Comparative investigation of some behavior traits of Honamlı, Hair, and Saanen goats in a Mediterranean maquis area

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Abstract: The study was conducted to investigate comparatively some behavior traits (grazing, resting, bipedal stance, agonistic behavior, rumination, and browsing) of Honamlı, Hair, and Saanen goat breeds in the morning and afternoon periods between April and September in maquis shrublands. A total of 30 two-year-old goats including 10 from each goat breed were used. While grazing behavior of Saanen goats was observed mostly in April and May as 75.45%–71.65% and 73.16%–78.25% for morning and afternoon in these months, respectively, these values were respectively 62.52%–64.23% and 59.94%–67.67% for Hair goats and 60.12%–62.94% and 46.42%–54.78% for Honamlı goats. It was observed that Hair goats exhibited more browsing and bipedal stance and Honamlı goats rested more and had more agonistic behaviors compared to the other breeds. Higher values were determined for rumination and standing behaviors in Saanen goats compared to the others (P < 0.05). This study has revealed that it is needed to examine factors in more detail such as grazing time, season, and condition of herbaceous plants on the basis of their effects on the interest of goats towards bushes and saplings.

Key words: Goat, behavior, maquis

1. Introduction

Animal behavior studies are scientific studies in which any kind of animal activity is observed. However, since there might be differences between species and breeds of animals, it is also needed to consider relationships of animals with each other and their environment in these studies. The fourth out of the 5 fundamental freedoms of animals, which were introduced in 1992 by the Farm Animal Welfare Committee, is about animals exhibiting their normal behaviors. Related studies indicate that animals exhibiting their natural behaviors move around more and have a healthier body structure; therefore, they also live for a longer time (1). Allowing animals to exhibit their natural behaviors is important in terms of meeting their needs (2). When the issue is approached from this perspective, it is significant to reveal goats' patterns of behavior in areas in and around forests found in their natural habitats.

Goat breeding in Anatolian geography is observed to be carried out generally in areas in and around forests, as well as lands with inappropriate terrain conditions and areas that are not suitable for plant and animal production (3). Goats have a feeding behavior quite different than other farm animals and can feed on numerous plant species, including bush, brier, and small saplings of maquis (4). Compared to other farm animals, they are more selective when they are both feeding in their feed boxes and grazing (5). Goats, with a very developed ability of adaptation, are able to efficiently utilize bushy grazing lands in every season (6). In addition, some indigestible substances contained by bushes also restrict goats to graze for a long time (7). Goats tend to exhibit grazing behaviors for longer times compared to other ruminants. Even though they consume the forage more rapidly compared to sheep, they have a longer period of grazing. This is associated with the fact that goats are quite active and behave selectively when they are grazing. Goats exhibit numerous patterns of behavior to adapt to adverse effects caused by high temperatures. One of these is reducing feed intake voluntarily. They are observed to graze more at early hours in the morning and at late hours in the evening during warm seasons (8). Goats are also reported to adjust their grazing rates based on hours in a day (9). Differently from other ruminants, goats reach the branches of trees by standing on their hind legs and can eat offshoots, buds, and leaves (bipedal stance) (10). This behavior constitutes a considerably important situation in terms of silvopastoral systems of the Mediterranean region (11). It is reported that goats can

reach to a height of 165–200 cm and use bipedal stance more in poor grazing lands (12).

The aim of this study was to comparatively reveal some behavioral patterns of Honamlı, Hair, and Saanen goat breeds in maquis shrublands.

2. Materials and methods

2.1. The study area, animals, and data collection

The study was conducted in a maquis shrubland of 1000 m² located on the İstiklal campus of Mehmet Akif Ersoy University (Figure 1). While kermes oak (*Quercus coccifera*) prevailed mostly in maquis shrubland where the experimental stage of the study was carried out, formations from cultures of green olive tree (*Phillyrea latifolia*), black pine (*Pinus nigra*), Calabrian pine (*Pinus brutia*), and cedar (*Cedrus*) were also found.

A total of 30 two-year-old female goats including 10 from each of the Honamlı, Hair, and Saanen goat breeds were used. These animals were brought to the Research and Application Farm of Mehmet Akif Ersoy University 1 month before the experimental stage of the study in order to ensure their adaptation to the region. During the study, any necessary types of prevention and control applications (vaccines, anthelmintic medicines, etc.) regarding their health were performed.

