



# Interspecific Relationship between the Yellow-Billed Oxpeckers and Livestock in Ndawara Village, North West Cameroon

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## Abstract

Oxpeckers are confined to the sub-Saharan African region and are vital for ungulates' health and the environment given their status as the world's only obligate mammal gleaners. In this study, we determined the interspecific relationship between Oxpeckers and livestock and the effects of anthropogenic activities on their activities. The study started in October 2021 and ended in June 2023 in North-West Region of Cameroon. We used point count method to collect data on birds during the wet and dry seasons. We found that the average duration spent by Yellow-billed Oxpeckers (YBOs) significantly differed with host type. Livestock with more Oxpecker visits were cattle but were frequently treated with poisonous acaricides. These acaricides have adverse effects on Oxpeckers and potential long-term ecological consequences on the entire ecosystem. Mutualistic relationship was significantly the most observed relationship between the YBOs and livestock compared parasitic and commensal relationships. However, there was a significant seasonal change in the feeding strategy of the Oxpeckers due to the impact of acaricides and variation in environmental factors. This study found that YBO-livestock relationship is chiefly mutualistic and can become parasitic or commensal when opportunity occurs. Our findings however, provide a crucial baseline that can contribute more knowledge on the ecological role of Oxpeckers to ungulates. Conservation education and awareness via workshops and focus group discussions on the ecological role of the species can inspire local people to become involved in the conservation of Oxpeckers.

## Keywords

Feeding Patterns, Yellow-Billed Oxpeckers, Livestock, Anthropogenic

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## 1. Introduction

Oxpeckers are native to sub-Saharan Africa, and they play a crucial role in maintaining the health of ungulates and the environment due to their unique status as the world's only obligate mammal gleaners [1]. There are two species of Oxpeckers: the Red-billed Oxpecker (*Buphagus erythrorhynchus*) and the Yellow-billed Oxpecker (*Buphagus africanus*). While both species share ecological similarities, only the Yellow-billed Oxpecker (YBO) is found in Cameroon. The YBOs are fairly gregarious, forming large, chattering flocks mostly in the late morning and late afternoon hours (Nshom, D. L. Pers. Obs). Oxpecker lays 2 - 3 eggs and non-breeding birds will roost on their host animals at night [2]. The North-West region was chosen for this study because it contains one of the biggest ranch of about 16000 ha which harbors different livestock species and thousands of individuals that serve as potential host for the YBOs. These Oxpeckers provide a vital ecosystem service by preying on ungulates' ectoparasites. For example, an adult Oxpecker can prey daily on more than 100 engorged female *Boophilus decoloratus* ticks or 13,000 larvae [3].

Oxpeckers have a widespread range but are highly dependent on large ungulates, resulting in patchy distribution across the landscape, closely linked to the availability of host species [4]. In many parts of sub-Saharan Africa, including Cameroon, Oxpeckers face significant population declines, primarily due to the extensive use of acaricides in livestock management, which reduces the availability of ectoparasites for feeding [5]. Our observations in the North West region confirmed that livestock are regularly treated with acaricides, which adversely affect the feeding behavior of Oxpeckers. During this study, we recorded the death of seven YBOs after they ingested poisoned ectoparasites from livestock.

Despite the ecological benefits of YBOs to cattle herders, many local farmers fail to recognize the birds' role in pest control, instead perceiving them as blood-suckers and vectors for diseases such as foot-and-mouth disease (Issa, M. *et al.*, 2022; Pers. Comm.). However, the ecological costs of Oxpecker blood and tissue consumption are far outweighed by the benefits of tick removal, which helps reduce the risk of cattle contracting vector-borne diseases [1] [6]. In fact, studies by [7] suggest that wound feeding is rare and only occurs opportunistically when a host is injured.

In addition to their role in pest control, YBOs exhibit unique behaviors, including utilizing livestock for water access in fast-flowing streams. The birds use two primary strategies: clinging to the legs or heads of cattle to access water, minimizing energy expenditure (Nshom, D. L. Pers. Obs.). Oxpeckers also benefit from the livestock by obtaining food, nesting materials, shelter, and protection from predators, thus fostering a unique symbiotic relationship.

Unfortunately, the use of acaricides, hunting for traditional purposes, and habitat degradation through deforestation and bushfires in the region pose significant threats to YBOs. These anthropogenic activities are not only detrimental to the birds' feeding ecology but also compromise their habitats and nesting sites (Nshom, D. L. Pers. Obs.). The need for public awareness and conservation efforts is critical to filling this knowledge gap and mitigating further harm.

In light of these challenges, this study aims to assess the feeding ecology of YBOs in the North West region of Cameroon by focusing on three primary objectives: 1) to determine the time spent by YBOs with different livestock species, 2) to examine seasonal variations in their feeding patterns, and 3) to analyze livestock behavior in response to the presence of YBOs. These findings will provide valuable insights for the development of effective management strategies to promote mutualistic relationships between Oxpeckers and livestock while ensuring their long-term conservation in the region.

## 2. Methods

### 2.1. Study Area

This study was carried out in Ndawara, a village found in the western hinterland of Boyo division and Bello sub-division in NW Cameroon (60° 51' 20.4" N and longitude 10° 02' 21.36.11" E). Ndawara harbors a ranch of about 16,000 ha, which is one of the biggest private ranches in Cameroon. Ndawara is endowed with rich soils which favor and encourage agro-tourism and as well as very cold weather that favors the growth of animals around the area. Livestock in the ranch that interact with oxpeckers include cattle, horses, camels, and sheep. Rainfall here varies between 1500 to 30,000 mm, and temperature ranges from 16°C to 32°C [8]. The Ranch (Elba ranch), typical of grassland savanna of varying vegetative structures: swampy grassland Savanna, dry grassland Savanna, Montane and lowland forested patches and degraded montane shrub forest that provide suitable different habitat types for the YBOs and livestock. The flora of Ndawara is currently threatened by bushfires and deforestation, mainly for livestock and farming, as well as a source of fuel for the local community (Nshom, D. L. Pers. Obs.). Ndawara contains a Highland Tea Estate, which the biggest privately owned estate in the world and certainly the largest in West Africa and was created in 2002 [8]. The tea estate sometimes serves as a source of food to the cattle especially in the dry seasons. The Ndawara tea estate dam and streams supply water to the ranch's livestock and other species (**Appendix 3**).

