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Determinants of Dogs' Helminth Treatment-Seeking Behavior among Dog Owners in Rural Northern Tanzania: Towards Control of *Taenia multiceps*, an Emerging Threat to Small Ruminants' Productivity

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Abstract: Taeniid infections pose a significant threat to both animal and public health, as certain tapeworms within this group can also infect humans, potentially leading to severe health conditions. Therefore, this calls for preventive and control measures, such as regular deworming of dogs. While the efficacy of deworming has been established in developed countries, there is a paucity of reported deworming practices in rural areas of developing countries, such as Tanzania. This study aims to understand determinants for helminth treatment-seeking behavior towards control of cestodial taeniid infections in rural settings in northern Tanzania. A cross-sectional study was undertaken in agropastoral and pastoral areas of northern Tanzania. Comprehensive data from household surveys in selected sub-villages were collected to ascertain dog ownership, dog deworming practices, and the availability of dewormers. Analytical methods were employed to discern how various determinants influenced deworming practices among dog owners in these communities. Awareness of dewormers specifically formulated for dogs emerged as a pivotal factor affecting dog deworming practices. Dog owners who were informed about appropriate dog dewormers were nearly two times more likely to engage in deworming compared to those with limited knowledge (OR = 1.78, 95% CI 1.77 - 4.18, $p < 0.001$). A majority 32(51.6%, 95% CI: 38.7-64.3) acknowledged accessing dewormers for livestock within their wards. Praziquantel a potent dewormer on cestodes was least known to most dog owners 2(13%, 95% CI: 2.3-41.6). Praziquantel, a potent and common dewormer effective against cestodial taeniid infections, remains relatively unknown in rural areas of northern Tanzania. Therefore, more awareness on appropriate deworming agents against taeniids in dogs should be raised in rural dog-keeping communities.

Keywords: *Taenia multiceps*; dogs; determinants; deworming-seeking behavior; celebral coenurosis

1. Introduction

Cestodial taeniid infections are a significant concern for both animal and public health, as some of these tapeworms can also infect livestock and other animals such as dogs, leading to potentially serious conditions [1]. Cerebral coenurosis in small ruminants is caused by metacestode stage (*Coenurus cerebralis*) of the cestodes of dog origin from a taeniid group of flat worms called *Taenia multiceps* [2]. The parasite in dogs poses a potential zoonotic threat, as human diseases associated with *T. multiceps* have been documented in countries and settings reporting much lower prevalences in sheep and dogs than those recorded in northern Tanzania [3].

Cerebral coenurosis in small ruminants in northern Tanzania remains the major neurologic parasitic disease, significantly impacting the productivity of these animals [4]. In small ruminants, the disease affects the brain and spinal cord with a range of neurological syndrome including circling,

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staggering gate, neck tilt, and seizures in affected animals [5]. The parasites affect small ruminants of all age and sex which results in premature culling and lowered market value of the affected animals [6]. The resultant losses are directed to the small ruminants' flock owners. Effective deworming of dogs and proper hygiene practices, are essential to manage and mitigate the impact of these infections [7]. Deworming is known to be practiced in ruminants for gastrointestinal worms however, there is limited information on the deworming practices, and extent of availability of appropriate dewormer for treatment and control of cestodes such as *T. multiceps* in agro-pastoral and pastoral communities

Transmission to dogs and other canids (definitive hosts) occurs when intermediate stages (*C. cerebralis*) of *T. multiceps* from intermediate hosts are ingested by canids and develop into mature taeniid worms within the intestines of these animals. This process leads to the excretion of proglottids through feces. Each mature proglottid from *T. multiceps* infected canids may contain as many as 37,000 eggs, enabling these hosts to increase environmental contamination and infection rates within an ecosystem [8–10]. In dogs, *T. multiceps* infection is subclinical with typically few health impacts however, under heavy infestation dogs can demonstrate non-specific gastrointestinal syndrome such as abdominal pain, diarrhea and constipations [11]. Although there is limited clinical impact in dogs, treatment of *T. multiceps* and related cestodes such as *Echinococcus granulosus* in dogs is recommended to safeguard ruminant hosts [11,12]. Dog deworming status against cestodial taeniid infections in rural dogs remains uncertain despite high prevalence of celebral coenurosis reported in small ruminants in rural settings where dogs are part and parcel of the herding households. Therefore, this study seeks to understand determinants for deworming and its influence on helminth treatment (deworming) seeking behaviour, extent of availability (dewormer outlets), awareness to appropriate dewormers towards control of *T. multiceps* in agro-pastoral and pastoral communities in northern Tanzania. of worm in the brain or spinal cord of coenurosis-affected goats or sheep are eaten and

2. Results

2.1. Descriptive Demographic Statistics

The overall number dogs kept per household was 2 dogs (range 1 to 22) dogs per household. Majority of these dogs were juveniles at the age of less than eight months. Most households both in agropastoral and pastoral kept slightly more adult males than females (Figure 2).