Behavior observations were carried out on for 6 months (April–September) during three consecutive days per month by allocating 1 day for each breed in the maquis area. They were performed for a total of 7 h in a day as 3.5-h periods in the morning (0830–1200 hours) and in the afternoon (1400–1730 hours). Honamlı, Hair, and Saanen goats were observed directly by an observer for each breed. Observations were recorded via time sampling with 15-min intervals by the observer for each breed.

Grazing, resting, bipedal stance, agonistic behavior, rumination, and browsing behaviors (13) of the goats in the maquis shrubland were determined according to attempts of behaviors during the observation period (Figures 2 and 3). Animals whose behaviors were observed on each observation day were determined randomly every time.

The study was approved by the Mehmet Akif Ersoy University Local Ethics Committee on Animal Experiments (29.08.2014, meeting number: 14, resolution number: 89).

2.2. Statistical analysis

In statistical comparison of the data, Minitab 16.1 statistical software (14) was used. An intense descriptive statistical analysis was first applied to the data. Nonparametric tests such as the Mann–Whitney U and Kruskal–Wallis tests were also used in statistical evaluation of the data not showing normal distribution.

3. Results

In the study, breed-based evaluations and comparisons were performed for some behavior traits of Honamlı, Hair, and Saanen goats in maquis shrubland in the morning and afternoon periods between April and September. Grazing and browsing among the behavior patterns of the goats were the most prominent behaviors.

### 3.1. Behavior traits of Saanen goats

Grazing behavior of Saanen goats in the maquis shrubland was observed mostly in April and May as 75.45%–71.65% and 73.16%–78.25% for morning and afternoon in the mentioned months, respectively (Table 1). Values in other months of measurement decreased approximately by half; when grazing decreased, browsing increased in these months. On the other hand, Saanen goats generally grazed more and were more active by spending more time in the bushes in the morning compared to afternoon; they mainly displayed more bipedal stance and resting behaviors in the afternoon.

