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# Perceptions on anthelmintic use and resistance development in goats under communal production systems

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## Abstract

For decades, farmers relied on anthelmintic drug treatments to control gastrointestinal nematode (GIN) infections, which has led to the development of anthelmintic resistance (AR). The objective of this study was to investigate the perceptions of communal goat farmers regarding anthelmintic resistance in communal goat flocks. A structured, close-ended questionnaire was used to carry out face-to-face interviews with communal goat farmers ( $n=384$ ) across four local municipalities in the uMkhanyakude district. The results showed that elderly farmers were 1.4 times more likely to underdose compared to younger farmers ( $p<0.05$ ). Educated farmers were aware of the negative influence on AR development brought by using substandard drugs ( $p<0.01$ ) and repetitive use of one drug ( $p<0.05$ ). However, lack of professional veterinary assistance ( $p<0.01$ ) resulted in more than 65% of elderly farmers underdosing the anthelmintic drugs ( $p<0.05$ ) while 68% were using expired drugs ( $p<0.05$ ). Despite varying levels of education, most farmers treated goats only showing GIN infection signs ( $p<0.05$ ) in their flocks which can potentially delay the AR development. The elderly farmers are less likely to delay the development of AR due to their inability to adhere to the recognized principles of responsible and sustainable drug use. Despite reasonable awareness of AR as a problem in their flocks, communal farmers proved to have poor perceptions regarding the development of AR. This was attributed to old age, illiteracy and under dosing. Engaging veterinarians, farmers and animal health technicians could achieve sustainable management of GIN infections.

**Keywords** Dosing, Parasite refugia, Anaemia, Demographic factors, Farmer's attitudes

## Introduction

Goats play a crucial role in communal farming systems in the developing world. Goats are cheap to acquire, possess a short production cycle and are a cheap source of protein for resource-poor farmers [12, 20]. Gastrointestinal nematode infections (GIN) pose a huge threat to goat production worldwide particularly through high treatment costs and reduced meat & milk production [28]. Severe parasite infections in goat flocks occur where warm and moist environments provide a suitable environment for parasite development and transmission [1].

The use of anthelmintic drugs has been the mainstay of combating GIN infections in goats [10, 15]. The

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extensive use of these drugs has resulted in the challenge of anthelmintic resistance (AR) [11]. Anthelmintic resistance refers to the ability of a parasite population to survive anthelmintic drug doses that they were in the past susceptible to [36]. Anthelmintic resistance has been reported in all broad-spectrum anthelmintic drug classes such as benzimidazoles, macrocyclic lactones, levamisole and amino-acetonitrile derivatives. While the biochemical and genetic mechanisms driving AR are increasingly characterised, the socio-economic drivers influencing drug misuse in resource-constrained farming systems remain poorly elucidated.

In South Africa, the impact of communal goat farmers' socio-economic status, such as reliance on subsistence practices, income disparities, and low literacy rates, on AR development is inadequately understood [20]. This knowledge gap hinders the design of context-specific interventions to mitigate resistance in regions reliant on communal livestock production, where poor management practices and economic constraints exacerbate AR risks. The development of GIN vaccines and new anthelmintic drugs could present a possible solution to the anthelmintic resistance challenge [14]. These processes, however, require newer technologies in gene discovery and antigen identification resulting in drug products which may be expensive for resource-poor farmers [35]. Keeping parasite refugia has been the major tool that reduces anthelmintic resistance development in goat flocks [21]. This can be achieved by treating a certain group of animals, and leaving another group untreated, preserving the susceptible genes in the parasite population [8]. The development of anthelmintic resistance largely depends on underdosing, prophylactic mass treatment of the flock and repetitive use of the same drug [7].

Anthelmintic resistance (AR) in communal goat farming systems is exacerbated by practices rooted in farmers' perceptions and resource limitations. For instance, communal farmers, often managing livestock with limited veterinary access and informal practices [20], may underestimate the risks of underdosing or drug rotation due to misconceptions about parasite biology or cost-saving priorities. Such perceptions directly influence AR development, as evidenced by Morgan et al. [24], who identified underdosing as a critical driver of resistance, often stemming from farmers' beliefs that reduced drug quantities are sufficient or economically prudent. A deeper understanding of these perceptions, including motivations for non-compliance with dosing guidelines or reliance on expired drugs, is essential to design targeted interventions that align with farmers' realities and mitigate AR risks [8]. Therefore, the objective of the current study was to investigate the perceptions of communal goat farmers regarding anthelmintic resistance in their flocks. It was hypothesised that farmers' socio-demographic

factors do not influence their perceptions on anthelmintic resistance in goat flocks under communal production systems.

