalides (Flea)	*Ctenocephalides spp.*	11	0.65	0.36 – 1.16
Mixed	Lice, Mite, Tick	*Menacanthusstramineus* + *Menopon gallinae* + *Cnemidocoptes mutans* + *Argaspersicus*	23	1.36	0.91 – 2.03
	Lice	*Lipeurus caponis* + *Menopon gallinae* + *Gonoides gigas*	18	1.07	0.68 – 1.68
Overall	-	All combined	1276	75.73	73.63 – 77.72

Key: N = Total number of chickens sampled; CI = Confidence Interval; LL – UL = Lower limit – Upper limit

Table 2. Anatomical Localization and Mean Intensity of Ectoparasites in Chickens (Gallus domesticus) from Maiduguri, Borno State, Nigeria

Genus	Species of Ectoparasites Encountered	Anatomical Site(s)	Number of Chickens Infested (N = 1685)	Mean Intensity (± SD)	95% CI (LL - UL)
***Menacanthus* (Lice)**	*Menacanthus stramineus*	Vent, Breast, Abdomen	381	12.3 ± 3.5	20.68 – 24.67
***Lipeurus* (Lice)**	*Lipeurus caponis*	Wing Feathers, Back	173	8.5 ± 2.7	8.91 – 11.81
***Gonoides* (Lice)**	*Gonoides gigas*	Head, Neck, Thighs	181	9.1 ± 3.2	9.35 – 12.31
***Ornithonyssus* (Mite)**	*Ornithonyssus bursa*	Vent, Under Feathers	82	6.7 ± 2.4	3.94 – 6.00
***Cnemidocoptes* (Mite)**	*Cnemidocoptes mutans*	Legs, Feet (Scaly areas)	147	7.9 ± 2.8	7.47 – 10.16
***Menopon* (Lice)**	*Menopon gallinae*	Breast, Tail Base	90	8.2 ± 3.1	4.36 – 6.52
***Goniocotes* (Lice)**	*Goniocotes gallinae*	Head, Neck	93	7.4 ± 2.9	4.53 – 6.72
***Argas* (Tick)**	*Argas persicus*	Skin folds, Under wings	62	5.1 ± 2.2	2.88 – 4.69
Flea	*Echidnophaga gallinacean*	Face, Comb, Wattles	15	4.3 ± 1.8	0.54 – 1.46
Flea	*Ctenocephalides spp.*	Head, Neck	11	3.9 ± 1.6	0.36 – 1.16
Mixed Infestation	*Menacanthus stramineus* + *Menopon gallinae* + *Cnemidocoptes mutans* + *Argas persicus*	Multiple body sites	23	15.6 ± 4.2	0.91 – 2.03
Mixed Infestation	*Lipeurus caponis* + *Menopon gallinae* + *Gonoides gigas*	Multiple body sites	18	14.8 ± 3.9	0.68 – 1.68
Overall	All combined	-	1276	10.2 ± 3.4	73.63 – 77.72

Mixed infestations were recorded in a smaller proportion of chickens. The most common mixed infestation involved *Menacanthus stramineus*, *Menopon gallinae*, *Cnemidocoptes mutans*, and *Argas persicus*, occurring in 1.36% of the birds (95% CI: 0.91–2.03). Another mixed infestation pattern consisting of *Lipeurus caponis*, *Menopon gallinae*, and *Gonoides gigas* was observed in 1.07% of chickens (95% CI: 0.68–1.68).

The anatomical localization and mean intensity of various ectoparasites identified in chickens (*Gallus domesticus*) examined in Maiduguri, Borno State, Nigeria (Table 2). Out of the total 1,685 chickens inspected, 1,276 (75.7%) were found to be infested with one or more ectoparasite species. A total of 10 different ectoparasite taxa, comprising lice, mites, ticks, and fleas, were recovered, with varying degrees of infestation and predilection sites on the birds.

Among the lice, *Menacanthus stramineus* was the most frequently encountered species, infesting 381 chickens, predominantly around the vent, breast,

and abdominal regions. It also recorded the highest mean intensity of 12.3 ± 3.5 parasites per bird (95% CI: 20.68–24.67). Other lice species included *Gonoides gigas* (181 birds; 9.1 ± 3.2 parasites; CI: 9.35–12.31), *Lipeurus caponis* (173 birds; 8.5 ± 2.7 parasites; CI: 8.91–11.81), *Menopon gallinae* (90 birds; 8.2 ± 3.1 parasites; CI: 4.36–6.52), and *Goniocotes gallinae* (93 birds; 7.4 ± 2.9 parasites; CI: 4.53–6.72), each exhibiting characteristic predilection for specific body regions such as the wings, back, head, neck, and tail base.

Mite infestation was recorded in 229 chickens, with *Cnemidocoptes mutans*, affecting the scaly regions of the legs and feet, being more prevalent (147 birds) than *Ornithonyssus bursa* (82 birds), which was typically located in the vent area and beneath feathers. Their mean intensities were 7.9 ± 2.8 (CI: 7.47–10.16) and 6.7 ± 2.4 (CI: 3.94–6.00), respectively.

Tick infestation by *Argas persicus* was observed in 62 chickens, with a relatively lower mean intensity of 5.1 ± 2.2 (CI: 2.88–4.69), commonly localized in skin folds and under the wings. Fleas were less frequently encountered, with *Echidnophaga gallinacea* infesting 15 chickens and *Ctenocephalides* spp. found in 11 birds, mainly on the face, comb, wattles, and neck, and with mean intensities of 4.3 ± 1.8 (CI: 0.54–1.46) and 3.9 ± 1.6 (CI: 0.36–1.16), respectively.

Mixed infestations involving multiple ectoparasite species were documented in 41 chickens (2.4%). The combination of *Menacanthus stramineus*, *Menopon gallinae*, *Cnemidocoptes mutans*, and *Argas persicus* was observed in 23 birds with a mean intensity of 15.6 ± 4.2 parasites (CI: 0.91–2.03), while a mixture of *Lipeurus caponis*, *Menopon gallinae*, and *Gonoides gigas* was found in 18 birds with a mean intensity of 14.8 ± 3.9 (CI: 0.68–1.68).

Overall, the mean ectoparasite intensity across all infested chickens was 10.2 ± 3.4 parasites per bird, with a 95% confidence interval ranging from 73.63 to 77.72.

It was presented the seasonal distribution and prevalence of various ectoparasites identified in chickens (*Gallus domesticus*) (N = 1685) across the rainy, cold dry, and hot dry seasons in Maiduguri, Borno State, Nigeria (Table 3). Overall, ectoparasitic infestation was significantly higher ($p < 0.0001$) during the rainy season (29.38%; 95% CI: 27.25–31.60), followed by the cold dry (24.57%; 95% CI: 22.57–26.68), and lowest during the hot dry season (22.61%; 95% CI: 20.68–24.67), with a significant seasonal variation ($\chi^2 = 65.29$).