Figure 1. Study area, maquis shrubland.
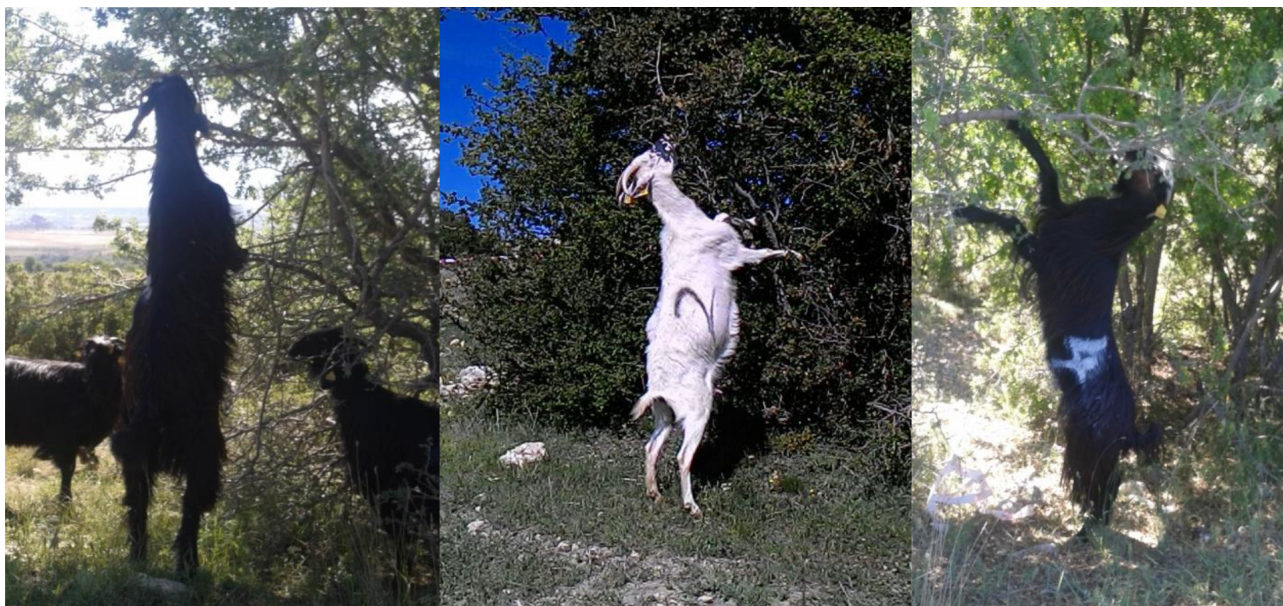
Figure 2. Bipedal stance of goats.
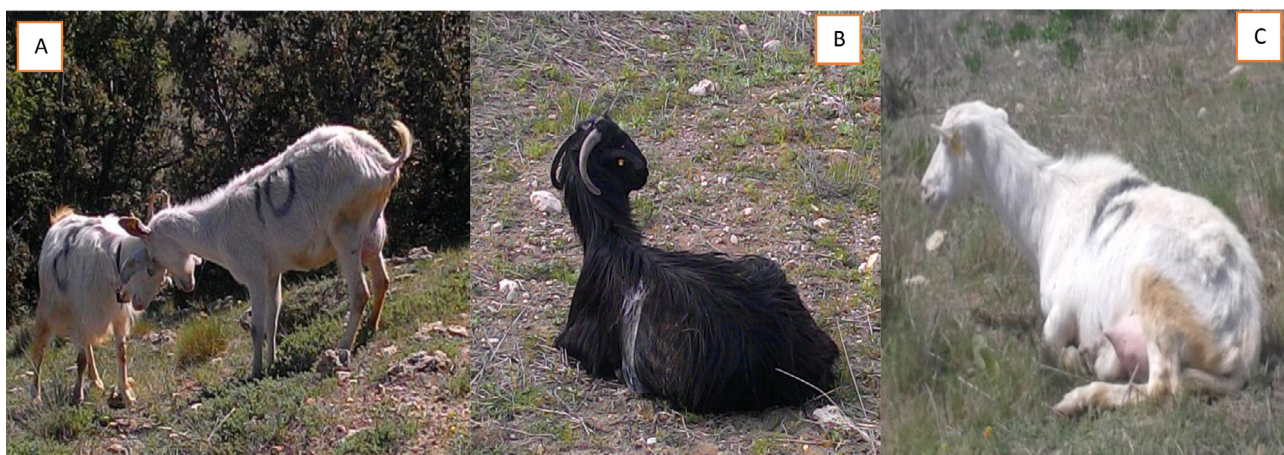
Figure 3. Some behavior traits of goats: A) agonistic behavior, B) resting, C) rumination.

3.2. Behavior traits of Hair goats
Table 2 shows some behavior traits of Hair goats in the maquis shrubland. It was observed that Hair goats grazed more in the afternoon compared to morning, except for June and July. Hair goats rested in a very short period of time in measurements taken in the afternoon in June and September and in measurements taken only in May among the months of measurements. Hair goats exhibited more bipedal stance behaviors in September compared to the other months (6.98% and 8.09%).

3.3. Behavior traits of Honamlı goats
Table 3 shows behavior traits of Honamlı goats in days of measurements taken for 6 months in a maquis shrubland of 1000 m². It was observed that agonistic behavior of

Honamlı goats in the maquis shrubland did not reach 1% in any month during the observation period. While Honamlı goats grazed mostly in April, they displayed browsing mostly in the morning in August (68.46%). In addition, differences of up to 10% were determined in Honamlı goats between observation periods of morning and afternoon in terms of browsing. Higher values were observed in the afternoon in terms of resting and rumination behaviors.

3.4. Comparison of goats' behavioral patterns
When behaviors of the goats in the maquis shrubland were compared, it was observed that Hair goats were more active and exhibited more browsing and bipedal stance behaviors compared to the other two breeds (Table 4).

Table 1. Some behavior traits of Saanen goats in maquis shrubland (%) (mean ± standard errors).