## Materials and methods

### Ethical approval

The University of Pretoria's Faculty of Veterinary Science Research Ethics Committee (reference: REC166-22) and Faculty of Humanities Ethics Committee (reference: HUM013/0223) provided the ethical approval for the study. Participants were informed of the study's aim and their voluntary participation prior to the commencement of the study. Informed written consent was obtained from all participants prior to their participation in the study. Participants under the age of 18 were not included in the study.

### Study site

The study was conducted at uMkhanyakude District (Fig. 1) which is located at coordinates 27°40'06.9" S; 32°11'48.6" E in Northern KwaZulu-Natal (KZN) [30].

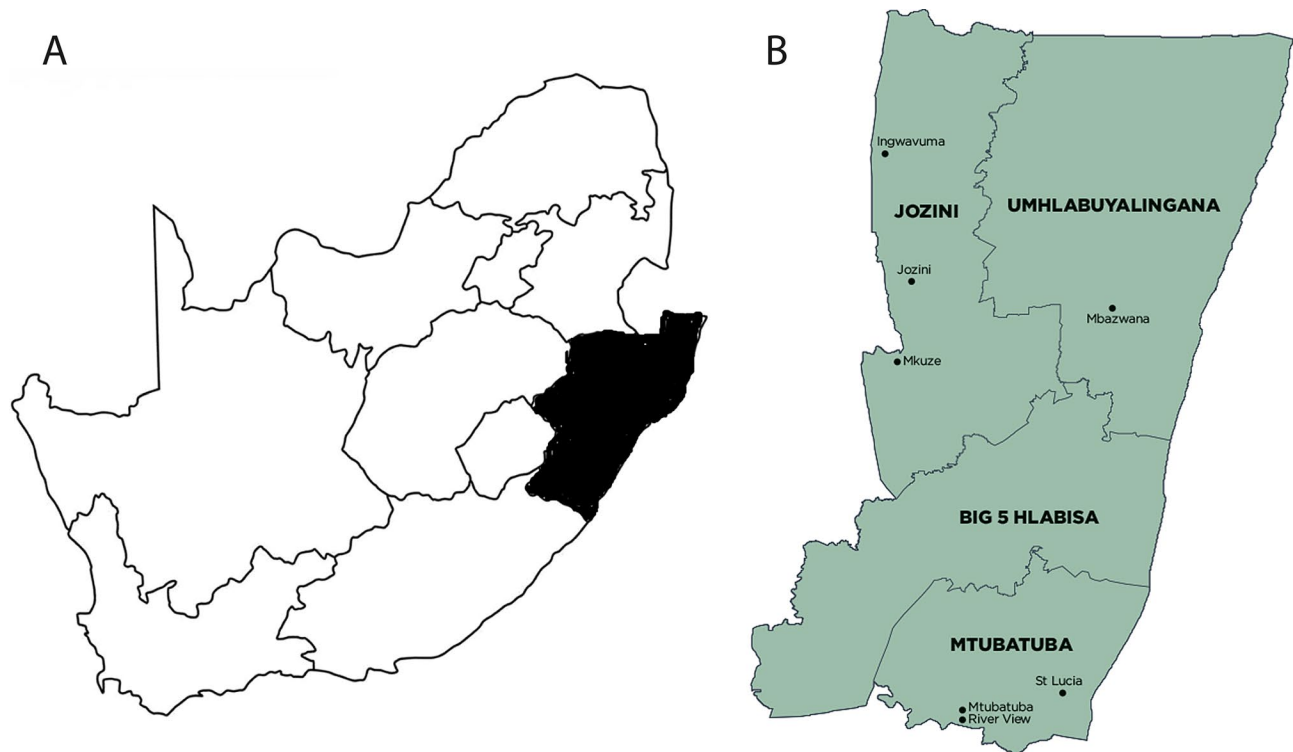
This is the second largest district in KZN and comprises of four municipalities viz.: Jozini, uMhlabuyalingana, Hluhluwe Big 5 and Mtubatuba. UMkhanyakude district has 5 164 livestock farmers who own 21 786 cattle and 40 916 goats to meet their immediate household needs [19].