Menacanthus stramineus was the most prevalent ectoparasite, with the highest infestation observed in the hot dry season (12.94%; 95% CI: 11.42–14.63), followed by the rainy (7.18%) and cold dry seasons (2.49%). The differences were statistically significant ($p < 0.0001$, $\chi^2 = 153.6$). *Lipeurus caponis* infestation was highest during the rainy season (4.39%), decreasing across the cold dry (3.62%) and hot dry (2.26%) seasons ($p = 0.0015$, $\chi^2 = 12.95$). Similarly, *Gonoides gigas* showed a significantly higher prevalence in the rainy season (5.76%), followed by cold dry (4.09%) and hot dry (0.89%) seasons ($p < 0.0001$, $\chi^2 = 64.54$).

Ornithonyssus bursa (tropical fowl mite) infestations were also significantly seasonal ($p = 0.0215$), with prevalence rates of 2.26%, 1.54%, and 1.07% in the rainy, cold dry, and hot dry seasons, respectively. *Cnemidocoptes mutans*, the scaly leg mite, was most frequently detected in the cold dry season (5.40%), with significantly lower occurrences in the hot dry (2.49%) and rainy (0.83%) seasons ($p < 0.0001$, $\chi^2 = 70.49$). *Menopon gallinae* showed a declining trend in infestation from rainy (2.85%) to cold dry (1.90%) and lowest during the hot dry season (0.59%) ($p < 0.0001$, $\chi^2 = 25.55$).

Other lice species, such as *Goniocotes gallinae*, also showed significantly higher prevalence during the rainy season (3.38%) compared to cold dry (1.72%) and hot dry (0.42%) ($p < 0.0001$, $\chi^2 = 42.47$). For the tick *Argas persicus*, the highest prevalence was in the cold dry season (2.79%), followed by the hot dry (0.89%) and rainy (0.83%) seasons, with significant seasonal variation ($p < 0.0001$, $\chi^2 = 30.43$).

In contrast, infestations by fleas such as *Echidnophaga gallinacean* and *Ctenocephalides* spp. were not significantly influenced by season ($p = 0.0783$ and $p = 0.3113$, respectively), with prevalence rates remaining consistently low across all seasons.

Mixed infestations involving lice, mites, and ticks occurred most frequently during the rainy season (0.71%), followed by the cold dry (0.53%) and hot dry (0.12%) seasons ($p = 0.0305$, $\chi^2 = 6.983$). Similarly, mixed lice infestations were also significantly more common in the rainy season (0.71%) than in the cold dry (0.24%) and hot dry (0.12%) seasons ($p = 0.0096$, $\chi^2 = 9.285$).

It was presented an age-based comparison of ectoparasite prevalence in chickens from Maiduguri, Borno State, Nigeria (Table 4).

Table 3. Seasonal prevalence of ectoparasites in chickens (*Gallus domesticus*) (N=1685) by species in Maiduguri, Borno State, Nigeria

Species of Ectoparasites Encountered	Season	Number of Chickens Examined	Number (%) of Chickens Infested	Prevalence (%)	95% CI (LL – UL)	p-value	χ^2
Menacanthus stramineus	Rainy	566	121 (21.38)	**7.18**[a]	6.04 – 8.51	< 0.0001	153.6
	Cold Dry	553	42 (7.59)	**2.49**[b]	1.85 – 3.35		
	Hot Dry	566	218 (38.52)	**12.94**[c]	11.42 – 14.63		
Lipeurus caponis	Rainy	566	74 (13.07)	**4.39**[a]	3.51 – 5.48	0.0015	12.95
	Cold Dry	553	61 (11.03)	**3.62**[b]	2.83 – 4.62		
	Hot Dry	566	38 (6.71)	**2.26**[c]	1.65 – 3.09		
Gonoides gigas	Rainy	566	97 (17.14)	**5.76**[a]	4.74 – 6.98	< 0.0001	64.54
	Cold Dry	553	69 (12.47)	**4.09**[b]	3.24 – 5.14		
	Hot Dry	566	15 (2.65)	**0.89**[c]	0.54 – 1.46		
Ornithonyssus bursa	Rainy	566	38 (6.71)	**2.26**[a]	1.65 – 3.09	0.0215	7.681
	Cold Dry	553	26 (4.70)	**1.54**[b]	1.05 – 2.25		
	Hot Dry	566	18 (3.18)	**1.07**[c]	0.68 – 1.68		
Cnemidocoptes mutans	Rainy	566	14 (2.47)	**0.83**[a]	0.49 – 1.39	< 0.0001	70.49
	Cold Dry	553	91 (16.46)	**5.40**[b]	4.42 – 6.58		
	Hot Dry	566	42 (7.42)	**2.49**[c]	1.85 – 3.35		
Menopon gallinae	Rainy	566	48 (8.48)	**2.85**[a]	2.16 – 3.76	< 0.0001	25.55
	Cold Dry	553	32 (5.79)	**1.90**[b]	1.35 – 2.67		
	Hot Dry	566	10 (1.77)	**0.59**[c]	0.32 – 1.08		
Goniocotes gallinae	Rainy	566	57 (10.07)	**3.38**	2.62 – 4.35	< 0.0001	42.47
	Cold Dry	553	29 (5.24)	**1.72**	1.20 – 2.46		
	Hot Dry	566	7 (1.24)	**0.42**	0.20 – 0.86		
Argas persicus	Rainy	566	14 (2.47)	**0.83**[a]	0.49 – 1.39	< 0.0001	30.43
	Cold Dry	553	47 (8.50)	**2.79**[b]	2.10 – 3.69		
	Hot Dry	566	15 (2.65)	**0.89**[c]	0.54 – 1.46		
Echidnophaga gallinacean	Rainy	566	6 (1.06)	**0.36**[a]	0.17 – 0.78	0.0783	5.095
	Cold Dry	553	1 (0.18)	**0.06**[a]	0.01 – 0.34		
	Hot Dry	566	8 (1.41)	**0.47**[a]	0.24 – 0.93		
***Ctenocephalides* spp.**	Rainy	566	2 (0.35)	**0.12**[a]	0.03 – 0.43	0.3113	2.334
	Cold Dry	553	3 (0.54)	**0.18**[a]	0.06 – 0.53		
	Hot Dry	566	6 (1.06)	**0.36**[a]	0.17 – 0.78		
Mixed Infestation (Lice, Mite, Tick)	Rainy	566	12 (2.12)	**0.71**[a]	0.41 – 1.24	0.0305	6.983
	Cold Dry	553	9 (1.63)	**0.53**[b]	0.28 – 1.01		
	Hot Dry	566	2 (0.35)	**0.12**[c]	0.03 – 0.43		
Mixed Infestation (Lice)	Rainy	566	12 (2.12)	**0.71**[a]	0.41 – 1.24	0.0096	9.285
	Cold Dry	553	4 (0.72)	**0.24**[b]	0.09 – 0.61		
	Hot Dry	566	2 (0.35)	**0.12**[c]	0.03 – 0.43		
Overall Infestation	Rainy	566	**495 (87.46)**	**29.38**[a]	27.25 – 31.60	< 0.0001	65.29
	Cold Dry	553	**414 (74.86)**	**24.57**[b]	22.57 – 26.68		
	Hot Dry	566	**381 (67.31)**	**22.61**[c]	20.68 – 24.67		

Overall, adult chickens showed the highest prevalence of ectoparasitic infestation (40.95%, 95% CI: 38.63–43.32), followed by growers (29.79%, 95% CI: 27.65–32.02), and chicks (4.99%, 95% CI: 4.05–6.14), with a statistically significant difference across the age groups ($\chi^2 = 56.09$, $p < 0.0001$).