Observation month	Observation period	Grazing	Resting	Bipedal stance	Rumination	Browsing	Agonistic behavior
April	Morning	75.45 ± 2.27	0.00 ± 0.00	1.52 ± 0.30	0.55 ± 0.16	20.39 ± 1.57	0.23 ± 0.08
	Afternoon	71.65 ± 1.74	0.00 ± 0.00	2.40 ± 0.29	1.64 ± 0.31	21.79 ± 1.22	0.48 ± 0.08
May	Morning	73.16 ± 2.30	0.00 ± 0.00	0.51 ± 0.43	1.34 ± 0.04	18.80 ± 1.23	0.57 ± 0.05
	Afternoon	78.25 ± 2.23	0.00 ± 0.00	2.77 ± 1.36	1.98 ± 0.01	11.77 ± 1.16	0.49 ± 0.02
June	Morning	36.30 ± 3.81	0.15 ± 0.01	3.55 ± 0.52	1.48 ± 0.09	55.75 ± 2.62	0.14 ± 0.03
	Afternoon	32.94 ± 2.90	1.38 ± 0.06	2.13 ± 0.09	3.03 ± 0.63	57.30 ± 3.11	0.09 ± 0.01
July	Morning	27.80 ± 1.65	0.15 ± 0.07	1.55 ± 0.11	0.00 ± 0.00	68.34 ± 1.44	0.03 ± 0.01
	Afternoon	18.59 ± 0.69	1.98 ± 0.15	2.73 ± 0.07	1.54 ± 0.08	72.32 ± 1.18	0.23 ± 0.04
August	Morning	40.64 ± 3.71	0.19 ± 0.04	1.54 ± 0.09	0.00 ± 0.00	54.42 ± 0.84	0.14 ± 0.02
	Afternoon	39.20 ± 2.67	1.99 ± 0.07	0.99 ± 0.02	6.36 ± 0.33	44.81 ± 1.12	0.31 ± 0.11
September	Morning	24.42 ± 2.78	0.23 ± 0.04	2.24 ± 0.09	5.81 ± 0.75	58.90 ± 2.74	0.32 ± 0.02
	Afternoon	26.10 ± 2.10	1.16 ± 0.02	2.76 ± 0.08	7.32 ± 0.66	56.83 ± 2.59	0.31 ± 0.07

Table 2. Some behavior traits of Hair goats in maquis shrubland (%) (mean ± standard errors).

Observation month	Observation period	Grazing	Resting	Bipedal stance	Rumination	Browsing	Agonistic behavior
April	Morning	62.52 ± 2.07	0.00 ± 0.00	2.67 ± 0.06	0.00 ± 0.00	30.36 ± 0.93	0.34 ± 0.01
	Afternoon	64.23 ± 2.75	0.00 ± 0.00	3.75 ± 0.05	0.00 ± 0.00	27.53 ± 0.71	0.40 ± 0.03
May	Morning	59.96 ± 3.03	0.39 ± 0.01	2.52 ± 0.08	0.00 ± 0.00	28.86 ± 2.66	0.25 ± 0.05
	Afternoon	67.67 ± 2.81	1.55 ± 0.04	2.34 ± 0.13	0.64 ± 0.02	23.13 ± 2.21	0.28 ± 0.01
June	Morning	56.68 ± 2.24	0.00 ± 0.00	1.25 ± 0.04	0.00 ± 0.00	37.87 ± 1.21	0.15 ± 0.02
	Afternoon	48.02 ± 2.08	0.07 ± 0.01	5.24 ± 0.31	0.31 ± 0.02	45.45 ± 1.90	0.11 ± 0.01
July	Morning	30.75 ± 1.11	0.00 ± 0.00	2.71 ± 0.13	00.00 ± 0.00	64.65 ± 0.73	0.03 ± 0.01
	Afternoon	27.15 ± 0.92	1.11 ± 0.02	3.44 ± 0.21	0.28 ± 0.07	64.62 ± 1.25	0.00 ± 0.00
August	Morning	24.57 ± 1.45	0.00 ± 0.00	5.22 ± 0.96	0.15 ± 0.01	67.41 ± 2.17	0.32 ± 0.05
	Afternoon	39.29 ± 2.28	0.00 ± 0.00	2.52 ± 0.71	1.52 ± 0.08	54.17 ± 1.18	0.13 ± 0.06
September	Morning	21.87 ± 0.83	0.00 ± 0.00	6.98 ± 0.04	0.19 ± 0.04	69.06 ± 2.06	0.15 ± 0.05
	Afternoon	33.29 ± 1.94	0.00 ± 0.00	8.09 ± 0.06	0.46 ± 0.03	52.54 ± 1.86	0.25 ± 0.03

Honamlı goats were observed to rest more in the maquis shrubland and have more agonistic behaviors with each other compared to the other breeds. While higher values were determined for rumination and standing behaviors in Saanen goats compared to Honamlı and Hair goats and these values were statistically significant (P < 0.05), the difference observed in terms of grazing was not statistically significant (P > 0.05).