The uMkhanyakude district experiences four seasons namely, hot-wet (December to February, post-rainy (March to May), cool-dry (June to August) and hot-dry (September to November) season. The average highest temperature was recorded at 28 °C from December to February and average lowest temperature of 19 °C from June to mid-August. The highest rainfall ranges from 671 to 1002 mm between January and March. while June, July and August with least annual rainfall [25].

### Participants selection

A snowball sampling method was used to recruit the farmers for the interview. In addition, those farmers who owned more than six goats and were willing to participate in the study were included. All farmers who participated were 18 years or older. A structured questionnaire assessing perceptions of communal goat farmers on AR development was used to carryout face-to-face interviews with a total of 384 goat farmers (96 from each municipality) in the uMkhanyakude district. Sample size was calculated using Cochran's formula explained by Israel [13].

Farmers were selected using the snowball sampling method where 18 existing dip tank committee leaders helped to recruit goat farmers from their connections. Snowball sampling was employed to address the logistical and social challenges inherent in accessing communal goat farmers within the uMkhanyakude district, a region



**Fig. 1** (a) Map showing nine provinces of South Africa with KwaZulu Natal Province shown in a black color [16]. (b) Locality map depicting four study municipalities from uMkhanyakude districts where the survey was conducted [31]

characterised by dispersed rural settlements and limited formal registries of livestock producers. While acknowledging potential selection bias, this method was deemed optimal for capturing nuanced behavioural data reflective of the target population's realities.

#### Data collection

A structured questionnaire constructed in English and later translated to the local *IsiZulu* language by a language specialist, was used to collect data. All farmers were interviewed face-to-face by trained enumerators between August 2023 and March 2024. The structured questionnaire was pretested on 10 communal goat farmers, 3 animal health technicians and 2 agricultural extension officers to validate the clarity of questions. The questionnaire captured farmers' socio-economic, demographic data and AR awareness. The questionnaire further evaluated farmers on practices that influenced AR development like dosing frequency, whether or not they contact a veterinarian and whether they weigh goats during dosing.

#### Statistical analyses

Data were analysed using the Statistical Package for Social Sciences (SPSS Version 26). Chi-square test was used to determine the associations between socio-economic factors and communal farmers' perceptions

regarding AR. An ordinal logistic regression model (PROC LOGISTIC) was used to predict the odds of farmers' practices influencing the development of anthelmintic resistance in goats. The socio-economic variables that were fitted in the logit model included gender, marital status, age, level of education, and level of income to test perceptions of communal goat farmers regarding AR. The model used was:

$$\begin{aligned} \ln [p/1 - p] = & \beta_0 + \beta_1 X_1 \\ & + \beta_2 X_2 + \beta_3 X_3 + \dots \\ & + \beta_t X_t + \varepsilon \end{aligned}$$

where  $p$  is the probability of a farmer's perceived knowledge of GIN infection,  $[p/1 - p]$  is the odds ratio of farmer's likelihood to control GIN,  $\beta_0$  is the intercept,  $\beta_1 \dots \beta_t$  are the regression coefficients of predictors,  $X_1 \dots X_t$  are the predictor variables, and  $\varepsilon$  is the random residual error. When computing each predictor ( $\beta_1 \dots \beta_t$ ), the odds ratio for farmers' perceptions were interpreted as the proportion of communal farmers' positive versus negative perceptions regarding AR development. A similar model was performed to determine farmer perceptions on the control of GIN infection, with  $p$  being the probability of a farmer being able to control GIN infection.

**Results**

**Practices in controlling Gastrointestinal nematode infections**

**Socio-demographic characteristics of communal goat farmers**

Two hundred and eighty-eight (75%) communal goat farmers were interviewed the majority being male, 51% were above 50 years of age and only 18% had access to tertiary education while 33% had low levels of formal education (illiterate and primary school). More than 50% of the communal goat farmers owned between 1 and 20 goats, while 34% had no employed family member and relied on social grants (35%) for the source of income.