Among the ectoparasites identified, *Menacanthus stramineus* was the most prevalent species, with the highest infestation rate recorded in adult chickens (12.28%), followed by growers (9.38%), and chicks (0.95%). This difference was statistically significant ($p = 0.0003$, $\chi^2 = 16.08$). *Lipeurus caponis* and *Gonoides gigas* followed similar trends, being significantly more prevalent in adults (5.70% and 6.05%, respectively) and growers (4.57% and 4.69%, respectively), while no infestations were recorded among chicks ($p < 0.0001$ for both species). Interestingly, *Ornithonyssus bursa* showed a reverse trend, with the highest prevalence observed in chicks (2.85%), compared to growers (1.54%) and adults (0.47%). The age-related difference was statistically significant ($p < 0.0001$, $\chi^2 = 248.4$), indicating a higher vulnerability of chicks to this mite species.

Table 4: Age-based comparison of ectoparasite prevalence in chickens (*Gallus domesticus*) from Maiduguri, Borno State, Nigeria

Species of Ectoparasites Encountered	Age Group	Number of Chickens Examined	Number (%) of Chickens Infested	Prevalence (%)	95% CI (LL – UL)	p-value	χ^2
Menacanthus stramineus	Adult	861	207 (24.04)	12.28[a]	10.80 – 13.93	0.0003	16.08
	Grower	664	158 (23.80)	9.38[b]	8.08 – 10.87		
	Chick	160	16 (10.0)	0.95[c]	0.59 – 1.54		
Lipeurus caponis	Adult	861	96 (11.15)	5.70[a]	4.69 – 6.91	< 0.0001	20.31
	Grower	664	77 (11.60)	4.57[b]	3.67 – 5.67		
	Chick	160	0 (0.00)	0.00[c]	0.0 – 0.23		
Gonoides gigas	Adult	861	102 (11.85)	6.05[a]	5.01 – 7.29	< 0.0001	21.28
	Grower	664	79 (11.90)	4.69[b]	3.78 – 5.81		
	Chick	160	0 (0.00)	0.00[c]	0.0 – 0.23		
Ornithonyssus bursa	Adult	861	8 (0.93)	0.47[a]	0.24 – 0.93	< 0.0001	248.4
	Grower	664	26 (3.92)	1.54[b]	1.05 – 2.25		
	Chick	160	48 (30.00)	2.85[c]	2.16 – 3.76		
Cnemidocoptes mutans	Adult	861	94 (10.92)	5.58[a]	4.58 – 6.78	< 0.0001	20.95
	Grower	664	53 (7.98)	3.15[b]	2.42 – 4.10		
	Chick	160	0 (0.00)	0.00[c]	0.0 – 0.23		
Menopon gallinae	Adult	861	48 (5.57)	2.85[a]	2.16 – 3.76	0.4237	1.717
	Grower	664	37 (5.57)	2.20[a]	1.60 – 3.02		
	Chick	160	5 (3.12)	0.30[a]	0.13 – 0.70		
Goniocotes gallinae	Adult	861	54 (6.27)	3.20[a]	2.46 – 4.15	0.3793	1.939
	Grower	664	31 (4.67)	1.84[a]	1.30 – 2.60		
	Chick	160	8 (5.00)	0.47[a]	0.24 – 0.93		
Argas persicus	Adult	861	43 (5.00)	2.55[a]	1.90 – 3.42	0.0031	11.56
	Grower	664	19 (2.86)	1.13[b]	0.72 – 1.76		
	Chick	160	0 (0.00)	0.00[c]	0.0 – 0.23		
Echidnophaga gallinacean	Adult	861	5 (0.58)	0.30[a]	0.13 – 0.70	0.3840	1.914
	Grower	664	8 (1.20)	0.47[a]	0.24 – 0.93		
	Chick	160	2 (1.25)	0.12[a]	0.03 – 0.43		
***Ctenocephalides* spp.**	Adult	861	6 (0.70)	0.36[a]	0.17 – 0.78	0.5170	1.319
	Grower	664	3 (0.45)	0.18[a]	0.06 – 0.53		
	Chick	160	2 (1.25)	0.12[a]	0.03 – 0.43		
Mixed Infestation (Lice, Mite, Tick)	Adult	861	15 (1.74)	0.89[a]	0.54 – 1.46	0.2159	3.066
	Grower	664	5 (0.75)	0.30[a]	0.13 – 0.70		
	Chick	160	3 (1.87)	0.18[a]	0.06 – 0.53		
Mixed Infestation (Lice)	Adult	861	12 (1.39)	0.71[a]	0.41 – 1.24	0.2515	2.761
	Grower	664	6 (0.90)	0.36[a]	0.17 – 0.78		
	Chick	160	0 (0.00)	0.00[a]	0.0 – 0.23		
Overall Infestation	Adult	861	690 (80.14)	40.95[a]	38.63 – 43.32	< 0.0001	56.09
	Grower	664	502 (75.60)	29.79[b]	27.65 – 32.02		
	Chick	160	84 (52.50)	4.99[c]	4.05 – 6.14		

Cnemidocoptes mutans was significantly more prevalent in adults (5.58%) than growers (3.15%), with no infestations in chicks ($p < 0.0001$, $\chi^2 = 20.95$). Similarly, *Argas persicus* infestations were highest in adults (2.55%) and least in chicks (0.00%) with a significant age-related difference ($p = 0.0031$, $\chi^2 = 11.56$).

On the other hand, for ectoparasites such as *Menopon gallinae*, *Goniocotes gallinae*, *Echidnophaga gallinacea*, and *Ctenocephalides* spp., although slight differences in prevalence were observed among age groups, these were not statistically significant ($p > 0.05$), indicating a more uniform distribution across all age groups.

Mixed infestations involving lice, mites, and ticks were recorded in all age groups, with adults having the highest prevalence (0.89%), though the differences were not statistically significant ($p = 0.2159$). Mixed lice infestations were recorded only in adults and growers, with no cases among chicks ($p = 0.2515$).

The prevalence and sex-wise distribution of each ectoparasite species were presented (Table 5).