### 2.2. Research Design

Ndarawa Village has a large population of livestock (of cattle, horses, camels, and sheep) which serves as potential hosts for ectoparasites and the YBOs. The sampling stations for this study were established across the Ranch and preferred sites where the different herdsmen usually group or gather their livestock every morning and evening for feeding (water, salt, animal feed) most especially in the dry

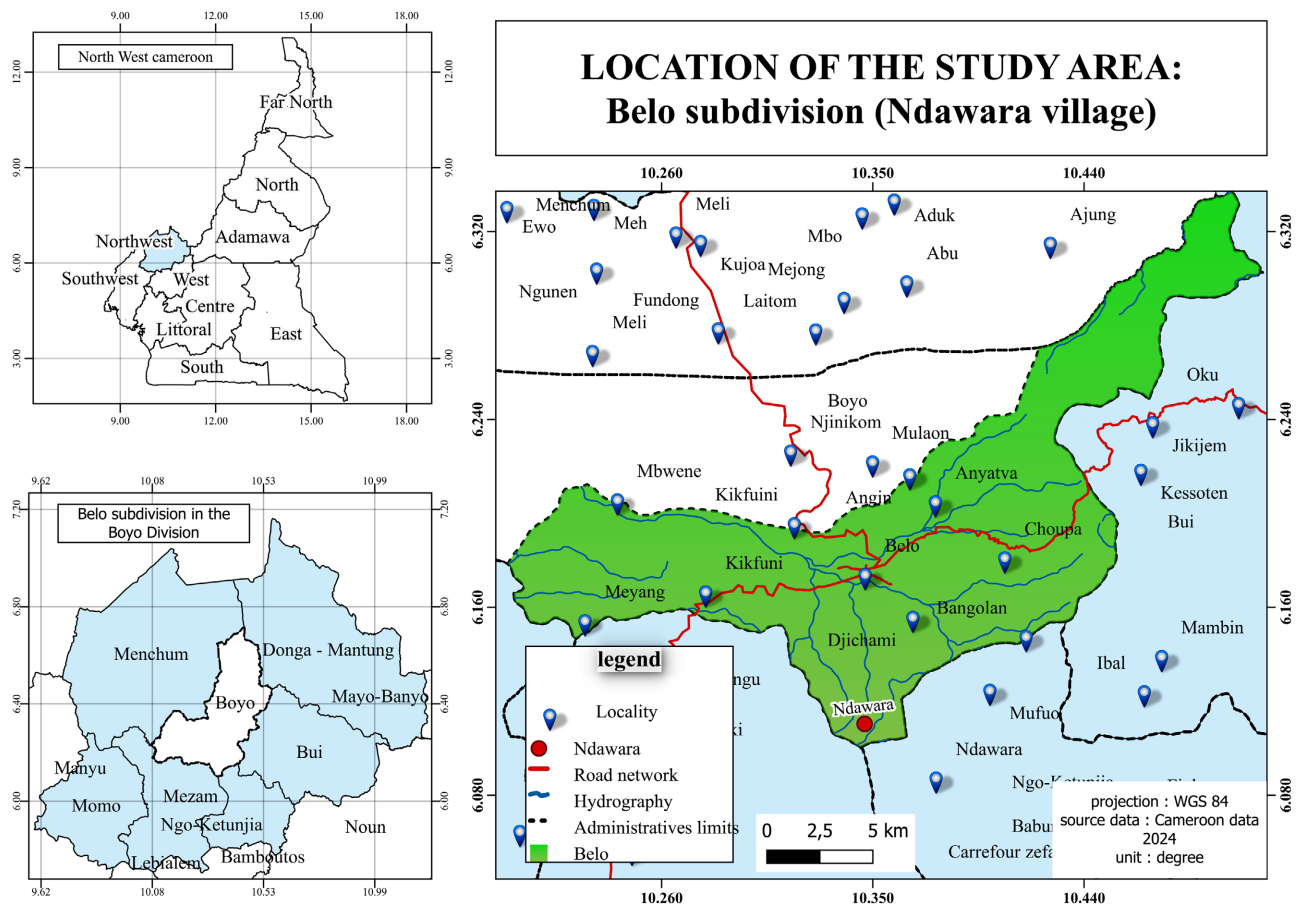


Figure 1. Location of the Ndawara Complex, North West Region.

season when pasture (weed) and water were scarce. Most of these feeding sites harbor feeding troughs (feed bunks) where the livestock farmers feed their animals and small streams for drinking water. Sampling stations were established 400 m with help of Compasses, Global Positioning systems and a Range-finders. The geographical coordinates of all the sampling stations were recorded with the aid of GPS. Compasses were used to create transects where the sampling stations were established. The Range-finders and Watches were used to measure the distance and amount of time spent by the YBOs on feeding and non-feeding activities on different hosts and body parts respectively. Wet and dry seasons were determined through direct observation of the presence or absence of rain for months and also through communication with the local farmers and residents from their traditional ecological knowledge in order to compare seasonal feeding patterns of the YBOs.

### 2.3. Data Collection

We collected YBOs data on feeding patterns, amount of time spent on feeding and non-feeding activities and Yellow-billed Oxpecker-livestock interactions in the wet and dry season, from October 2021 to June 2023. The farmers, herdsman and Vets revealed that acaricides application ranged from everyday application to annual use depending on ectoparasite infestation loads and season. Four acaricide

types were reported used: Amitraz, Capsidol, Flumethrin and Permethrin, using methods like dipping plant leaves in acaricides and applying them on livestock, SnapBack pressure Sprayers and putting the livestock dips with chemicals. We adopted a direct observation technique similar to [1] [9] [10]. See section 2.4 for the explanation of direct observation Technique.