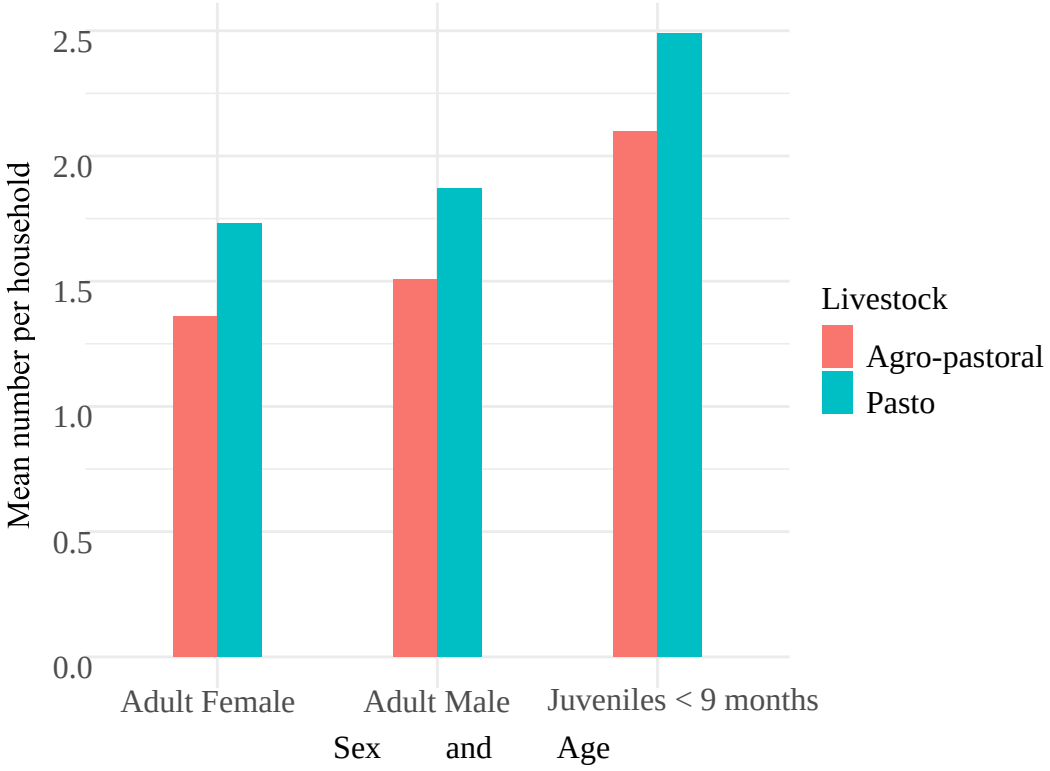

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Figure 1. Dog population characteristics by sex and age group in dog-owning households rural communities northern Tanzania.