Table 5: Sex-based comparison of ectoparasite prevalence in chickens **(*Gallus domesticus*)** from Maiduguri, Borno State, Nigeria

Species of Ectoparasites Encountered	Sex	Number of Chickens Examined	Number (%) of Chickens Infested	Prevalence (%)	95% CI (LL – UL)	p-value	χ^2
Menacanthus stramineus	Female	842	244 (28.98)	14.48[a]	12.88 – 16.24	< 0.0001	40.83
	Male	831	137 (16.49)	8.13[b]	6.92 – 9.53		
	Unclassified	12	0 (0.0)	0.0[c]	0.0 – 0.23		
Lipeurus caponis	Female	842	77 (9.14)	4.57[a]	3.67 – 5.67	0.1344	4.014
	Male	831	96 (11.55)	3.58[a]	4.69 – 6.91		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
Gonoides gigas	Female	842	108 (12.83)	6.41[a]	5.34 – 7.68	0.0147	8.443
	Male	831	71 (8.54)	4.21[b]	3.35 – 5.28		
	Unclassified	12	2 (16.67)	0.12[c]	0.03 – 0.43		
Ornithonyssus bursa	Female	842	52 (6.18)	3.09[a]	2.36 – 4.03	0.0375	6.565
	Male	831	30 (3.61)	1.78[b]	1.25 – 2.53		
	Unclassified	12	0 (0.0)	0.0[c]	0.0 – 0.23		
Cnemidocoptes mutans	Female	842	63 (7.48)	3.74[a]	2.93 – 4.76	0.0348	6.715
	Male	831	81 (9.75)	4.81[b]	3.89 – 5.94		
	Unclassified	12	3 (25.0)	0.18[c]	0.06 – 0.53		
Menopon gallinae	Female	842	56 (6.65)	3.32[a]	2.57 – 4.29	0.0003	16.29
	Male	831	31 (3.73)	1.84[b]	1.30 – 2.60		
	Unclassified	12	3 (25.0)	0.18[c]	0.06 – 0.53		
Goniocotes gallinae	Female	842	53 (6.29)	3.15[a]	2.42 – 4.10	0.0032	11.52
	Male	831	37 (4.45)	2.20[b]	1.60 – 3.02		
	Unclassified	12	3 (25.0)	0.18[c]	0.06 – 0.53		
Argas persicus	Female	842	40 (4.75)	2.37[a]	1.74 – 3.21	0.0584	5.682
	Male	831	22 (2.65)	1.31[a]	0.87 – 1.97		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
Echidnophaga gallinacean	Female	842	9 (1.07)	0.53[a]	0.28 – 1.01	0.7122	0.6789
	Male	831	6 (0.72)	0.36[a]	0.17 – 0.78		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
***Ctenocephalides* spp.**	Female	842	7 (0.83)	0.42[a]	0.20 – 0.86	0.6475	0.8694
	Male	831	4 (0.48)	0.24[a]	0.09 – 0.61		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
Mixed Infestation (Lice, Mite, Tick)	Female	842	14 (1.66)	0.83[a]	0.49 – 1.39	0.5458	1.211
	Male	831	9 (1.08)	0.53[a]	0.28 – 1.01		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
Mixed Infestation (Lice only)	Female	842	12 (1.43)	0.71[a]	0.41 – 1.24	0.3522	2.087
	Male	831	6 (0.72)	0.36[a]	0.17 – 0.78		
	Unclassified	12	0 (0.0)	0.0[a]	0.0 – 0.23		
Overall Infestation	Female	842	735 (87.29)	43.62[a]	41.27 – 46.0	< 0.0001	127.5
	Male	831	530 (63.78)	31.45[b]	29.28 – 33.71		
	Unclassified	12	11 (91.67)	0.65[c]	0.36 – 1.16		

Overall, the prevalence of ectoparasite infestation was significantly higher in female chickens (87.29%; 735/842) compared to males (63.78%; 530/831), with a statistically significant difference (χ^2 = 127.5, p< 0.0001). Only 11 of the 12 unclassified birds were infested (91.67%), representing 0.65% of the total prevalence.

Menacanthus stramineus was the most prevalent ectoparasite, with a significantly higher infestation rate in females (28.98%) than in males (16.49%) (p< 0.0001; χ^2 = 40.83). Similarly, *Gonoides gigas* showed a significantly higher prevalence in females (12.83%) compared to males (8.54%) (p = 0.0147; χ^2 = 8.443), and *Ornithonyssus bursa* followed the same trend, with females exhibiting a 6.18% infestation rate versus 3.61% in males (p = 0.0375; χ^2 = 6.565). *Menopon gallinae* and *Goniocotes gallinae* also showed significantly higher prevalence among females (6.65% and 6.29%, respectively) compared to males (3.73% and 4.45%, respectively), with corresponding χ^2 values of 16.29 (p = 0.0003) and 11.52 (p = 0.0032).

Contrastingly, *Cnemidocoptes mutans* was significantly more prevalent in male chickens

(9.75%) than in females (7.48%) (p = 0.0348; χ^2 = 6.715). Although *Argas persicus* had a higher numerical prevalence in females (4.75%) than males (2.65%), the difference was not statistically significant (p = 0.0584; χ^2 = 5.682). Similarly, *Lipeurus caponis* showed no significant difference between sexes (p = 0.1344; χ^2 = 4.014), despite a higher prevalence in males (11.55%) than in females (9.14%).

Low overall prevalence was recorded for *Echidnophaga gallinacean* and *Ctenocephalides* spp., with no statistically significant sex-based differences observed (p = 0.7122 and 0.6475, respectively). Mixed infestations involving lice, mites, and ticks were rare and not significantly different between sexes. Female chickens exhibited slightly higher occurrences of mixed infestations involving lice only (1.43%) and lice-mite-tick combination (1.66%) compared to males (0.72% and 1.08%, respectively), though these differences were not statistically significant (p> 0.05).

It was presented the comparative prevalence of ectoparasitic infestations between village and exotic chicken breeds in Maiduguri, Borno State, Nigeria (Table 6). Across all ectoparasite species identified, village chickens exhibited a consistently higher prevalence of infestation compared to exotic breeds, with statistically significant differences (p < 0.05) observed in nearly all cases.

Table 6: Breed-based comparison of ectoparasite prevalence in chickens (*Gallus domesticus*) from Maiduguri, Borno State, Nigeria

Species of Ectoparasites Encountered	Breed	Number of Chickens Examined	Number (%) of Chickens Infested	Prevalence (%)	95% CI (LL – UL)	p-value	χ^2	Relative Risk	Odds Ratio
Menacanthus stramineus	Village	835	204	12.11[a]	10.64 – 13.75	0.0384	3.133	1.173	1.229
	Exotic	850	177	10.51[b]	9.13 – 12.05				
Lipeurus caponis	Village	835	98	5.82[a]	4.80 – 7.04	0.0244	3.880	1.330	1.374
	Exotic	850	75	4.45[b]	3.56 – 5.54				
Gonoides gigas	Village	835	106	6.29[a]	5.23 – 7.55	0.0103	6.583	1.439	1.503
	Exotic	850	75	4.45[b]	4.80 – 7.04				
Ornithonyssus bursa	Village	835	51	3.03[a]	2.31 – 3.96	0.0189	5.509	1.675	1.719
	Exotic	850	31	1.84[b]	1.30 – 2.60				
Cnemidocoptes mutans	Village	835	88	5.22[a]	4.26 – 6.39	0.0089	6.847	1.518	1.579
	Exotic	850	59	3.50[b]	2.72 – 4.49				
Menopon gallinae	Village	835	70	4.15[a]	3.30 – 5.21	< 0.0001	30.30	3.563	3.797
	Exotic	850	20	1.19[b]	0.77 – 1.83				
Goniocotes gallinae	Village	835	55	3.26[a]	2.51 – 4.22	0.0286	3.617	1.473	1.507
	Exotic	850	38	2.26[b]	1.65 – 3.09				
Argaspersicus	Village	835	41	2.43[a]	1.80 – 3.28	0.0078	7.073	1.987	2.038
	Exotic	850	21	1.25[b]	0.82 – 1.90				
Echidnophaga gallinacean	Village	835	10	0.59[a]	0.32 – 1.08	0.2044	-	2.036	2.048
	Exotic	850	5	0.30[a]	0.13 – 0.70				
***Ctenocephalides* spp.**	Village	835	7	0.42[a]	0.20 – 0.86	0.3821	-	1.781	1.788
	Exotic	850	4	0.24[a]	0.09 – 0.61				
Mixed Infestation (Lice, Mite, Tick)	Village	835	20	1.19[a]	0.77 – 1.83	0.0004	-	6.627	6.764
	Exotic	850	3	0.18[b]	0.06 – 0.53				
Mixed Infestation (Lice)	Village	835	16	0.95[a]	0.59 – 1.54	0.0006	-	8.144	8.283
	Exotic	850	2	0.12[b]	0.03 – 0.43				
Overall Infestation	Village	835	766	45.46[a]	43.10 – 47.85	< 0.0001	230.8	1.529	7.401
	Exotic	850	510	30.27[b]	28.12 – 32.51				

