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Evaluation of Pakistani goat breeds for genetic resistance to *Haemonchus contortus*

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Abstract

This study aimed to evaluate the genetic resistance of Pakistani goat breeds (Beetal, Teddy, Angora, Nachi) against *Haemonchus contortus*. In total, 13 animals of each breed, irrespective of sex, were selected. Following artificial infection with 5000 L3 (third stage) larvae of *Haemonchus contortus* to each animal, susceptibility and resistance of each breed was then assessed on the basis of body weight, feacal egg counts, packed cell volume and FAMACHA system on days 0, 28, 35, and 42. Variation in response of all goat breeds to *H. contortus* was observed. Better resistance was observed in Teddy and Beetal breeds ($P < 0.05$) followed by Nachi and Angora breeds. Genetic diversity was noted among these four goat breeds which could be explored further to minimize the use of anthelmintics and to exploit the genetic potential of the different goat breeds.

Genetic variability, FAMACHA, Beetal goat, packed cell volume

Developing countries are rich in goat genetic resources. China, India, and Pakistan are top goat meat producing countries in the world. The goat population in Pakistan is 53.8 million, ranking third in the world (Khan et al. 2008). Good quality meat is exported in most of the Middle East and other Asian countries from Pakistan thus contributing an important role in the country's economy. However, parasitic infestation in goats impedes better production and growth of goats. Among the many parasites, *Haemonchus contortus* is of major concern as it is a voracious blood sucker. This parasite causes anaemia, low packed cell volume (PCV), internal fluid accumulation, and diarrhea dehydration by sucking the blood from abomasum, and may even lead to death in heavy infestation. Consequently, *H. contortus* plays an integral role in reduction of the overall productivity and profitability of an animal (Terrill et al. 2011). Strategies should be designed to cut down this problem. One of the sustainable options is the selection of goat breeds resistant to *H. contortus*. This strategy will provide animals with better resistance against gastrointestinal (GI) parasites and anthelmintic resistance, thus having overall better growth and performance (Baker et al. 2001). Recent studies have focused on the finding of genetic resistance against *H. contortus* at the molecular level in different goat breeds in advanced countries (Alberti 2012; Corley and Jarmon 2012a; Corley and Jarmon 2012b). Some developing countries have started this approach (Chiejina and Behnke 2011). But most developing countries, including Pakistan, are lacking in adopting this approach even at the phenotypic level for finding the native resistant goat breeds. This paper provides substantial evidence on the genetic variation for resistance to GI nematode parasites (especially *H. contortus*) in four goat breeds of Pakistan.

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Materials and Methods

Location and climate

The study was conducted at the Angora Goat Farm, Rakh Khairewala, District Layyah (Pakistan's largest small ruminant farm with 14,472 acres of land) under the Directorate of Small Ruminants. The climate is warm temperate with mean maximum and minimum temperatures, daily relative humidity, and mean annual rainfall of 45 °C and 12 °C, 80% (max) and 54% (min), and 135 cm, respectively.

Animal characteristics and management

Four goat breeds Beetal, Teddy, Angora, Nachi were selected. The locality of all breeds was Punjab districts except for Teddy, which is also found in Azad Jammu and Kashmir (AJK). Beetal and Teddy are used for meat and milk purposes, Angora is raised mainly for hair, while Nachi serves for meat, milk and hair production. All selected breeds were kept under uniform management conditions. Animals were not allowed to go out for open grazing to minimize the chances of getting the internal nematodes infestation from field and all were offered total mixed ration (TMR) at 3% body weight daily. TMR consisted of corn silage, wheat straw, and mineral mixture. All selected animals were dewormed by administering albendazole at the dose of 10 mg/kg orally (Albenzole granules; Selmore Agency, Pakistan).