It was observed that only Honamlı and Hair goats showed some different behavior traits during the observation time. Figure 4 shows those behaviors.

Table 3. Some behavior traits of Honamlı goats in maquis shrubland (%) (mean ± standard errors).
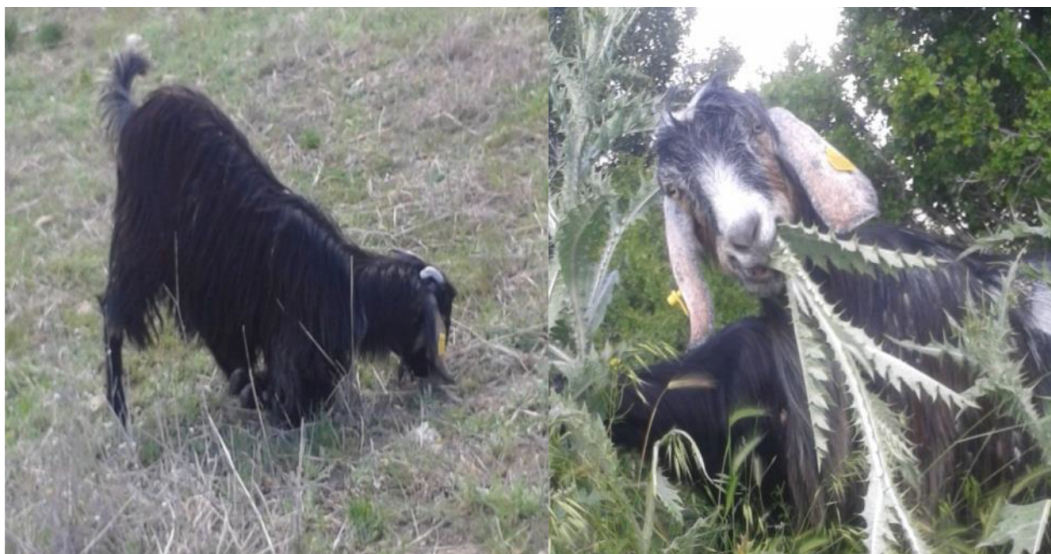
Observation month	Observation period	Grazing	Resting	Bipedal stance	Rumination	Browsing	Agonistic behavior
April	Morning	60.12 ± 1.44	0.00 ± 0.00	1.59 ± 0.03	0.00 ± 0.00	32.94 ± 1.77	0.46 ± 0.06
April	Afternoon	62.94 ± 2.06	0.95 ± 0.04	2.65 ± 0.41	0.31 ± 0.04	25.57 ± 1.38	0.54 ± 0.01
May	Morning	46.42 ± 2.12	0.43 ± 0.09	3.41 ± 0.95	0.27 ± 0.04	39.33 ± 1.13	0.81 ± 0.07
May	Afternoon	54.78 ± 2.88	7.83 ± 0.35	0.96 ± 0.06	2.02 ± 0.15	27.85 ± 0.67	0.54 ± 0.09
June	Morning	34.92 ± 1.38	2.64 ± 0.67	6.76 ± 0.81	1.42 ± 0.03	50.10 ± 1.53	0.63 ± 0.04
June	Afternoon	39.86 ± 1.81	2.66 ± 0.32	5.15 ± 0.55	0.95 ± 0.06	49.09 ± 1.07	0.50 ± 0.08
July	Morning	32.73 ± 1.05	0.00 ± 0.00	1.34 ± 0.04	0.00 ± 0.00	59.96 ± 2.20	0.15 ± 0.03
July	Afternoon	45.44 ± 1.38	0.00 ± 0.00	2.07 ± 0.21	0.00 ± 0.00	50.58 ± 1.48	0.11 ± 0.05
August	Morning	26.52 ± 1.13	0.00 ± 0.00	3.07 ± 0.55	0.00 ± 0.00	68.46 ± 1.19	0.21 ± 0.04
August	Afternoon	40.69 ± 0.72	1.84 ± 0.28	4.26 ± 0.73	1.50 ± 0.07	48.67 ± 1.67	0.36 ± 0.03
September	Morning	40.44 ± 0.82	0.00 ± 0.00	1.59 ± 0.18	0.11 ± 0.02	56.05 ± 1.72	0.00 ± 0.00
September	Afternoon	49.71 ± 1.12	0.00 ± 0.00	2.81 ± 0.33	1.33 ± 0.03	42.67 ± 1.20	0.00 ± 0.00

Table 4. The factors affecting goats' behaviors in maquis shrubland (mean ± standard errors).