**Practices of communal goat farmers when dosing anthelmintic drugs**

Descriptive statistics revealed distinct patterns in anthelmintic drug-use practices across socio-demographic groups (Table 1). Among 384 communal goat farmers, elderly respondents (≥ 61 years) exhibited the highest proportion of underdosing (65%), medicinal plant use (65%) and expired drug administration (68%), while younger farmers (18–30 years) reported lower rates (38%, 34% and 21%, respectively). Illiterate farmers disproportionately engaged in underdosing (46%) and substandard drug use (29%) compared to those with tertiary education (18% and 5%, respectively). Inferential analyses (chi-square tests) confirmed significant associations ( $p < 0.05$ ) between age, education, and non-compliant practices. Elderly farmers were significantly more likely to use medicinal plants ( $\chi^2=22.65, p < 0.01$ ) and expired drugs ( $\chi^2=21.13, p < 0.01$ ) than younger cohorts. Illiteracy

strongly correlated with underdosing ( $\chi^2=9.72, p < 0.05$ ) and substandard drug use ( $\chi^2=8.27, p < 0.05$ ). Tertiary education corresponded to reduced reliance on expired drugs (7% vs. 54% in illiterate farmers;  $\chi^2=8.27, p < 0.05$ ) and medicinal plants (21% vs. 57%;  $\chi^2=15.31, p < 0.05$ ). No significant association was observed between age and substandard drug use ( $p > 0.05$ ).

Farmers with low level of income (poor) were 1,1 times likely to use expired drugs compared with farmers earning high income (Table 2). Illiterate farmers were more likely to use medicinal plants. Lower-income farmers were more likely to use medicinal plants. Farmers in Hluhluwe Big 5 and uMhlabuyalingana were less likely to use medicinal plants compared to those in Jozini. Farmers in uMhlabuyalingana were 1.9 times more likely to use expired drugs ( $p > 0.05$ ) compared to other municipalities.

**Underdosing of anthelmintic drugs**

There was a significant difference between age and farmers who used less dewormer as opposed to the manufacturer’s instruction ( $p < 0.05$ ). Most elderly farmers were under dosing the anthelmintic drugs compared to younger farmers. Elderly farmers were 1.5 times likely to use less dewormer per goat ( $p < 0.05$ ) than younger farmers (Table 2). Female respondents were 2 times likely to use less dewormer as opposed to the manufacturer’s prescription. ( $p < 0.05$ ) compared to male respondents. Farmers in uMhlabuyalingana were 2.8 times more likely to use less dewormer as opposed to the manufacturer’s prescription ( $p < 0.01$ ).

**Farmers’ attitudes towards anthelmintic drug use**

Level of education ( $p < 0.01$ ) and age ( $p < 0.05$ ) of farmers were associated with considering anthelmintic drug meat and milk withdrawal periods (Table 3). A few farmers (7%) with tertiary education and about half of the respondents (54%) without formal education had never complied with meat and milk withdrawal periods. There were significant differences in both age and educational level of farmers deworming season ( $p < 0.05$ ). There was a significant difference between educational level of a farmer and practice if the administered drug were not effective. The majority of illiterate (58%) and those with primary school level (51%) chose to increase the anthelmintic drug dose if the previously administered drug was not effective as opposed to consulting the veterinarian. The significant difference was observed between farmers’ age and deworming season ( $p < 0.05$ ). Farmers from all age groups considered deworming their flocks in autumn.

**Famer’s perceptions with regards to GIN control**

Farmers with tertiary education always read the manufacturer’s instructions on how to use anthelmintic drugs

**Table 1** Association between socio-demographics and practices of communal goat farmers when using anthelmintic drugs

	Use less dewormer as opposed to the manufacturer prescription	Use sub-standard drugs	Use medicinal plants	Use expired drugs
Age				
18–30	12	8	6	10
31–40	15	17	12	21
41–50	20	12	10	18
51–60	22	24	21	20
61≥	31	39	51	31
$\chi^2$	11.25	5.21	22.65	24.82
p value	*	NS	**	**
Education level				
None	48	55	60	54
Primary	29	22	21	21
Secondary	19	13	15	18
Tertiary	4	10	4	7
$\chi^2$	9.72	8.27	15.31	19.01.
P value	*	*	*	*

NS not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference and  $\chi^2$  Chi-square

**Table 2** Odds ratio estimates for practices used by farmers in controlling GIN infections

	Predictor	Odds ratio	Lower Confidence Interval	Upper Confidence Interval	Standard Error	p value
<b>Use less dewormer per goat</b>						
	Gender	1.975	1.166	3.344	0.269	*
	Age	1.426	1.134	1.793	0.117	*
	Marital status	0.453	0.293	0.703	0.224	**
	Educational level	0.952	0.726	1.250	0.139	NS
	Monthly income	1.021	0.796	1.309	0.127	NS
	Jozini	1	-	-	-	**
	Hluhluwe Big 5	2.3	1.279	4.107	0.295	*
	Mtubatuba	1.2	0.657	2.044	0.290	NS
	uMhlabuyalingana	2.8	1.558	5.175	0.306	**
<b>Use of medicinal plants</b>						
	Gender	0.928	0.262	0.555	1.552	NS
	Age	1.062	0.119	0.842	1.340	NS
	Marital status	0.782	0.222	0.506	1.210	NS
	Educational level	0.755	0.143	0.571	0.999	*
	monthly income	0.718	0.131	0.556	0.927	*
	Jozini	1	-	-	-	*
	Hluhluwe Big 5	0.508	0.281	0.919	0.302	*
	Mtubatuba	0.726	0.407	1.293	0.295	NS
	uMhlabuyalingana	0.498	0.274	0.905	0.305	*