Experimental design and indicators

In total, 13 animals of each breed at the age between 5 to 8 months were selected. Out of 13 animals of each breed, two animals of each breed were kept as control. Larvae 3 of *H. contortus* were produced and used as challenge to the selected animals with controlled dosage. Ethical permission was taken from the Ethics Committee of the University of Veterinary and Animal Sciences Lahore, Pakistan prior to start the experiment. *Haemonchus contortus* was obtained from the positive field sample from goats after faecal egg count using a microscope. The eggs were cultured in the laboratory up to stage L3. On day 0 the initial readings were taken and doses of 5 000 L3 were administered to the animals. Data were recorded for evaluating the susceptibility and resistance of each breed against *H. contortus* by body weight, feacal egg counts (FEC), and packed cell volume (PCV) by Wintrobe's method (Maxwell and Wintrobe 1929) and FAMACHA on days 0, 28, 35, and 42. Faecal samples were collected directly from rectum and microscopic examination was carried out to count the eggs by using McMaster technique. Blood samples with anti-coagulant (ethylene diamine tetraacetic acid; EDTA) were taken from the jugular vein. Packed cell volume percentage was determined by the microhaematocrit method. FAMACHA system was used to determine the level of anaemia. The eye was examined in the sunlight and the colour was compared with the FAMACHA card as per instructions. The highest value (5) showed highly anaemic animals whereas the lowest value (1) indicated healthier animals.

Statistical analysis

For differences among breeds in terms of FEC, PCV, and body weight, FAMACHA was performed using the SAS version 6 (SAS Institute Inc., 1996). ANOVA was used to determine the difference among breed data. Differences were considered significant at $P \leq 0.05$.

Results

The FEC varied ($P < 0.05$) between goats within breeds and between weeks of exposure. A marked difference ($P < 0.05$) was observed in FEC among four breeds and Teddy and

Table 1. Analysis of variance (ANOVA) for faecal egg count among goat breeds.

Source of variance	Degree of freedom	Sum of square	Mean of square	F ratio	Pr > F
Breed	3	863667.96	287889.32	3.50	0.015
Dose	1	380461.12	380461.12	4.63	0.032
Reading	4	3607612.39	901903.10	10.98	< 0.0001
Sex	1	20882.87	20882.87	20882.87	0.614
Breed × dose	3	1271858.87	423952.96	5.16	0.001
Breed × reading	12	22900616.07	1908384.67	23.22	< 0.0001
Breed × sex	3	51096.87	17032.29	0.21	0.8913
Dose × reading	4	6577859.26	1644464.81	20.01	< 0.0001
Sex × dose	1	55232.11	55232.11	0.67	0.4130
Sex × reading	4	10827.71	2706.93	0.03	0.9979

Beetal showed less FEC compared to Nachi and Angora (Table 1). No anaemia and no blood parasites were found on day zero of the experimental period. The mean values per breed, for PCV during the entire trial period are presented in Table 2. Almost similar pattern was observed for PCV in all goat breeds.

Table 2. Analysis of variance (ANOVA) for packed cell volume among goat breeds.

Source of variance	Degree of freedom	Sum of square	Mean of square	F ratio	Pr > F
Breed	3	199.487617	66.495872	2.77	0.0418
Dose	1	12.507660	12.507660	0.52	0.4712
Reading	4	392.730038	98.182509	4.08	0.0030
Sex	1	36.850219	36.850219	1.53	0.2165
Breed × dose	3	58.937751	19.645917	0.82	0.4850
Breed × reading	12	1544.762093	128.730174	5.36	< 0.0001
Breed × sex	3	77.267839	25.755946	1.07	0.3612
Dose × reading	4	2.111842	0.527961	0.02	0.9991
Sex × dose	1	51.689403	51.689403	2.15	0.143
Sex × reading	4	244.113902	61.028475	2.54	0.03

Significant results ($P < 0.05$) were found for live weight among goat breeds as shown in Table 3. Maximum weight gain was observed in Teddy followed by Beetal, whereas weight loss was seen in the Angora and Nachi breeds. The FAMACHA score showed the level of anaemia due to *H. contortus* in the four breeds (Table 4). The Teddy breed had a lower mean FAMACHA score (2.12) compared to other breeds. The highest level of anaemia was observed after the experimental infection during the trial concluding the susceptibility of this breed to *H. contortus*.

Table 3. Analysis of variance (ANOVA) for weight gain among goat breeds.