## 2.4. Direct Observation Technique

Data collection on feeding patterns, amount of time spent by the YBOs (time budget) on different activities on different hosts, and Yellow-billed.

Oxpeckers-livestock interactions were done through simple observations with the aid of Binoculars in the morning (9 - 12 h) and late in the afternoon (15 - 17 h), which coincides with the Yellow-billed Oxpeckers' peak feeding periods. The YBOs observation time was modified from 7 - 11 h to 9 - 12 h in Ndawara because the early morning hours were usually very cold or frigid and the birds were less active. The YBOs exhibited increased activity during warmer temperatures and reduced activity during colder early morning hours (Nshom, D. L. Pers. Obs.). Binoculars were used to view oxpeckers that were on a host at a distance of 20 m to 50 m to identify activity type and duration with the help of a Range-finder and Watch respectively. Three host categories were compared for the duration (in minutes) spent by Yellow-billed Oxpeckers (YBOs) on them: cattle, other livestock (camel, sheep, and horse), and plant/soil hosts., Data was collected on the following (**Appendix 1**): 1) Identity of the host species; 2) Number of hosts available; 3) Number of YBOs present; 4) Age class of each YBO observed (adult or juveniles base on physical appearance especially the bills); 5) Presence or absence of wounds on the host; 6) Location of YBO on the host; 7) Behavior of each YBO; 8) Host response (tolerance or rejection); 9) Time of each observation and **Table 1**. Explanation of how Response Behaviors of Host to Yellow-billed Oxpeckers (YBOs) were Categorized; 10) GPS coordinates and time of each activity observed until the YBO flew off or was no longer more visible. Oxpecker behavioral variations was recorded continuously from the first observation until the bird flew away [1] [9].

Two types of livestock responses recorded: 1) resistant behavior, considered as a response where livestock (host) interrupt YBO attendants, and 2) tolerance behavior, which entails a behavioral strategy used by livestock (host) to attain a YBO (**Table 1**) [1].

Also, behaviors were divided into non-parasitic (mutual and commensal) feeding behaviors (ticks, mouth, nose, eye, ano-genital, other insect/scurf cells feeding), parasitic feeding behaviors (wound feeding) and non-feeding (commensal) behaviors (perching, preening, calling, mating and soil-bathing). We collected behavioral observations of the YBOs until the YBOs was no longer visible or flew off the host. Behavior was considered mutual when both species benefit (oxpeckers feed on ectoparasites, livestock reduces parasite infestations). In addition, behavior was considered parasitic behavior when only one species benefits, the other is harmed (oxpeckers feed on wounds/blood, harming livestock). Also,

**Table 1.** Explanation of how response behaviors of Host to Yellow-billed Oxpeckers (YBOs) were categorized.

| Types of response  | Grouped host responses to YBOs | Operational definition  |
|--------------------|--------------------------------|---|
| Resistant behavior | Rejection                      | Host responses that resulted in YBOs either changing their body position on the host body or departing (e.g., swinging the head, jumping foot movements, and skin shake).   |
|                    | Running                        | An attempt by the host to evade YBO attacks through running.  |
| Tolerance behavior | Receptive                      | Host making certain body regions accessible through postural adjustments such as lifting the tail or lowering the ears to the YBOs and maintaining a certain posture making it easy for the YBOs to fully exhibit their activities. |
|                    | Neutral                        | Host remains standing still in response to the YBO attendant.   |

behavior was considered commensal when only one species benefits, the other is unaffected (oxpeckers use livestock for transportation/food without harming them, source of nesting material).

## 2.5. Bird Survey

Field records on the abundance and distribution of Oxpeckers were collected whilst walking through the Ranch in a series of trail networks because the distribution of Oxpeckers is closely associated with and dependent on the livestock spatial distribution. Surveys were done in the morning (8 - 12 h) and late in the afternoon (15 - 17 h) as this coincides with the bird activity periods [1] [10]. All the Oxpeckers present at each sampling station were counted.

## 2.6. Statistical Analysis

We performed all statistical analyses using R statistical software [11]. Results at a probability level of 5% were considered significant. Some livestock species were lumped together when comparison was not related to host type. This was done for species with very scanty distribution data points.

## 2.7. Amount of Time Spent by the Yellow-Billed Oxpeckers

A non-parametric Kruskal-Wallis Test was used to test whether the mean ranks of the observed duration of the Yellow-billed Oxpeckers (YBOs) on different hosts or different body parts of livestock were similar. To find out which behavioral (non-parasitic, parasitic and non-feedings) durations among the hosts or body parts were significantly different from the others, a non-parametric post-hoc Dunn's test was adjusted to compare the mean ranks of the classes.

A non-parametric two-sample Mann-Whitney test was used to compare the

duration of Yellow-billed Oxpeckers spent on feeding and that spent on other activities (lumped together as a single class for statistical purposes).

### 2.8. Analysis of the Feeding Patterns of Individual Yellow-Billed Oxpecker

Pearson's chi-squared statistic ( $\chi^2$ ) of homogeneity was employed to compare the frequencies of different feeding behaviors (non-parasitic and parasitic, and non-feeding behaviors of the YBOs. Similarly, Pearson's chi-squared statistic ( $\chi^2$ ) of independence was used to test for any association between the season and the feeding behavior. When there was significance, we performed the Post hoc chi-squared test of proportions with adjusted p-value ( $0.05/n$ , where  $n$  = number of possible combinations), to identify which combination (s) made the difference. We pooled categories together to raise the sample size wherever necessary for statistical convenience.