Factors	Grazing	Resting	Bipedal stance	Rumination	Browsing	Agonistic behavior
Breed						
Saanen	45.37 ± 1.21	0.60[ab] ± 0.07	2.06[b] ± 0.30	2.58[a] ± 0.30	45[b].12 ± 1.03	0.28[ab] ± 0.03
Hair	44.66 ± 1.03	0.26[b] ± 0.03	3.89[a] ± 0.47	0.29[b] ± 0.07	47[a].13 ± 1.43	0.20[b] ± 0.05
Honamlı	44.54 ± 0.78	1.36[a] ± 0.23	2.97[ab] ± 0.51	0.66[b] ± 0.11	45[b].77 ± 0.84	0.36[a] ± 0.08
P	0.917[ns]	0.003**	0.000***	0.000***	0.036*	0.018*
Observation period						
Morning	43.07 ± 0.84	0.23 ± 0.06	2.78 ± 0.25	0.63 ± 0.07	48.86 ± 1.17	0.27 ± 0.03
Afternoon	46.65 ± 1.24	1.25 ± 0.18	3.17 ± 0.60	1.73 ± 0.25	43.16 ± 0.60	0.28 ± 0.05
P	0.042*	0.000***	0.271[ns]	0.002**	0.001**	0.806[ns]
Observation month						
April	66.14[a] ± 1.48	0.15[b] ± 0.04	2.43[abc] ± 0.41	0.41[b] ± 0.08	26.42[c] ± 0.67	0.41[ab] ± 0.05
May	63.37[a] ± 1.05	1.70[a] ± 0.32	2.08[c] ± 0.25	1.04[ab] ± 0.15	24.95[c] ± 0.49	0.49[a] ± 0.07
June	41.45[b] ± 0.76	1.15[ab] ± 0.16	4.01[ab] ± 0.83	1.20[ab] ± 0.19	49.29[b] ± 1.13	0.27[abc] ± 0.02
July	30.41[c] ± 0.42	0.54[ab] ± 0.05	2.31[bc] ± 0.12	0.30[b] ± 0.06	63.41[a] ± 1.78	0.09[c] ± 0.01
August	35.15[bc] ± 1.65	0.67[ab] ± 0.17	2.93[abc] ± 0.30	1.59[ab] ± 0.23	56.33[ab] ± 0.86	0.25[bc] ± 0.08
September	32.64[c] ± 0.88	0.23[b] ± 0.08	4.08[a] ± 0.43	2.54[a] ± 0.43	55.65[ab] ± 0.44	0.17[c] ± 0.02
P	0.000***	0.007**	0.002**	0.004**	0.000***	0.000***

[a,b,c]: Values in the same column with different superscripts are statistically different (P < 0.05).
[ns]: Nonsignificant (P > 0.05). *: P < 0.05, **: P < 0.01, ***: P < 0.001.

Figure 4. One of the interesting behavior traits examined during the observation period.

4. Discussion

It was determined that the goats exhibited mostly grazing and an interest in shrubs in the maquis shrubland for 7 h on observation days. The goats were observed to graze mainly in April and May averagely at the respective rates of 66.14% and 63.37%. While these values were compatible with the values reported by Schlecth et al. (12), various researchers (9,15,16) reported that grazing behavior may vary between 60% and 85%. Grazing behavior is known to vary depending on season and hours within a day (9,17). Time spent by Saanen goats for grazing was longer in the morning compared to the afternoon. This is compatible with the results of the study by Morand-Fehr (18). However, the contrary was seen in Honamlı and Hair goats in the study. Considering the fact that there might be fluctuations seen in grazing behaviors of goats during the day depending on various factors (6,19), it would not make sense to compare breeds in this regard.