Source of variance	Degree of freedom	Sum of square	Mean of square	F ratio	Pr > F
Breed	3	162.0262425	54.0087475	4.90	0.0025
Dose	1	20.0364666	20.0364666	1.82	0.1786
Reading	3	17.3619481	5.7873160	0.53	0.66
Sex	1	98.2615569	98.2615569	8.92	0.003
Breed × dose	3	103.2580429	34.4193476	3.12	0.02
Breed × reading	8	124.7832460	13.8648051	1.26	0.25
Breed × sex	2	557.7483911	185.9161304	16.88	< 0.0001
Dose × reading	3	15.9689437	5.3229812	0.48	0.6942
Sex × dose	1	11.8776226	11.8776226	1.08	0.3000
Sex × reading	3	5.0039101	1.6679700	0.15	0.9287

Discussion

The mean values of all the recorded readings of FEC, FAMACHA, body weight and PCV showed that there was variation in the responses of all goat breeds to the internal parasite (*H. contortus*).

Table 4. Analysis of variance (ANOVA) for FAMACHA among goat breeds.

Source of variance	Degree of freedom	Sum of square	Mean of square	F ratio	Pr > F
Breed	3	10.86	3.621	12.79	< 0.0001
Dose	1	2.90084390	2.90084390	10.24	0.0015
Reading	4	57.4357	14.3589	50.71	< 0.0001
Sex	1	0.177	0.17712007	0.63	0.4295
Breed × dose	3	2.9170	0.972	3.43	3.43
Breed × reading	12	16.01441980	1.33453498	4.71	< 0.0001
Breed × sex	3	1.51101841	0.50367280	1.78	0.1509
Dose × reading	4	2.84482532	0.71120633	2.51	0.0416
Sex × dose	1	0.00962448	0.00962448	0.03	0.8538
Sex × reading	4	1.82021833	0.45505458	1.61	0.1720

Packed cell volume and FEC are considered valuable for finding whether breeds have resistance against internal nematodes. The PCV is a measure of resilience by showing the animal's ability to endure against infestation, and FEC points out indirectly the resistant animal. Ideally, there should be low FEC and higher PCV in genetically resistant animals. These traits are key to evaluate the genetic resistance among breeds against nematode parasites and they are usually estimated by the statistical estimates of heritability for finding resistance within breeds.

The mean live weight gain in resistant breeds was due to their ability to cope with the internal nematode infection compared to susceptible breeds. Live weight has also its significance in the judgment of resistance and susceptibility status of sheep/goats as was formerly implicated by different authors (Amarante et al. 2004; Burke and Miller 2004; Vanimisetti et al. 2004; Mugambi et al. 2005). All the breeds continued to grow but they could not gain normal weight due to haemonchosis. Breeds showed a significant difference ($P < 0.001$) at all the weighing times, contrary to Vanimisetti et al. (2004). The practicality of the weight gain/loss criterion in the assessment of genetically resistant breeds is supposed to rely on the similarity or dis-similarity in the hereditary potential, performance, and overall size of animals.

Since anaemia is the primary pathologic effect from infection with *H. contortus*, FAMACHA system could be a valuable approach for selecting resistant breeds. However, this tool should be employed along with other tools (Bath et al. 2001). FAMACHA could be helpful in improving the herds or flocks in addition to minimizing the cost and anthelmintic resistance (Bath et al. 2001). The present findings reveal greater significant associations among the FEC, PCV, and the eye score. Previously, there was an established fact that breed resistance against *H. contortus* evaluated on the FEC and PCV indicators are moderately hereditary traits (Kaplan 2005), but the current study has indicated that FAMACHA scores could also be used as a heritable trait in investigating the resistance of goat breeds to the *H. contortus* infection (Van Wyk and Bath 2002). Thus this qualitative measure coupled with PCV estimation produced significant findings in establishing the fact of immune suppressed and resistant breeds. Moreover, the FAMACHA tool could be used for the culling of susceptible animals to avoid the transmission of a poor genetic pool from herds, exploiting the best genetic pool with greater genetic herd resistance against *H. contortus.* Such achievement could not be attained by using conventional anthelmintic treatment (Kaplan et al. 2004).

The recorded data showed that the Angora goat has more tendencies to infestation from this parasite. This breed is not native to our environment and was imported from foreign countries. Out of our local animals Teddy and Beetal goat showed better resistant behaviour and hence are considered as immune competent. On the other hand, Nachi goat showed less tendency to resist against *H. contortus*. After taking all the readings, deworming was done twice using the best effective anthelmintic drug to clear the selected animals from the parasitic load.

In conclusion, genetic heritability to *H. contortus* within breeds should be considered to evaluate the heritabilities of the studied indicators in goats under our native conditions and to find the epidemiology and control of *H. contortus* in goats.

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