### 2.9. Behavior of Livestock in Response to the Presence of Yellow-Billed Oxpeckers

Pearson's chi-squared statistic ( $\chi^2$ ) of homogeneity was employed to compare the frequencies of different reactions of the host to the YBOs. Similarly, Pearson's chi-squared statistic ( $\chi^2$ ) of independence was used to test for any relationship between the resting locations of the YBOs on the host and response behavior of the host. When there was significance, we performed the Post hoc chi-squared test of proportions with adjusted p-value ( $0.05/n$ , where  $n$  = number of possible combinations), to identify which combination (s) made the difference. We pooled categories together to raise the sample size wherever necessary for statistical convenience.

## 3. Results

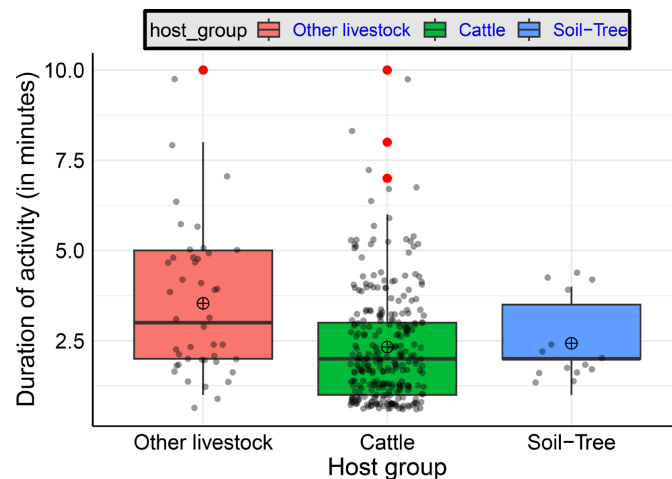
Three forms of interaction between the yellow-billed Oxpecker and livestock were analysed.

### 3.1. Amount of Time Spent by the Yellow-Billed Oxpeckers on Hosts

The average duration spent by YBOs on hosts significantly differed with host type (Kruskal-Wallis test:  $\chi^2 = 16.29$ ,  $df = 2$ ,  $P < 0.001$ ). Dunn's test of multiple comparisons suggested that the duration was significantly shorter on cattle (median = 2 min) than on other livestock (camel, sheep and horse collapsed together) (median = 3 min) ( $Z = -4.02$ ,  $P_{adj} < 0.001$ ) (**Figure 2**), but was similar when comparing other combinations. However, livestock with more visits of YBO were cattle as the proportion of cattle with YBO ( $\hat{P}_{abs.} = 0.04$ ) was significantly greater than that ( $\hat{P}_{abs.} = 0.02$ ) of other livestock (prop. test:  $\chi^2 = 34.13$ ,  $df = 1$ ,  $P < 0.001$ ).

In relation to season, the frequency of livestock with YBO were as follows: cattle (dry = 235, wet = 68), horse (dry = 29, wet = 11), camel (dry = 2, wet = 0), sheep

(dry = 0, wet = 0), others (soil/tree)(dry = 4, wet = 1). Both the cattle and the horse had similar proportions of livestock with YBO in relation to the season ( $\hat{P}_{cattle(dry/wet)} = 0.78 / 0.22$ ,  $\hat{P}_{cattle(dry/wet)} = 0.73 / 0.27$ ).



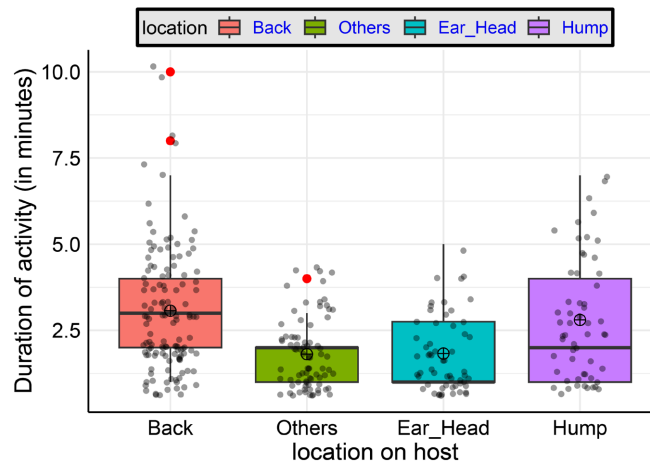
**Figure 2.** Amount of time spent (in minutes) by the YBOs on different hosts [cattle, other livestock (horse/sheep/camel), soil/tree]. While the red dots are the outliers, the grey dots and the crossed circles are the data point distributions and the mean durations, respectively.

### 3.2. On Body Parts of Hosts

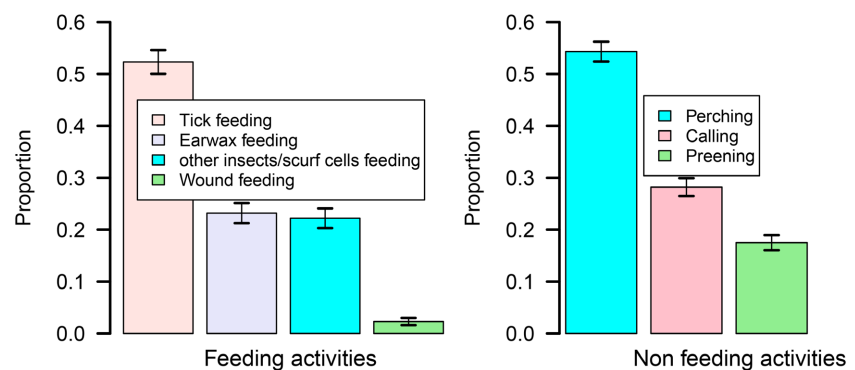
The average duration of the YBOs on the different body parts of the hosts (**Appendix 2**) was significantly different with the Kruskal-Wallis test ( $\chi^2 = 40.041$ ,  $df = 3$ ,  $P < 0.001$ ). Dunn's test of multiple comparisons suggested that the duration on the backs of the hosts was longer than on-ear/head ( $Z = 5.014$ ,  $P_{adj} < 0.001$ ) as well as when compared to other body parts collapsed together (belly, eye, genitals, leg, mouth, neck, tail and nose) and (soil, tree) ( $Z = 5.175$ ,  $P_{adj} < 0.001$ ) but was similar to the hump ( $Z = 1.209$ ,  $P_{adj} = 0.453$ ). The duration on the humps of the cattle was more greater when compared to other body parts collapsed together ( $Z = 3.004$ ,  $P_{adj} = 0.008$ ) and when compared to the ear/head ( $Z = -3.202$ ,  $P_{adj} = 0.006$ ). Hence, the ear/head and other body parts with similar durations of YBOs ( $Z = -0.571$ ,  $P_{adj} = 0.568$ ) were the least in the amount of time spent by the t YBOs (see **Figure 3**).