The higher the odds ratio, the stronger the predictions to control GIN infection. NS:  $p > 0.05$  \*  $p < 0.05$ , \*\*  $p < 0.01$ , gender (male vs. female), age (elderly vs. young), marital status (single vs. married), educational level (educated vs. illiterate) and monthly income (rich vs. poor)

**Table 3** Farmer's practices regarding the administration of anthelmintic drugs

Practices		Farmer's age					Education level			
		18–30	31–40	41–50	51–60	61≥	illiterate	1st	2nd	3rd
Consider Meat & milk withdrawals (%)	Yes	24	47	64	49	35	32	28	44	80
	Sometimes	31	25	21	20	19	14	32	24	13
	Never	45	28	15	31	46	54	40	32	7
$\chi^2$		35.27					65.11			
P value		*					**			
Administered drug not effective (%)	Increase dose.	64	51	36	56	43	58	51	53	28
	Consult a vet.	10	18	40	30	21	13	12	23	45
	Change the drug	26	30	24	17	36	29	36	25	28
$\chi^2$		24.30					31.46			
P value		*					**			
Deworming Season (%)	Winter	11	4	9	5	3	8	2	1	2
	Summer	19	20	23	36	33	20	24	21	42
	Autumn	60	66	48	49	56	68	64	65	42
	Spring	10	11	19	10	8	4	11	14	14
$\chi^2$		24.72					19.16			
P value		*					*			

NS not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference  $\chi^2$  Chi-square, 1st Primary, 2nd Secondary and 3rd tertiary

than illiterate farmers and those with primary education ( $p < 0.01$ ) (Table 4). Treating goats which showed severe signs (diarrhoea, body weight and rough coat) of GIN infection was associated with gender ( $p < 0.05$ ) but not with the level of education ( $p > 0.05$ ). The majority of both male (47%) and female (50%) farmers always treated only animals showing signs of GIN infections as opposed to treating the whole flock. In comparison with males, over 60% of females had never consulted a veterinarian,

7% did not read manufacturer's instructions while 15% did not practice targeted GIN treatment.

Anthelmintic drug classes used by farmers are summarised in Table 5. Significant associations were observed between gender and using ivermectin ( $p < 0.05$ ) and closantel ( $p < 0.01$ ) but not for albendazole and levamisole. More male farmers used anthelmintic drugs in comparison with females. More than half of male (83%) and female (77%) farmers used albendazole, while some of the farmers also used levamisole (male, 25%;

**Table 4** Association between socio-demographic factors with farmer's practices influencing the development of anthelmintic resistance

	Consult a veterinarian (%)					Read manufactures Instructions (%)					Treating only goats showing severe infection signs				
	A	U	S	R	N	A	U	S	R	N	A	U	S	R	N
Gender															
Male	28	8	14	5	45	68	18	9	2	3	47	23	9	14	6
Female	15	7	8	7	63	51	29	12	1	7	50	24	4	6	15
χ <sup>2</sup>	13.08					13.67					13.17				
P value	*					*					*				
Education level															
None	12	6	15	4	63	35	29	7	8	21	50	11	13	13	14
Primary	18	9	13	5	55	46	30	12	2	10	50	20	11	9	9
Secondary	26	6	10	7	51	70	21	8	0	1	45	31	7	12	7
Tertiary	42	12	16	3	27	97	2	1	0	0	51	22	3	16	9
χ <sup>2</sup>	29.50					87.04					18.92				
P value	*					**					NS				

NS not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference χ<sup>2</sup>=Chi-square, A always, U usually, S sometimes, R rarely and N never

female, 17%). There was a significant association between the use of levamisole and farmers who owned more than 41 goats ( $p < 0.01$ ). Similarly, the use of closantel was linked to farmers who owned more than 30 goats.