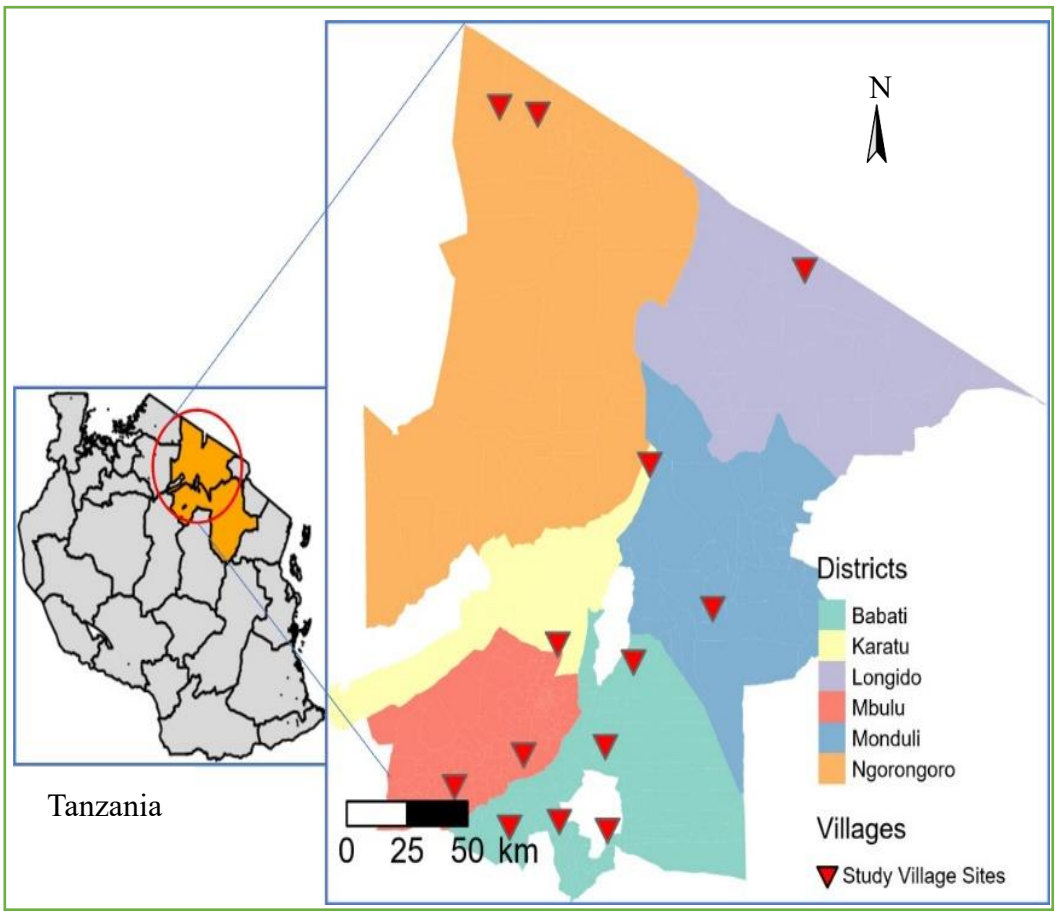

Figure 2. A map displaying the locations of the Arusha and Manyara regions in northern Tanzania (left) along with their respective districts (right) and study villages (marked by red triangles) is presented. The map was generated using R software version 4.3.2 and the Thematic Map R package. Shapefiles outlining administrative boundaries from the 2012 census were acquired from the Tanzania National Bureau of Statistics (NBS).

2.2. Awareness for Dogs Dewormer

Twelve villages participated in the study with 62 participating households. All participants who responded to the questions on awareness and importance of deworming dogs, only 15(24.2%, 95% CI: 14.6-37.0) would recall the drugs they knew. In Table 1, Levamisole and Albendazole were commonly mentioned, these are known for their potence against gastrointestinal round worms. Praziquantel a potent dewormer on cestodes such as *T. multiceps* was least mentioned 2(13%, 95% CI: 2.3-41.6).

Table 1. Common dewormer mentioned to have been used to deworm dogs in rural communities in northern Tanzania.

Dewormer type	Frequency	Percentages	95% CI
Alben® (Albendazole)	6	40.1	22.2-72.6
Ascaten P® (Praziquantel)	2	13.3	23.4-41.6
Levafas diamond® and Nilzan® (Levamizole)	7	46.6	17.4-67.1

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® = trade name in the market and all names in brackets are compound names of the products.

2.3. Dewormer Source

From Table 2, the predominant source of dewormer was agrovets located outside the villages but within the same ward, accounting for the majority 32(51.6%, 95% CI: 38.7-64.3).

Table 2. Suggested common dewormer outlet (source) in rural communities in northern Tanzania.

Suggested dewormer outlets	Frequency	Percentage (%)	95% CI
Agrovet outside village (within the ward)	32	51.6	38.7-64.3
Agrovets within village	14	22.6	13.3-35.3
Agrovets at district Headquarter Market	8	13.0	6.1-24.4
Local regular market (within village)	4	6.4	2.1-16.5
Local regular markets (outside village)	4	6.4	2.1-16.5

2.3. Analysis of Determinants Which Influence Deworming among Dog Owning Households

2.3.1. Univariate Analysis

Univariate logistic regression was used to determine how factors are linked to the deworming of dogs and what influences treatment seeking behaviour for helminths infections in dogs (Table 3). This involved 62 households that participated in a detailed survey on dog deworming and control of broad range of helminths including taeniid such as *T. multiceps.* The only significant variables within cut off level of significant p=0.25 were awareness of the appropriate dewormer for dogs and source of dewormer, with a level significant of $p < 0.001$ and p=0.1627 respectively. Hence these two were carried forward for multivariate analysis.