### 3.3. Feeding Patterns

The amount of time spent by the Oxpeckers spent on feeding and that spent on other activities (lumped together) was similar (Mann-Whitney:  $W = 12,498$ ,  $P = 0.502$ ). However, a chi-squared test of homogeneity revealed a significant difference among the feeding and non-feeding behaviours of ox-peckers, respectively. Tick feeding ( $n = 250$ ) was significantly the most preferred feeding activity ( $\chi^2 = 243.15$ ,  $df = 3$ ,  $P < 0.001$ ) compared to other forms of feeding (earwax feeding,  $n = 111$ ; other insects/scurf cells,  $n = 106$ , and wound feeding,  $n = 11$ ; **Figure 4**).



**Figure 3.** Amount of time spent by the YBOs on host body parts (back, others, ear/head, hump). The “others” category comprises: belly, eye, genitals, leg, mouth, neck, nose and tail. While the red dots are the outliers, the grey dots and the crossed circles are the data point distributions and the mean durations, respectively.



**Figure 4.** Occurrence proportions of feeding activities (tick feeding, earwax feeding, other insects/scurf cells feeding and wound feeding) of the YBOs on the host and non-feeding activities (perching, calling and preening. The error bars represent the standard errors.

Among non-feeding behaviors of ox-peckers, there was a significant difference among the occurrences of perching ( $n = 366$ ), calling ( $n = 190$ ) and preening ( $n = 118$ ) ( $\chi^2 = 144.9$ ,  $df = 2$ ,  $P < 0.001$ , **Figure 4**). Other non-feeding behaviors that were scarcely detected include dust bathing ( $n = 4$ ), fighting ( $n = 1$ ), and mating ( $n = 1$ ), which were only observed in the dry season.

There was a significant seasonal change in the feeding strategy of the YBO ( $\chi^2 = 27.319$ ,  $df = 2$ ,  $P < 0.001$ ) such that the proportion of tick-feeding (72%) increased significantly in the dry season compared to the proportions of other insects/scurf cells feeding ( $P_{adj} < 0.001$ ) and earwax-feeding ( $P_{adj} < 0.001$ ), (50% and 48%, respectively; **Figure 5**). Wound feeding was observed chiefly in the dry season ( $n = 10$ ) but was uncommon in the wet season ( $n = 1$ ).

### 3.4. Behavior of Livestock in Response to the Presence of Yellow-Billed Oxpeckers

Cattle and horses were more likely to remain neutral to interactions with yellow-

billed oxpeckers compared to other responses” (Table 2) ( $\chi^2 = 57.332$   $df = 1$ ,  $P < 0.001$ ). Interactions of YBO with sheep were uncommon (Table 2). Rejection behavior was the second most common behavior, while receptive behavior was the least observed. There was substantial evidence of an association between the type of response behaviour (rejection or neutral or receptive behaviors) and two host species (cattle or horse) ( $\chi^2 = 11.56$   $df = 2$ ,  $P = 0.003$ ).

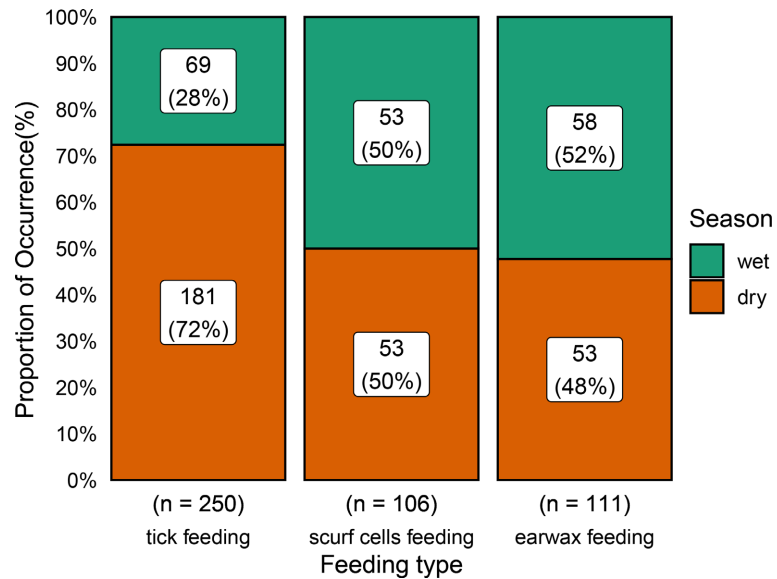


Figure 5. Seasonal feeding behavior of the yellow-billed oxpecker.

Table 2. Response behavior in association to host

| Response behaviour | Host species |        |       | Total |
|--------------------|--------------|--------|-------|-------|
|                    | Camel        | Cattle | Horse |       |
| Neutral            | 2            | 245    | 27    | 274   |
| Receptive          | 0            | 7      | 5     | 12    |
| Rejection          | 0            | 48     | 8     | 56    |

The “eye” and “tail” positions were always associated with the rejection behavior of cattle and horses (Table 3 and Table 4). Receptive behavior was not (or rarely) observed for the following locations of these two main hosts: belly, eye, genitals, head, leg, mouth, neck, nose, and tail. Neutral behavior was most observed with the “back”, “belly”, “leg” and “hump” positions for both cattle and horses (Table 3 and Table 4). We observed one case of receptive and one case of neutral behavior with camels. None of those behaviors were recorded for sheep.