**Attitudes towards anthelmintic resistance**

Women were less aware of the impact of non-principled use of anthelmintic drugs in AR development than males ( $p < 0.01$ ) (Table 6). Shared pasture grazing, repeated use of a specific anthelmintic drug and quarantining newly introduced animals were all significantly associated with the respondent's gender ( $p < 0.01$ ). Male farmers demonstrated greater awareness of parasite transmission through shared grazing areas compared to female farmers. Additionally, female farmers were less informed than males about the potential for repeated use of the same drug to contribute to the development of anthelmintic resistance. Neither male nor female farmers considered quarantining new flock members to be a useful practice on their farms. Literate farmers showed significantly greater awareness than illiterate farmers regarding the role of improper anthelmintic use in the development of resistance ( $p < 0.01$ ). Furthermore, the respondents' level of education significantly influenced their views on key risk factors: shared pasture grazing and failure to quarantine new animals were recognized as contributors to gastrointestinal nematode (GIN) transmission ( $p < 0.05$ ), and repeated use of the same anthelmintic drug was seen as a driver of anthelmintic resistance ( $p < 0.05$ ).

There was an association between gender and farmers who presumed anthelmintic resistance as a problem in South Africa ( $p < 0.01$ ). More male farmers presumed anthelmintic resistance as a problem compared to Women (Table 7). More male farmers recommended consulting a veterinarian before administering anthelmintic drugs ( $p < 0.05$ ) compared to females.

There was a significant association between farmers' age and their perception of anthelmintic resistance as a problem in South Africa ( $p < 0.05$ ), with most farmers aged 41–50 not viewing it as an issue. However, no significant association was found between age and the belief that consulting a veterinarian before administering a drug is a good practice. Additionally, there were no significant differences across genders or age groups regarding the importance of reading the manufacturer's instructions. Farmers across all age groups (96%) and both genders considered reading the manufacturer's instructions to be good practice.

**Discussion**

The present study aimed to assess the knowledge and perceptions of communal goat farmers regarding anthelmintic resistance. Anthelmintic resistance has been reported across nearly all drug classes used to control

**Table 5** Association between anthelmintic drugs used with number of goats owned and gender

Anthelmintic drug class	Male (%)	Female (%)	$\chi^2$	P value	Number of goats owned (%)					$\chi^2$	P value
					1–10	11–20	21–30	31–40	41≥		
Albendazole	83	77	2.23	NS	30	31	18	11	11	2.70	NS
Levamisole	25	17	0.34	NS	14	19	22	16	29	38.69	**
Ivermectin	24	9	8.89	*	11	24	27	17	24	77.12	**
Closantel	32	6	11.04	**	0	14	29	21	36	15.39	*

NS: not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference and  $\chi^2$  Chi-square

gastrointestinal nematode (GIN) infections in both small and large ruminants [4, 8, 26, 29]. Key operational factors contributing to the emergence of resistance include underdosing, frequent or indiscriminate drug administration and mass deworming practices [26]. Understanding the decision-making drivers among communal farmers is crucial for designing sustainable nematode control strategies.

In this study, socio-demographic factors were significantly associated with farmers' attitudes toward the development and spread of anthelmintic resistance in communal goat flocks. Male farmers were more likely than females to recognize that improper use of anthelmintics contributes to resistance. Improper use refers to practices such as administering drugs without proper diagnosis, using incorrect dosages, failing to rotate drug classes, and treating animals unnecessarily [8]. Male farmers also showed greater awareness of parasite transmission through shared grazing areas, while most female farmers were less informed about the role of repeated drug use and lack of quarantine in resistance development. These findings are consistent with those of Mahanjana and Cronje [17], who reported that male farmers in the Eastern Cape Province were generally more knowledgeable about farming practices than their female counterparts. Similarly, Paudel et al. [33] found that male farmers were more actively involved in livestock farming, a trend attributed to the physically demanding nature of animal husbandry.

Education level also played a critical role in shaping farmers' understanding of anthelmintic resistance. Farmers with tertiary education were more aware that improper use of anthelmintics can lead to the development of resistance, compared to those with no formal education. Educated farmers also recognised the importance of quarantining newly acquired stock to ensure they are free from gastrointestinal nematodes (GIN) before integration into the main flock. In contrast, uneducated farmers typically did not quarantine new animals, instead prioritising the immediate social integration of new and existing flock members. This lack of quarantine practice was particularly evident among communal farmers in the Free State and Northern Cape provinces. High levels of illiteracy among rural communal farmers have been documented [22], and according to Qokweni et al.