The most prevalent ectoparasite species in both breeds was *Menacanthus stramineus*, with a significantly higher prevalence in village chickens (12.11%; 95% CI: 10.64–13.75) than in exotic chickens (10.51%; 95% CI: 9.13–12.05) (χ^2 = 3.133; p = 0.0384). This was followed by *Gonoides gigas* (6.29% in village vs. 4.45% in exotic; χ^2 = 6.583; p = 0.0103) and *Lipeurus caponis* (5.82% vs. 4.45%; χ^2 = 3.880; p = 0.0244), which also showed significant breed-associated variation.

A similarly notable trend was observed for *Cnemidocoptes mutans* (5.22% in village vs. 3.50% in exotic; χ^2 = 6.847; p = 0.0089), *Ornithonyssus bursa* (3.03% vs. 1.84%; χ^2 = 5.509; p = 0.0189), *Goniocotes*

gallinae (3.26% vs. 2.26%; $\chi^2 = 3.617$; $p = 0.0286$), and *Argas persicus* (2.43% vs. 1.25%; $\chi^2 = 7.073$; $p = 0.0078$). The most significant breed difference was observed in the prevalence of *Menopon gallinae*, which was three times more common in village chickens (4.15%) than in exotic breeds (1.19%), with a highly significant chi-square value ($\chi^2 = 30.30$; $p < 0.0001$), relative risk (RR = 3.563), and odds ratio (OR = 3.797).

Mixed infestations involving lice, mites, and ticks were more frequently recorded among village chickens (1.19%) than exotic breeds (0.18%), with statistically significant differences ($p = 0.0004$; RR = 6.627; OR = 6.764). Likewise, mixed lice infestations alone were significantly more prevalent in village birds (0.95%) than exotic birds (0.12%) ($p = 0.0006$; RR = 8.144; OR = 8.283).

Although *Echidnophaga gallinacea* and *Ctenocephalides* spp. were detected at low levels in both breeds, the breed differences were not statistically significant ($p > 0.05$), suggesting a more uniform distribution of these flea species.

Overall, a markedly higher infestation burden was observed among village chickens, with 45.46% (766/835) of birds affected (95% CI: 43.10–47.85), compared to 30.27% (510/850) in exotic chickens (95% CI: 28.12–32.51), a difference that was highly significant ($\chi^2 = 230.8$; $p < 0.0001$). Village chickens were 1.53 times more likely to be infested than exotic chickens (RR = 1.529), with an odds ratio of 7.401, indicating substantially greater risk and odds of ectoparasite infestation.

The present study revealed a notably high overall prevalence (75.73%) of ectoparasitic infestation in chickens (*Gallus domesticus*) in Maiduguri, Borno State, Nigeria. The findings highlighted the considerable burden ectoparasites pose in semi-intensive and backyard poultry systems—particularly in tropical environments where warmth and humidity support arthropod survival and reproduction. This observed prevalence aligns closely with previous studies, including 75.85% in Gwagwalada Area Council, Abuja (Odenu *et al*., 2016), 56.6% in Emene, Southeastern Nigeria (Okechukwu and Ikpeze, 2020), 52.0% in Awka – Anambra State (Onyekachi, 2021), 43.3% in Agbani – Enugu State (Mbah-Omeje, 2023) and 77.9% in Ethiopia (Demise *et al*., 2021). Similarly, Singh *et al*. (2021) and Elmi (2024) reported a high prevalence of ectoparasites in chickens in Uttar Pradesh, India and in and around Dire Dawa, Ethiopia respectively, confirming that poultry ectoparasitism was a shared challenge across agroecological zones in both Africa and Asia. In agreement with present findings, Muhammed *et al*. (2024) reported 44.44% lice prevalence as the most abundant ectoparasite group in chickens from Akko, Gombe State, Nigeria, followed by mites (25.93%), fleas (15.74%), and ticks (13.89%). This regional comparison reflected the widespread dominance of lice and supports the hypothesis that lice are ecologically well-adapted to extensive and semi-intensive management systems prevalent in northeastern Nigeria.

The predominance of lice in the current study, with *Menacanthus stramineus* (22.61%) as the most dominant species, is consistent with findings by Odenu *et al*. (2016), who identified lice as accounting for 87.9% of infestations, and also aligns with reports from Adang *et al*. (2009), Onyekachi (2021), Muhammed *et al*. (2024), where *M. stramineus* was frequently isolated in commercial as well as rural poultry systems. Notably, Rezaei *et al*. (2016) and Singh *et al*. (2021) similarly highlighted that lice exhibited the highest species diversity among all ectoparasites in Iranian and Indian chickens respectively, reinforcing the ecological dominance and adaptive advantage of lice in free-ranging poultry across varied geographies. *M. stramineus*, the chicken body louse, thrives in unhygienic, overcrowded environments and contributes to reduced growth, anemia, stress-induced immunosuppression, and economic losses (Rezaei *et al*., 2016).

Other commonly encountered lice species in this study include *Gonoides gigas* (10.74%) and *Lipeurus caponis* (10.27%), which reflect similar prevalence patterns reported by Odenu *et al*. (2016), Tessema (2019), and Kebede *et al*. (2017). These species, though often neglected, have pathophysiological impacts through irritation, epidermal damage, and interference with thermoregulation and feed conversion efficiency (Arends, 2003). The co-existence of other lice such as *Menopon gallinae* and *Goniocotes gallinae* further supports the concept of ecological niche sharing and poor control practices, a phenomenon noted by Singh *et al*. (2021), who documented multiple lice species co-infesting the same hosts.