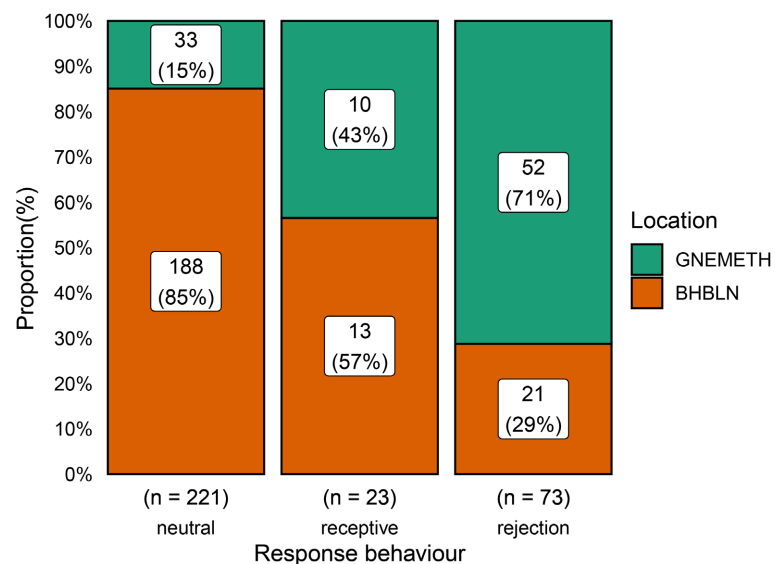
While we grouped resting locations on the host into two classes (potentially sensitive resting locations, and potentially less sensitive resting locations), we found significant ( $\chi^2 = 85.03$ ,  $df = 2$ ,  $P < 0.001$ ) and relatively strong ( $\hat{V}_{Cramer} = 0.51$ ,  $CI_{95\%} : 0.42 - 1.00$ ) association with the response behaviors of the host. Figure 6 shows a clear trend in which moving from neutral behavior to more active responses

**Table 3.** Response behavior of cattle in association to the location of YBO on the hosts.

| Response behavior | Location on cattle |       |     |     |          |      |      |     |       |      |      |      |
|-------------------|--------------------|-------|-----|-----|----------|------|------|-----|-------|------|------|------|
|                   | Back               | Belly | Ear | Eye | Genitals | Head | Hump | Leg | Mouth | Neck | Nose | Tail |
| Neutral           | 87                 | 11    | 4   | 0   | 6        | 16   | 36   | 16  | 1     | 3    | 4    | 0    |
| Receptive         | 6                  | 1     | 9   | 0   | 0        | 0    | 3    | 0   | 0     | 0    | 0    | 0    |
| Rejection         | 7                  | 2     | 11  | 9   | 6        | 14   | 7    | 2   | 2     | 0    | 6    | 3    |
| Running           | 0                  | 0     | 1   | 0   | 0        | 0    | 0    | 1   | 0     | 0    | 0    | 0    |

**Table 4.** Response behavior of horse in association to the location of YBO on the hosts.

| Response behavior | Location on horses |       |     |     |          |      |      |     |       |      |      |      |
|-------------------|--------------------|-------|-----|-----|----------|------|------|-----|-------|------|------|------|
|                   | Back               | Belly | Ear | Eye | Genitals | Head | Hump | Leg | Mouth | Neck | Nose | Tail |
| Neutral           | 111                | 12    | 4   | 0   | 7        | 17   | 45   | 16  | 1     | 4    | 4    | 0    |
| Receptive         | 7                  | 1     | 10  | 0   | 0        | 0    | 4    | 0   | 0     | 1    | 0    | 0    |
| Rejection         | 8                  | 2     | 11  | 10  | 6        | 14   | 8    | 2   | 2     | 1    | 6    | 3    |
| Running           | 1                  | 0     | 1   | 0   | 0        | 0    | 0    | 1   | 0     | 0    | 0    | 0    |

**Figure 6.** Response behavior of the host in association with the resting location of the Yellow-billed Oxpecker: BHBLN = back-hump-belly-leg-neck resting locations, GNEMETH = genitals-nose-ear-mouth-eye-tail-head resting locations.

(receptive and rejection) of the host was less observed on BHBLN resting location, but was more observed on GNEMETH resting location. Post hoc chi-squared test of proportions confirmed that the location of YBO on the GNEMETH compared to BHBLN resting location strongly generated more rejection behavior (71% of observations) than neutral behavior (15% of observations) ( $P_{adj} < 0.001$ ). Receptive behavior (43% of observations) was significantly more observed than neutral behavior (15% of observations) when YBO was on the GNEMETH location com-

pared to BHBLN location ( $P_{adj} = 0.003$ ). Finally, more rejection behavior (71% of observations) compared to receptive behavior (43% of observations) was observed when YBO was on the GNEMETH resting location than on the BHBLN resting location ( $P_{adj} = 0.02$ ).



**Figure 7.** Response behavior of the host in association with the resting location of the Yellow-billed Oxpecker: BHBLN = back-hump-belly-leg-neck resting locations, GNEMETH = genitals-nose-ear-mouth-eye-tail-head resting locations.

#### 4. Discussion

In ecosystems, almost every living thing interacts directly or indirectly with one another to survive and these interactions can be harmful, beneficial or harmless to one another (symbiosis). This is the case of YBOs and livestock in North West Cameroon. Generally, we found that the foraging patterns of the YBOs were influenced by acaricides, host body size, host species, seasons, temperature, and water sources. YBOs are dependent on livestock to survive in the North West Region of Cameroon. We found that the livestock-oxpeckers relationship was chiefly mutualistic although, it might become parasitic or commensal due to anthropogenic activities variations in environmental factors and coevolutionary adaptations. These findings are consistent with the findings of [5] [12] reported that tick feeding was not observed in their research due to routine herd treatment by the use of acaricides. In addition, [10], and [12], who reported that wound feeding accounted for only 3.1% and 7.9% of the total observations respectively, which showed that wound feeding is not the regular means of feeding by these birds.