[34], limited education hampers farmers' ability to grasp fundamental agricultural concepts, including effective parasite control measures.

Male farmers demonstrated greater awareness of the problem of anthelmintic resistance in South Africa and were more likely to consider seeking veterinary advice than their female counterparts. This may be due to traditional gender roles in rural households, where elderly men are often regarded as heads of households and primary decision-makers. Consequently, men are more likely to attend livestock information seminars, enhancing their farming knowledge [3]. Middle-aged farmers showed greater concern about anthelmintic resistance than both younger and older farmers, potentially due to the youth's general disinterest in farming and the high illiteracy rates among the elderly [34]. However, this finding contrasts with Mhlanga et al. [22], who reported that older farmers are typically more knowledgeable about helminth control due to their extended experience in livestock farming.

In uMkhanyakude district, around 80% of farmers responded with "I do not know" when asked if they suspected anthelmintic resistance on their farms. A similar lack of awareness was observed in Iran, where over 80% of goat farmers were uncertain about resistance on their farms [35]. Although farmers across all age groups agreed that consulting a veterinarian is advisable, few actually did so before administering anthelmintics. Consequently, treatments were often given without confirming infection or assessing the goats' body weights, increasing the risk of incorrect dosing. Visual estimation of weight, due to a lack of weighing equipment, was common and often led to underdosing, a major contributor to anthelmintic resistance [27, 37].

Sending samples for faecal egg count test can allow a farmer to treat only the heavily infected goats while leaving the rest of the herd in refugia thus reducing the chances of anthelmintic resistance development [6]. On the other hand, incorrect dosing may occur if animals are not weighed during administration of anthelmintic drugs [37]. More than 60% of the total elderly farmers underdose and use expired drugs in their flocks. This is associated with lack of weighing instruments among communal farmers subsequently leading to visual weighing of goats. Underdosing is one of the major practices associated

**Table 6** Attitudes of communal goat farmers regarding the development and the spreading of anthelmintic resistance

	Non-principled use of drugs influence anthelmintic resistance			Shared pasture leads to parasite transmission			One drug can be used repetitively			New stock should be quarantined		
	T	F	IDK	T	F	IDK	T	F	IDK	T	F	IDK
Gender												
Male	57	4	39	42	3	56	64	2	34	33	50	17
Female	31	2	66	12	7	81	35	3	61	11	55	31
χ <sup>2</sup>	21.10			31.12			23.07			18.77		
P value	**			**			**			**		
Education Level												
None	34	5	62	32	2	66	51	2	48	12	63	25
Primary	44	2	55	22	5	73	50	3	47	9	67	23
Secondary	51	4	45	34	5	60	55	2	43	31	43	23
Tertiary	74	2	25	46	0	53	75	3	22	51	12	7
χ <sup>2</sup>	20.70			13.03			13.43			41.65		
P value	**			*			*			**		

NS not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference and χ<sup>2</sup>Chi-square, T true, F False and IDK I don't know

with the development of anthelmintic resistance in goat flocks worldwide [21].

The use of medicinal plants to control GIN infections was associated with illiterate and elderly farmers. Mhlongo et al. [23] reported that most farmers in Africa use medicinal plants to treat gastrointestinal infections. Among the traditional medicinal plants used by communal goat farmers to treat GIN infections in uMkhanyakude are *Volkameria glabra* (umqoqongo), *Aloe marlothi* (inhlaba), *Cissus quadrangularis L.* (inhlashwana) and *Tatradenia riparias* (iboza) [5]. The use of medicinal plants over conventional anthelmintic drugs may be attributed to high anthelmintic drug cost while there is an easy access to medicinal plants [2]. The use of medicinal plants may be beneficial in reducing the frequency of using anthelmintic drugs and therefore delaying the development of the anthelmintic resistance [39].

Log odds ratio indicated that female farmers and elderly farmers were likely to accelerate the spread of and development of anthelmintic resistance. This is because livestock farming is associated with males more than females and there is a high level of illiteracy among elderly farmers [38]. Younger and elderly farmers were less likely to observe drug withdrawal periods for meat and milk, unlike educated farmers who could read and understand manufacturer instructions. Ignoring withdrawal periods can lead to drug residues in food, posing human health risks [32].