Table 3. Univariate analysis of household's determinant attributes in relation to deworming practices in rural communities northern Tanzania.

Variable	Variable response	Univariate regression	
		Odds Ratio (95% CI)	P-value
Livestock systems	Agro-pastoral	Ref	
	Pastoral	1.01 (0.70-1.44)	0.9635
Involved in herding	No	Ref	
	Yes	1.02 (0.8-1.3)	0.8212
Awareness of dewormers	No	Ref	
	Yes	1.74 (0.68-1.62)	<0.001*
Dogs per household	High (5-9)	Ref	
	Low (1-4)	1.05 (0.56-3.01)	
	Very high (≥10)	1.00 (0.44-2.26)	0.9595
Dewormer availability	Agrovet outside village (within the ward)	Ref	

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Agrovets within village	0.85(0.62-1.16)	
Agrovets district HQ	0.85 (0.58-1.25)	
Local regular market (within village)	0.85(0.51-1.42)	
Local regular markets (outside village)	0.52 (0.31-0.86)	0.1627

*Variable with p<0.25 were included in the multivariate analysis. HQ= Headquarter.

2.3.2. Multivariate Analysis

Ultimately, a multivariate model for determinants for deworming against helminth in dogs established. The final model indicated that dog owning households which were aware of appropriate dewormer for treatment and control of helminths in dogs were nearly two times more likely deworm their dogs than those not in the same study area (OR = 1.78, 95% CI 1.77 - 4.18, $p < 0.001$)

3. Discussion

The current study investigated the determinants for helminth-treatment seeking behaviour as a key aspect towards control *T. multiceps* in dogs among dog owning communities in rural northern Tanzania. The study revealed that on average a household owned two dogs per household which would signify a substantial burden for regular deworming in resource-poor households where dogs rarely given a single meal [13]. Adult female dogs were the slightly least preferred group of dogs kept in both agro-pastoral and pastoral communities. This could be due to slightly low survival rate in female than male dogs as reported in previous studies in rural Tanzania [14].

This study reveals that, dog owners who were aware of appropriate dewormer were nearly two times more likely to practice deworming than those with little knowledge about appropriate dewormers for dogs. These results shed critical insight on the starting point towards control of helminths in dogs in resource poor settings. Awareness to appropriate drugs is becomes an important than the price or cost of deworming. While a popular thought on hinderance to could be affordability of dewormers which is no doubt is a fact but, preliminary results from the study by the earlier studies by Kibona et al., 2022 on risk factors and determinants for *T. multiceps*, found that limited deworming practices were not associated with price of the dewormer. Therefore, limited knowledge on appropriate dewormers specific for dogs could have confounded the association between price of dewormer and deworming practices. While the current study focused to understand deworming towards control of taeniids and other cestodes, common product (Praziquantel) used for against taeniids was the least mentioned product to dog-owning households which generally practiced deworming. On the other hand, Levamisole and Albendazole were commonly mentioned deworming agents, these deworming agents are known for their effectiveness against gastrointestinal round worms. Hence, more emphasize should be directed to holistic helminths treatment and control including taeniids and other groups of cestodes. Such holistic deworming of dogs offers benefit to both animal and public health as most cestodial taeniid infection presents as subclinical cases as opposed to other worms with severe clinical manifestation such as *Toxocara canis* in dogs [15,16]. Majority of dog owners pointed out that they sourced dewormer outside the village but within the ward, this implies that most wards at least had a point source for dewormers. This highlights an important point to start with if the treatment and control of helminths is to be scaled up in rural settings if mobilization for awareness for dog deworming is properly implemented.

Deworming has been proven to be effective on controlling taeniids in dogs in Europe [17], this remains a fact in veterinary practices even developing countries like Tanzania. Therefore, dog-owners in rural areas both agro-pastoral and pastoral should be enlightened on a wide range deworming agents to safe guard the health of their dogs. However, sustaining mass deworming initiatives for dogs in many resource-poor communities, especially in Africa and specifically in

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Tanzania, poses significant challenges. Nevertheless, there are possibilities for awareness-raising efforts if control programs can be integrated into other impactful campaigns related to canine health, such as the promotion of rabies vaccinations, as illustrated in a case study addressing Echinococcus control in dogs in Morocco [18].

In conclusion, awareness to appropriate deworming agents for dogs and a point for dewormer availability is important towards helminths control such as taeniid problems in dogs. In addition, more studies on willingness to pay for dogs' dewormers in rural areas are warranted.