Mite infestations, though less prevalent than lice in this study, remain clinically significant due to their potential for chronic skin lesions and pathogen transmission. *Cnemidocoptes mutans* (8.72%), the causative agent of scaly leg dermatitis, was the

most predominant mite identified. This is in agreement with Tamiru *et al*. (2014), Odenu *et al*. (2016), Kebede *et al*. (2017), Kaboudi *et al*. (2019) and Maru *et al*. (2023), who also reported high incidences of this burrowing mite. Singh *et al*. (2021) also confirmed that mites had the second-highest ectoparasitic diversity after lice, suggesting their adaptive presence across varied management systems. The impact of *C. mutans* is often underestimated due to its insidious progression, yet its effects on mobility and productivity in chickens are profound.

The detection of hematophagous mites such as *Ornithonyssus bursa* (4.87%) and the tick *Argas persicus* (3.68%) in the current study adds a public health dimension, as these vectors are capable of transmitting pathogens such as *Borrelia anserina* and *Salmonella* spp. (Wall & Shearer, 2001). Similar observations have been made by Tessema (2019), Enaro (2021), Nuguse and Tesfaye (2021), Nahal *et al*., (2021) and Singh *et al*. (2021), who noted that ticks, despite low diversity, showed high prevalence in some localities—likely due to their resilience and long life cycles. The presence of such vectors in poultry environments underscores the need for stringent biosecurity and regular ectoparasite surveillance.

Fleas were the least represented ectoparasite group in the current study, with *Echidnophaga gallinacea* (0.89%) and *Ctenocephalides* spp. (0.65%) occurring only marginally. It was sharply in contrast with Tessema (2019), who reported *E. gallinacea* as the most prevalent ectoparasite (83.5%), and with Odenu *et al*. (2016), who recorde 4.84% flea prevalence. Singh *et al*. (2021) similarly reported only one flea species with low prevalence. Muhammed *et al*. (2024) reported comparatively higher flea prevalence (15.74%), likely due to differing microclimatic conditions, organic litter availability, and environmental hygiene. These geographical discrepancies could be attributed to variations in environmental humidity, litter management practices, and the presence of intermediate hosts. The notably low flea burden observed in Maiduguri with semi-arid climate may be attributed to its hot, dry climate and reduced organic debris, which are unfavorable for flea breeding.

Mixed ectoparasite infestations were relatively low in the present study (1.36% and 1.07%), yet their implications should not be overlooked. Co-infestations exacerbate stress, compromise immune function, and increase susceptibility to secondary infections (Permin *et al*., 2002). While this study's co-infestation rates are lower than the 19.87% reported by Tessema (2019), they reinforce the multifactorial nature of ectoparasite-related morbidity and justify the need for integrated pest management (IPM) strategies that combine chemical, biological and managerial controls.

Overall, the ectoparasite fauna identified in this study closely parallels those reported across sub-Saharan Africa and parts of Asia. For instance, Kebede *et al*. (2017) in Ethiopia reported *L. caponis*, *M. gallinae*, *M. stramineus*, *C. mutans*, and *E. gallinacea*, while Singh *et al*. (2021) in India similarly highlighted the dominance of lice, presence of mites, and low flea diversity. This regional congruence in ectoparasite profiles underscores a global ectoparasitic ecology shaped by low-input poultry systems, environmental conditions, and minimal veterinary intervention

In the present study, the lice species *Menacanthus stramineus*, which had the highest frequency and mean intensity (12.3 ± 3.5), was predominantly observed to exhibit a marked preference for the vascular regions of the vent, breast, and abdomen. This finding aligned with previous studies by Lawal *et al*. (2016), Shitta *et al*. (2017), and Mohammed *et al*. (2021), who similarly reported these vascular areas as the primary predilection sites for this lice species in infested birds. It was noted that heavy infestations in these regions can lead to severe irritation, feather loss, anemia, and reduced productivity.

Other lice species identified in this study also showed distinct site-specific preferences on the host's body. *Gonoides gigas* and *Lipeurus caponis* were mainly found infesting the wing feathers and back, *Menopon gallinae* was observed on the vascular regions of the breast and tail base, while *Goniocotes gallinae* predominantly occurred around the head and neck. Additionally, *G. gigas* was frequently located on the vascular regions of the wings and body feathers. These findings were consistent with the observations of Amenu (2023) and Okechukwu and Ikpeze (2020), who reported similar anatomical distributions of these lice species in infested chickens. Such spatial predilections may influence host grooming efficiency and interspecies competition, as highlighted by Clayton and Walther (2001).

The mite species *Cnemidocoptes mutans*, with a mean intensity of 7.9 ± 2.8, was encountered on the

legs predominantly, specifically in the scaly regions of the shanks. The anatomical localization of these mites to the legs and shanks is associated with scaly leg dermatitis observed in some of the heavily infested chickens. This condition was characterized by hyperkeratosis, crusting and lameness which may eventually lead to deformities if left untreated. These findings were consistent with earlier reports from parts of Nigeria and Ethiopia, where *C. mutans* was similarly observed on the legs and feather bases of infested birds, causing scaly leg dermatitis with similar clinical manifestations (Nnadi and George, 2010; Amenu, 2023).

Furthermore, in the present study, the mite species *Ornithonyssus bursa*, with a mean intensity of 7.9 ± 2.8, was identified beneath the feathers of the vent region. This observation aligned with the findings of Bhowmick *et al*. (2019) and Sparagano and Ho (2020), who reported the activity of this mite in the ventral region, where it causes significant irritation and a decline in egg production in laying hens, particularly under humid tropical conditions.

The detection of the soft tick *Argas persicus*, with a mean intensity of 5.1 ± 2.2 in the present study, is of significant epidemiological importance. This avian tick is a known vector of *Borrelia anserina* (avian spirochetosis) and was associated with toxemia and paralysis, both of which can lead to considerable morbidity in poultry (Ouchene *et al*., 2020; Zahid *et al*., 2023). Its predilection for skin folds and under-wing regions, as observed in this study, aligned with the findings of Mohammed *et al*. (2021), who also identified these anatomical sites as high-risk zones and preferred attachment areas for this tick species. The persistence of *A. persicus* in free-range poultry systems, particularly in the absence of systematic acaricidal control, presents a serious veterinary and zoonotic concern.

Fleas such as *Echidnophaga gallinacea* (mean intensity 4.3 ± 1.8) and *Ctenocephalides* spp. (3.9 ± 1.6) were less frequently encountered in this study but remain of notable concern due to their hematophagous behavior and zoonotic potential. These flea species exhibited a preference for attaching to facial regions—including the eyes, wattles, comb, head, and neck—which corresponds with the anatomical predilection sites reported by Amenu (2023). Although their infestation intensity was relatively low, chronic or heavy infestations can result in anemia, restlessness, and secondary bacterial infections. These effects may negatively impact feed intake and egg production, particularly in commercial poultry systems, as reported by Okechukwu and Ikpeze (2020).

The occurrence of mixed infestations—particularly involving *Menacanthus stramineus*, *Menopon gallinae*, *Cnemidocoptes mutans*, and *Argas persicus*—was observed across multiple body sites and resulted in a significantly higher mean parasite intensity (15.6 ± 4.2). Such co-parasitism may exert synergistic effects that increase host stress and immunosuppression, thereby predisposing birds to secondary infections (Kaboudi *et al*., 2019). This finding underscores the importance of understanding co-infestations and their potential influence on disease ecology and productivity in poultry systems.