Younger farmers and illiterate farmers opted to increase the dose if the previously administered drug was not effective. This increases the treatment frequency, which could subsequently lead to the rapid development of anthelmintic resistance [8]. The FAMACHA chart is the tool that is used to assess the severity of the GIN burdens by observing the ocular membrane of the eye in sheep and goats. This study revealed that farmers did not use the FAMACHA scoring method to detect the severity of anaemia confirming the degree of GIN infection among individual goats in the flock. This is essential in maintaining the parasite refugia in the flock by choosing the animal group that should be dosed while preserving the susceptible alleles from the untreated group [21].

The study also revealed that both literate and illiterate farmers treat only goats showing severe GIN infection signs. This was associated with poor socio-economic status of communal farmers as their focus in dosing more members of the flock at minimal costs. The targeted drug treatment prevents the drug-sensitive group of animals from exposure to drugs. The drug susceptible flock will later dilute the survived parasite species from the treated flock and therefore delaying the development of the anthelmintic resistance [18]. Most farmers acknowledged that consulting a veterinarian before administering anthelmintic drugs is a prudent practice. However,

**Table 7** Association between socio-demographic factors with the attitudes of communal farmers regarding the anthelmintic resistance

	Is anthelmintic resistance a problem? (%)				Is it good to consult a veterinarian before administering drugs? (%)			
	SA	A	D	SD	SA	A	D	SD
Male	28	54	13	6	74	23	2	1
Female	9	40	34	17	58	17	2	1
$\chi^2$	41.58				8.84			
P value	**				*			
Age	SA	A	D	SD	SA	A	D	SD
18–30	14	19	48	19	79	19	0	2
31–40	11	26	46	16	65	32	4	0
41–50	14	12	32	42	78	19	1	1
51–60	7	37	30	26	69	26	5	0
61≥	10	21	36	35	65	29	3	3
$\chi^2$	29.18				12.35			
P value	*				NS			

NS not significant, \* ( $p < 0.05$ ) \*\* ( $p < 0.01$ ) significant difference and  $\chi^2$  Chi-square, SA strongly agree, A agree, D disagree, SD strongly disagree

in reality, only a small number of both male and female farmers actually sought veterinary advice prior to treatment. In Ghana, barriers such as illiteracy, inadequate road infrastructure, and limited resources have been identified as key challenges to effective communication between veterinary professionals and rural communal farmers [9]. Similarly, in this study, farmers with tertiary education were significantly more likely to seek expert veterinary assistance compared to those with no formal education.

## Conclusions

Although the perceptions of communal farmers regarding anthelmintic resistance appeared to be acceptable the majority still adopted poor practices in mitigating the anthelmintic resistance development. This discrepancy between the perceptions and practices of communal goat farmers in uMkhanyakude district was associated with the elderly and illiterate farmers. Treatment of goats without veterinary help led to farmers underdosing their flocks and deworming without FAMACHA scoring. The study highlights the principle that increased awareness and positive perceptions do not necessarily result in positive practices in communal farmers because communal farmers are aware of the AR as a problem. However, they still fail to follow protocol in delaying AR. Methods to streamline the communication between veterinary experts and communal farmers with the particular emphasis on the female, illiterate and elderly farmers should be studied and implemented. The supervision of anthelmintic drug sales to farmers would be helpful to generate the appropriate awareness and rational decision-making regarding sustainable GIN management.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12917-025-04893-8>.

Supplementary Material 1

## Acknowledgements

The authors would like to acknowledge the AgriSETA and University of Pretoria Bursary for funding this research project. The veterinary and agricultural extension officers at uMkhanyakude district office are thanked for the assistance that they extended in the data collection phase of the research. The authors are forever thankful to the smallholder goat farmers in uMkhanyakude district for their participation in the research.

## Author contributions

K.C., M.C., A.T.K and M.C.M designed the study; K.C. collected the data; K.C. and M.C. interpreted results and wrote the manuscript. K.C., M.C., A.T.K and M.C.M have read, reviewed and agreed to the published version of the manuscript.

## Funding

Authors acknowledge the AgriSETA bursary and the University of Pretoria funding scheme for funding this project.

## Data availability

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical considerations.

## Declarations

### Ethics approval and consent to participate

The study protocol was approved by the University of Pretoria faculty of Humanities (Reference number: HUM013/0223). Farmers signed the consent form before the interviews. During the study all methods were performed in accordance with the relevant guidelines and regulations.

### Consent for publication

Not applicable.

### Competing interests

The authors declare no competing interests.

Received: 19 March 2025 / Accepted: 20 June 2025

Published online: 09 July 2025

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