Moreover, Oxpeckers visited and spent most of their time feeding on ectoparasites on the body of different livestock species especially cattle. The cattle had the higher relative abundance, shorter hair and larger home ranges which could enabled them to harbor diverse ectoparasite loads when compare with horses and camels. Our findings concur with that of [13] and [14]; who stated that Oxpeckers live and feed almost exclusively on the body of large herbivores. Similarly, [15] and [16], stated that larger hosts also have more extensive home ranges, travel longer distances, and may visit more diverse habitats than smaller hosts, all of which increase the likelihood of acquiring a diverse ectoparasites. Oxpeckers helps

in controlling ectoparasite loads on livestock preventing diseases such tick-borne diseases, and tick-worry. This Oxpeckers behavior could help mitigate the burdens that ectoparasites poses to livestock species, herders and farmers. For instance, the amount of money that could be invested in buying acaricides would reduce and this would lead to healthier ecosystems and increase in the population status of Oxpeckers and other wildlife species. However, tick infestation of a domestic cattle host can ensure 25 kg of the carcass weight lost at slaughter due to appetite and bleeding and loss, because the tick's saliva contains a toxin that suppresses appetite [17]. Ticks also carry diseases that affect cattle's reproductive organs and damage their skin, reducing the grade of their leather quality [17]. Similarly, [5] also reported that South African farmers reported that, they preferred oxpeckers to forage on the ectoparasite load of their cattle as ticks are constantly building resistance to acaricides alternatives. Based on our findings, conservation actions such as educating herders about the benefits of oxpeckers, promoting sustainable grazing practices, and developing alternative methods to control parasites that do not harm oxpeckers and the ecosystems are urgently needed. In addition, few cases of parasitic relationships (wound-feeding) and commensal relationships between the YBOs and livestock. Our observation concurs with that of [1] [4]-[6] [18] who stipulated that wound feeding is an opportunistic behavior that is manifested when a host is injured, and this only occurs rarely. Wound feeding was only observed in the dry season and this could be explained by the fact that most livestock travel over long distances to look for water and pasture encountering obstacles that could injured them enhancing the opportunity for YBOs to feed on injured host. Moreover, there was decrease in tick abundance and increase in YBOs abundance in the dry season which could lead to food scarcity. The population status of the YBOs significantly reduced during the wet season and increased in the dry season as they migrate to different areas due to decrease in temperature, and increase in rainfall and acaricides application (Nshom, D. L and Gnbai. B Pers. Obs., 2024).

In a conversation with a veterinarian and herdsman (personal communication, Gnbai. B and Issa. M, 2023), it was noticed that the abundance of ectoparasites on livestock tends to increase during the wet season, which is why treatment rates with acaricides increases during this time. These acaricides have adverse effects on Oxpeckers and long-term ecological consequences on the entire ecosystems such as potential secondary poisoning, and impacts on non-targeted species. Our observations are similar to that of [19] [20] who stipulated that monitoring of Oxpecker body condition coupled with feeding behavior can also indirectly be used to understand the seasonal variation in the bird's food abundance, forage effort and behavior.

Therefore, future studies should quantify tick abundance because it could influence the relationship between the Oxpeckers and their host.

Furthermore, we found that perching and calling were the most observed non-feeding behaviour in YBOs (*Buphagus africanus*) and livestock. This observation

is in line with that of [5], who outlined that perching and calling were the most observed non-feeding behavior in YBOs and domestic ungulates. In addition, our findings are similar to those of [21], who stipulated that domestic ungulates are supposedly quieter and more docile than their wild counterparts, providing a more stable perch. The YBOs spent more time on non-sensitive body parts (than on sensitive body parts of their hosts). Our investigation concurs with that of [1] [13], who stated that at the host level of resource selection, oxpeckers seem to favor some body parts of their hosts. Oxpeckers in the N-W region, exhibit a unique behavior, preferring to feed on livestock near water bodies where they frequently drank water. Also, we observed a livestock-oxpecker commensal relationship where the YBOs were using the livestock as a means of transport mostly of which could save them some energy that could be spent on flights.

The eyes and the tail were very sensitive and use for vision and defence respectively hence, this explains why the livestock usually dislodge them to other body parts that can tolerate their activities without impairing their activities. We recommend that further research should consider incorporating automated methods such as camera traps or drones to monitor Oxpeckers behavior more accurately. Also, research into alternative, non-toxic methods for pest control would strengthen the conservation recommendations and make the study more innovative in addressing anthropogenic threats.

Furthermore, single-site studies and observers bias are limited by lack of generalization of results to other locations or populations, while observer bias may lead to inaccurate results due to researchers' prejudices influencing data collection and interpretation. Therefore, further research implementing multi-site sampling, clear contextualization, blinded observation, standardized protocols, and data validation methods such as camera traps, and audio recordings to strengthen research design and credibility are recommended.

## 5. Conclusion

This research aimed to characterize the interspecies relationships between YBOs and livestock. This research found that acaricides, host species, abundance, body parts, fur thickness, behavior, seasonal variations, temperatures, and food availability all influenced the foraging patterns of the YBOs. Finally, neutral behaviour of hosts towards YBOs and tick feeding were the most observed behaviors. Therefore, we conclude that YBOs -livestock relationships are chiefly mutualistic but could become parasitic when the main source of food (ticks) is scarce or disrupted. We also found that sometimes the relation between the YBOs and livestock is commensal. These results provide a crucial baseline that will aid in the conservation and ecology of YBOs in regions with similar ecological conditions.