The overall mean ectoparasite burden of 10.2 ± 3.4 parasites per bird was comparable to figures reported for community poultry flocks in Nigeria (Nnadi and George, 2010), Ethiopia (Belihu *et al*., 2010; Berihun *et al*., 2024), and Tanzania (Materu and Mkhandi, 2022), highlighting the need for focused and strategic ectoparasite control interventions.

Furthermore, the spatial distribution of ectoparasites across body regions—such as the neck, breast, thighs, and vent—observed in this study corroborates the findings of Okechukwu and Ikpeze (2020) and Mohammed *et al*. (2021). These regions, often characterized by sparse feather coverage and easy accessibility, serve as favorable sites for ectoparasite attachment and feeding.

This study demonstrated a clear seasonal pattern in ectoparasite prevalence among chickens in Maiduguri, with infestation rates significantly higher during the rainy season. This finding concurs with reports by Fabiyi *et al*. (2017), Arce *et al*. (2022) and Serge *et al*. (2024), who associated high humidity and moderate temperatures with enhanced ectoparasite reproduction and transmission in free-ranging poultry.

The highest overall prevalence (29.38%) recorded during the rainy season aligned with observations from similar tropical regions, including Tanzania, Kenya, and southern Nigeria (Nnadi and George, 2010; Sabuni *et al*., 2010; Rukambile *et al*., 2020). In contrast, the lower prevalence during the hot dry season (22.61%) may be attributed to desiccating conditions that impair egg and larval survival, particularly for lice and mites (Soulsby, 1982).

Menacanthus stramineus was the most prevalent species, peaking unexpectedly during the hot dry

season (12.94%). This may reflect its resilience to arid conditions, possibly due to its ability to shelter in feather bases (Rezaei *et al*., 2016), and year-round persistence in traditional systems lacking ectoparasite control (Mohammed *et al*., 2021).

Conversely, *Lipeurus caponis*, *Gonoides gigas*, and *Goniocotes gallinae* peaked during the rainy season, consistent with findings from southern parts of Nigeria (Ehisianya *et al*., 2021; Elele *et al*., 2021). Their reliance on moisture for egg development and larval survival explains this trend.

Ornithonyssus bursa showed a significant rise during the rainy season (2.26%), supporting reports by Gharsan *et al*. (2019) and Gimba *et al*. (2019) that linked mite proliferation to humid, poorly ventilated environments.

Scaly leg mite *(Cnemidocoptes mutans)* peaked in the cold dry season (5.40%), corroborating Mansur *et al*. (2019) and Tamilam *et al*. (2022), who noted increased burrowing in colder temperatures. Dust and poor hygiene during this period likely promote transmission, particularly in floor-managed systems.

Menopon gallinae showed a declining seasonal trend, with highest prevalence in the rainy season (2.85%) and lowest in the hot dry season (0.59%), consistent with Nnadi and George (2010), who observed that moist conditions favor lice proliferation, while dryness enhances control.

The cold dry season favored *Argas persicus* (2.79%), in line with Mbah-Omeje (2024). Reduced prevalence during the rainy season may be due to habitat flooding and lower egg viability under saturated soil conditions.

Fleas (*Echidnophaga gallinacea*, *Ctenocephalides spp*.) exhibited low, stable prevalence with no significant seasonal variation, suggesting their population dynamics are more influenced by nesting substrate and host density than climate (Ruff, 1999; Wall and Shearer, 2008).

Mixed infestations were notably higher during the rainy season, likely due to overlapping favorable conditions for multiple ectoparasite taxa. This supports findings by Peter *et al*. (2022), who reported high co-infestation rates in traditional systems with minimal control. Concurrent infestations may also increase host susceptibility through stress and immunosuppression.

Higher rates of mixed lice infestations during the rainy season (0.71%) reflect the ecological compatibility of *M. stramineus*, *G. gigas*, and *L. caponis*, which share microhabitats and feeding strategies (Abubakar and Aliyu, 2024).

This study revealed a significant age-related variation in ectoparasite prevalence among chickens in Maiduguri, Nigeria. Adults exhibited the highest infestation rate (40.95%), followed by growers (29.79%) and chicks (4.99%), with a statistically significant difference ($p < 0.0001$). This trend corroborated findings from various agro-ecological zones, attributing higher ectoparasite loads in older birds to prolonged environmental exposure, larger surface areas, and complex plumage that favors parasite attachment (Kebede *et al*., 2017; Hagos *et al*., 2021; Mohammed *et al*., 2021). In contrast, Tessema (2019) and Wondimu (2019), who reported significantly higher in younger than adult birds. However, Wangelu *et al*. (2021) and Moges *et al*. (2023), found no significant difference between age groups. This difference in ectoparasite prevalence between age groups may be due to physiological differences, behavioral factors and variations in feather density and grooming habits.

The elevated burden in adults also reflects cumulative exposure in extensive or semi-intensive systems common in the region, where ectoparasite control is often inadequate (Mohammed *et al*., 2021). *Menacanthus stramineus* was the most prevalent species, particularly in adults (12.28%) and growers (9.38%), aligning with findings from Ethiopia and Nigeria (Luka *et al*., 2022; Pete *et al*., 2022; Kebede *et al*., 2021; Refisa and Rebuma, 2024). Its preference for mature plumage and higher body temperatures makes adults more suitable hosts.

Similarly, *Lipeurus caponis* and *Gonoides gigas* were absent in chicks but prevalent in older birds, reflecting their affinity for feathered regions like wings and tails (Sabuni *et al*., 2010; Bala *et al*., 2011). In contrast, *Ornithonyssus bursa* showed the highest infestation in chicks (2.85%), suggesting increased vulnerability due to softer skin, weak immunity, and exposure to infested rooding areas—hotspots for mite proliferation (Gimba *et al*., 2019).

Infestation by *Cnemidocoptes mutans* was restricted to growers (3.15%) and adults (5.58%), consistent with its predilection for keratinized leg scales absent in chicks (Fabiyi *et al*., 2017). *Argas persicus* was also more common in adults (2.55%), likely due to their frequent roosting near wall crevices, providing ideal habitats for fowl ticks (Refisa and Rebuma, 2024).

Ectoparasites like *Menopon gallinae*, *Goniocotes gallinae*, *Echidnophaga gallinacea*, and *Ctenocephalides* spp. showed no significant age differences, possibly

due to lower host specificity or wide environmental distribution. For instance, *E. gallinacea*, a zoonotic flea, can affect all age groups under poor hygienic conditions (Wall and Shearer, 2008; Shamsi *et al*., 2020; Mbah-Omeje, 2024).