4. Materials and Methods

4.1. Study Design

This was a cross-sectional study conducted in northern Tanzania between January and December 2019. The study area included purposively selected districts; Longido, Karatu, Monduli and Ngorongoro districts in Arusha region; and Mbulu and Babati districts in Manyara region (Figure 1). From purposively selected districts, a comprehensive list was compiled of villages previously chosen at random for the Zoonoses and Emerging Livestock System (ZELS) [19] research study where cerebral coenurosis due to *T. multiceps* was reported to be high. These villages were subsequently classified as either pastoral or agro-pastoral. Out of this list, 12 villages were randomly selected. For each village, village leaders provided a list of sub-villages, then one sub-village was then randomly selected, and a questionnaire survey was administered to at least five randomly selected dog-owning households in each sub-village.

4.2. Household Questionnaire Survey on Deworming and Its Determinants

Data were initially collected from selected households in chosen sub-villages to determine ownership of dogs and small ruminants, as well as the availability of dewormers and dog deworming practices. Additionally, detailed data on the number of dogs per household were collected from each selected household in the sub-village. Individual dog data included sex and age (owners report), where age was categorized as adult (≥9 months) or juvenile (<9 months). The number of dogs per household was grouped as follows: up to four dogs were considered low (1-4); five to ten dogs were regarded as high (5-9); and more than or equal (≥10) were considered as very high. Dog owners were also asked about specific practices related to feeding and patterns of movement (moving with dogs for herding). Furthermore, respondents in each dog-owning household were asked where they are likely to source dewormers, whether they are aware of any dewormers suitable for dogs, and the names of specific dewormers.

4.3. Data Management and Analysis

4.3.1. Preliminary Data Analysis Plan

Data from deworming practice surveys were entered into Microsoft Excel® (Microsoft Corporation, Washington, USA) before analysis using R statistical environment version 4.3.2 by R Core Team (2023) (https://cran.r-project.org). Descriptive statistics on village data were summarized as the percentage of responses on various options related to dog deworming practices across study villages in rural northern Tanzania. A p-value of 0.05 or less was considered significant where applicable.

4.3.2. Regression Analysis for Determinants for Helminth Treatment Seeking Behaviour

A mixed effects logistic regression analysis was employed to identify and investigate potential helminths status in dogs and dog management practices, in this regression analysis; village included and livestock system as random effects.

First, univariable analysis of each predictor variable for helminths deworming practices in dogs was performed. The response variable was deworming of a dog (yes/no) determined as either the dog-owning household practiced deworming in last 12-months. The predictor variables were:

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livestock system (agro-pastoral or pastoral), and whether the dog moved with the herders during grazing (no/yes), awareness of appropriate dewormer (no/yes), number of dogs per household; low (1-4), High (5-9), and Very high (≥10) and point of dewormer outlet; Agrovet outside village (within the ward), Agrovets within the village, Agrovets at District Headquarter market, Local regular markets (within the village), Local regular markets (outside village).

Second, variables related to deworming practices that were significant at a level of $p \leq 0.25$ in univariate analysis were included in the full multivariable models for response to deworming of dogs. The final models were established through backward elimination, systematically dropping one variable at a time from the full model based on the Akaike information criterion (AIC). Likelihood ratio tests (LRT) were employed to assess the significance of each variable in the final model. A p-value of ≤ 0.05 from the LRT was deemed significant, leading to the retention of variables in the model. Interaction and confounding effects were evaluated using LRT, with significance determined by the presence or absence of variables in relation to others. Furthermore, due to the relatively small sample size in this study, in the case of singularity, a partially Bayesian approach was employed. This method generates maximum a posteriori (MAP) estimates by utilizing regularizing priors, as detailed by Chung et al. and McNeish [20,21]

Author Contributions: Tito Kibona: Conceptualized and designed the study: Tito Kibona: Performed data collection and laboratory analysis.: Tito Kibona and Joram Buza Performed data organization, analysis and interpretation of results; Tito Kibona: Wrote the first draft and subsequent revisions of the manuscript.: Tito Kibona, Joram Buza, and Gabriel Shirima: Participated in critical review and editing of the final manuscript.

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Institutional Review Board Statement: This study was ethically approved the National Institute for Medical Research (NIMR), NIMR/HQ/R.8c/Vol.I/732

Data Availability Statement: The datasets and related information generated during this study can be obtained by contacting the corresponding author upon request.

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Conflicts of Interest: The authors declare no conflict of interest

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