## 6. Implications for Conservation

This study directly addresses issues that have implications for wildlife conservation, particularly the context of livestock management and human-wildlife inter-

actions. By providing baseline data and linking this information to local conservation efforts, the research has the potential to influence both local community awareness and policy recommendation. Lastly, the integration of local ecological knowledge (through interviews and discussions with herders and farmers) is a key strength. It enhances the relevance of the research for the community and strengthens the link between sustainable local grazing practices and scientific research.

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## Authors' Contribution

Conceptualization and methodology: Docas Looh NSHOM. Investigation (field work): Docas Looh NSHOM. Writing of drafts and data analysis: Docas Looh NSHOM. Reading and correction of Drafts: Docas Looh NSHOM.

Reviewed and performed the final write-up of the manuscript: Docas Looh NSHOM.

Supervision: Tsi Evaristus Angwafo.

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### Data Availability Statement

Data used for the study is available from the corresponding authors upon request.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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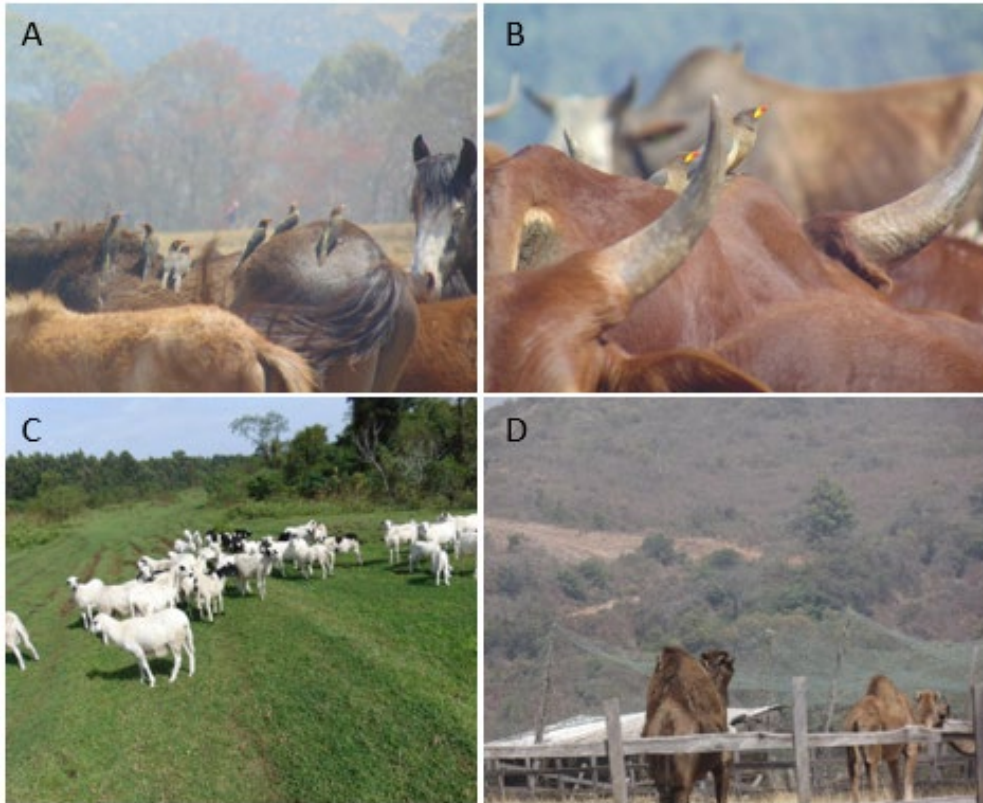
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## Appendix 2. A Sample of Livestock Species Found in Ndawara

**A** = Horses and the Yellow-billed Oxpeckers; **B** = Cattle and Yellow-billed Oxpeckers; **C** = Sheep; **D** = Camels and the Yellow-billed Oxpeckers.



### Appendix 3. Form to Assess Feeding Patterns, Amount of Time Spent by the YBOs on Activities, and Interactions of YBOs with Livestock in the Ndawara Ranch

| Point ID | Observer's Name  | Direct Observation Technique | Data Sheet A     | Sheet Number           |                  |                           |            |                 |                  |                  |                      |                            |                       |                  |                     |
|----------|------------------|------------------------------|------------------|------------------------|------------------|---------------------------|------------|-----------------|------------------|------------------|----------------------|----------------------------|-----------------------|------------------|---------------------|
| S/N      | Timestamp :D/M/Y | Ranch Section                | Weather: R/C/S/W | GPS Coordinates: (E/W) | GPS Height (ASL) | Host species: Ca/Cm/S/T/H | No of YBOs | Age of Op (J/A) | Location on Host | Activity of YBOs | Duration of activity | Distance from Observer (M) | Total No host species | Total No of YBOs | Observer's comments |
| 1        |                  |                              |                  |                        |                  |                           |            |                 |                  |                  |                      |                            |                       |                  |                     |
| 2        |                  |                              |                  |                        |                  |                           |            |                 |                  |                  |                      |                            |                       |                  |                     |
| 3        |                  |                              |                  |                        |                  |                           |            |                 |                  |                  |                      |                            |                       |                  |                     |

#### Key to Data Sheet Table (Appendix 3)

|  |  |  |   |  |
|--|--|--|---|--|
| <b>A:</b><br>D- Day<br>M-Month<br>Y-Year | <b>B:</b><br>H- Hour<br>M-Minutes                                  | <b>C:</b><br>D- Dry Season<br>R-Rainy Season<br>M-Mixed Season | <b>D:</b><br>R- Rainy<br>S- Sunny<br>C-Cloudy | <b>E:</b><br>UTM Point<br>Count Location:<br>E-Eastt |
| <b>F:</b><br>ASL- At Sea Level           | <b>G:</b><br>Ca-Cattle<br>Cm-Camel<br>H-Horse<br>S-Sheep<br>T-Tree | <b>H:</b><br>YBOs- Yellow-billed Oxpeckers                     | <b>I:</b><br>J- Juvenile<br>A-Adult           |  |