Although mixed infestations were more frequent in adults, age differences were not statistically significant, supporting earlier findings that such patterns are influenced more by environmental and management factors than age alone (Mansur *et al*., 2019). The co-occurrence of multiple lice species in older birds may reflect overlapping ecological niches. The findings of the present study emphasize the need for age-targeted ectoparasite control, focusing on adults and growers as reservoirs

This study revealed a high prevalence of ectoparasite infestation in chickens in Maiduguri, with significantly higher rates in females (87.29%) than males (63.78%). This finding is consistent with those of Wondimu (2021), Mohammed *et al*. (2021) and Moges *et al*. (2023) who also found significantly higher prevalence in females compared to the male birds. The sex-related difference may be linked to prolonged retention of females in flocks for egg production, increasing exposure to parasites (Tessema, 2019). Hormonal influences, particularly the immunosuppressive effects of estrogens, may also contribute (Saif *et al*., 2003).

The findings of the present study was inconsistent with those of Girmay *et al*. (2018) who recorded higher prevalence in males compared to female chickens. However, Gharsan *et al*. (2019) and Nahal *et al*. (2021), reported no significant impact of sex on ectoparasite infestation. The inconsistency may be due to differences in grooming habits, hormonal fluctuations, feather density and the fact that females spend more time in the nest which may increase their exposure to ectoparasites

Menacanthus stramineus was found significantly affecting more females (28.98%) than males (16.49%). This blood-feeding louse can cause anemia and reduced productivity (Clayton *et al*., 2010), with similar findings reported in Nigeria and Ethiopia (Ahaotu *et al*., 2019; Abubakar and Aliyu, 2024; Hagos *et al*., 2021).

Gonoides gigas, another chewing louse, showed a higher prevalence in females (12.83%) than males (8.54%) (p = 0.0147). Its association with feather damage and reduced carcass quality has been documented in Tanzania and Nigeria (Sabuni *et al*., 2010). Likewise, the mite *Ornithonyssus bursa* was more common in females, consistent with reports by Azeez and Yassin (2024).

Menopon gallinae and *Goniocotes gallinae* also showed significantly higher infestation in females (6.65% and 6.29%, respectively). These species affect feather integrity and feed efficiency, possibly exacerbated by reduced grooming during nesting (Lakyat *et al*., 2022).

In contrast, *Cnemidocoptes mutans*, the scaly leg mite, was more prevalent in males, likely due to increased ground contact and morphological leg differences favoring colonization (Luka *et al*., 2022). *Argas persicus* was numerically higher in females but without statistical significance. Despite its low prevalence, this tick poses a risk due to its role in transmitting *Borrelia anserina* and causing anemia (Walker*et al*., 2003; Wamboi *et al*., 2020).

Lipeurus caponis showed no significant sex-related difference, suggesting other factors like grooming behavior may influence infestation (Kebede *et al*., 2021). Low prevalence rates of *Echidnophaga gallinacea* and *Ctenocephalides* spp. were noted, with no sex difference. Their occurrence may reflect environmental or seasonal limitations (Fabiyi *et al*., 2017).

Mixed infestations were uncommon and not statistically different between sexes, though slightly higher in females. These may increase health risks and reduce productivity in poorly managed systems (Permin and Hansen, 1998; Nnadi and George, 2010).

The observed sex-based variations in ectoparasite prevalence in the present study call for targeted control strategies, especially in traditional poultry settings. Effective management is essential not only for improving poultry productivity but also for minimizing potential public health risks in communities where humans and poultry coexist closely.

The findings of the present study revealed a significantly higher prevalence of ectoparasites in village chickens compared to exotic breeds, reflecting the impact of production systems and environmental exposure. Similar patterns have been reported in sub-Saharan Africa, where free-range indigenous chickens experience greater parasite burdens due to minimal biosecurity (Sabuni *et al*., 2010; Bala *et al*., 2011; Kebede *et al*., 2017).

Village chickens recorded a 45.46% infestation rate, significantly exceeding the 30.27% observed in exotic breeds. This disparity was linked to their

continuous exposure to contaminated environments and lack of prophylactic care (Singh *et al*., 2021; Amenu, 2023; Hassan*et al*., 2023; Muhammed *et al*., 2024), unlike exotics, which benefit from better hygiene and veterinary services (Onyekachi, 2021).

Menacanthus stramineus was found to be significantly higher in village chickens. As a hematophagous louse, it causes feather loss, anemia, and reduced productivity (Murillo *et al*., 2024; Refisa and Rebuma, 2024). Similar dominance of *M. stramineus* has been noted in tropical poultry in Nigeria and Ethiopia (Ehisianya *et al*., 2021; Amenu, 2023).

Other lice such as *Gonoides gigas* and *Lipeurus caponis* also showed higher prevalence in village chickens, aligning with previous findings that associate their spread with poor hygiene and limited grooming (Mohammed *et al*., 2021; Peter *et al*., 2022).

Scaly leg mite (*Cnemidocoptes mutans*) was significantly more prevalent in village chickens, consistent with reports that link its presence to unsanitary, moist litter (Saif *et al*., 2003). Likewise, the higher detection of *Ornithonyssus bursa* and *Argas persicus* in village chickens reflected their role in transmitting blood-borne pathogens and exacerbating stress, blood loss, and feather pecking (Tessema, 2019; Peter *et al*., 2022).

Menopon gallinae showed the greatest disparity, a finding that mirrors its known association with irritation, poor feeding, and lowered egg production in unmanaged systems (Nunn *et al*., 2020).

Mixed infestations (lice-mite-tick and lice-only) were significantly more common in village chickens, intensifying stress and disease susceptibility (Lawal *et al*., 2017; Peter *et al*., 2022). This reflected greater ecological parasite diversity in free-range settings with ongoing exposure to multiple vectors.

Although *Echidnophaga gallinacea* and *Ctenocephalides* spp. were found in both breeds without significant differences, their presence likely stems from shared scavenging areas in peri-urban settings. Their low prevalence may also relate to the dry climate of Maiduguri, where flea survival is limited (Luka *et al*., 2022).

Conclusion

It was concluded that a high overall prevalence (75.73%) of ectoparasitic infestation among chickens in Maiduguri, Borno State, underscoring the substantial burden of ectoparasites on poultry health and productivity in the region. A total of ten ectoparasite species were identified, comprising lice, mites, ticks, and fleas, with *Menacanthus stramineus* being the most predominant species. The infestation was most commonly localized to specific anatomical regions, with the vent, breast, and abdominal areas being the primary predilection sites, especially for lice species. Notably, *M. stramineus* not only had the highest prevalence but also the highest mean intensity of infestation, suggesting its key role in ectoparasitic morbidity in chickens. Seasonal patterns demonstrated a statistically significant variation in infestation rates, with the rainy season recording the highest prevalence, followed by the cold dry and hot dry seasons. This highlights the influence of environmental conditions such as humidity and temperature on ectoparasite ecology. Likewise, age, sex, and breed were significantly associated with infestation prevalence. Adult and female chickens were more infested than growers and chicks, and males respectively, while village chickens exhibited significantly higher infestation rates compared to exotic breeds, likely due to extensive management systems and poor biosecurity. The occurrence of mixed infestations, although relatively low (2.4%), further complicates control efforts due to potential additive or synergistic pathogenic effects. Importantly, species such as *Cnemidocoptes mutans*, *Ornithonyssus bursa*, and *Argas persicus*—all of which possess zoonotic or severe pathological potential—were identified with significant prevalence across seasons and host categories.

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