Grazing behavior is also known to vary depending on age, sex, and physiological periods of animals (20). While pregnancy and lactation are prominent factors in these aspects (21), it is reported that animals learn structural characteristics of plants with increasing age and this affects grazing behavior (22). Since the conditions stated in study were not factors, they were eliminated. Goats at the same age and with the same physiological condition were used in the study in order to allow behavioral differences between breeds to arise from only differences between genotypes as much as possible. It is reported that time spent by different breeds of goat for grazing might also be different. Beker et al. (23) reported that Boer goats tended to spend more time for grazing compared to Spanish goats. In the study conducted by Fedele et al. (24) in Italy, they also stated that

Maltese goats farmed in a more controlled manner were more selective compared to a domestic goat breed farmed under extensive circumstances. In this situation, it was observed that there might be differences between grazing behaviors of different breeds. A similar situation was also observed in this study; Saanen goats were determined to spend more time grazing compared to the other two breeds. On the other hand, the grazing rate of Saanen goats was lower compared to the rate (70.7%) reported for Turkish Saanen goats by Tölü (25). It is thought that this is associated with the age and physiological conditions of Saanen goats used in the study (not being pregnant, therefore being out of the lactation period) and the composition of herbaceous plants on the base.

An obvious increase was remarkable in summer months in terms of tendency for shrubs. This situation verifies the results reported by Ventura et al. (26), indicating that bushes have an important place for meeting food requirements of goats especially in summer in regions where characteristics of a Mediterranean climate are dominant. Orihuela and Solano (27) reported that as the time goats spent with herbaceous plants increased, the interest in woody formations decreased and vice versa. The results of this study are parallel to this; browsing increased in the period when grazing decreased. It was reported that while the goats preferred bush mostly in July at the rate of 63.41% averagely, browsing behavior of the goats could vary between 50% and 90% (28). In addition, Solanki (9) stated that bushes had a share of about 52% in total consumption.

Hair goats were explicitly observed to spend more time on bush compared to Honamlı and Saanen goats (P < 0.05). Similarly, Mill (29) determined statistically

significant differences between Boer goats and a domestic goat genotype in terms of browsing. As in grazing in the bush, the goats were observed to spend more time in the morning compared to afternoon in this study. This situation indicated that temperature and shade conditions within a day were not effective in the browsing of goats.

One of the most significant behavioral patterns distinguishing goats from other ruminants is bipedal stance behavior, namely raising the front legs (Figure 2). Even though every breed whose behaviors were examined showed bipedal stance at variable rates, as is the nature of the species, Hair goats showed bipedal stance more compared to the other two. In addition, the specified rate was lower than the rates reported by various other researchers (17,30). This might be associated with the abundance of grass species in maquis shrubland because bipedal stance behavior of goats increases further in poor grazing lands.

Statistically significant differences were observed between breeds in terms of rumination (P < 0.05). Likewise, Mill (29) determined that there were statistically significant differences between breeds in terms of rumination behavior. Saanen goats ruminated more during the observation period compared to the other two breeds. Low rumination rate in Honamlı and Hair goats is thought to be associated with the will of these breeds to mainly rest in barns and therefore to have rumination in these times. Honamlı goats rested at higher rates compared to Hair and Saanen goats, which makes us think that this was associated with a lack of sufficient mechanical pressure at low frequency of rumination (20).

Saanen goats spent most of the time on rumination and watching the area around them by standing when they were not grazing and interested in the bush. When the same situation was evaluated for Hair goats, they were generally observed to exhibit a more active behavior compared to the other two genotypes other than grazing and browsing. Honamlı goats spent their time remaining after grazing and browsing for resting more than the other breeds. Even though this is an important finding in terms of choices of breeds, it can also be evaluated as an open area in terms of its disputability with further studies. Although there were statistically significant differences between breeds in terms of agonistic behavior in this study, the relatively tremendous horn structure of Saanen goats compared to the other breeds was not effective in this situation. In addition, it could be more appropriate to determine agonistic behavior in environments with more competition (forage limitation, mating time, etc.) in more limited areas like barns.

Additionally, some detected behaviors reflected the level and ability of adaptation for Honamlı and Hair goats in the area. These should be determined in detail with further studies.

In conclusion, the results of the study have carried discussions into a more objective course by representing scientific data on goat grazing, forest, and maquis issues. This study has revealed that it is needed to examine factors in more detail, such as grazing time, season, and condition of herbaceous plants, on the basis of their effects on interests of goats towards bushes and saplings.

It is not rational to ignore goats as "forest pests" in these days when the world and especially Turkey has a red meat problem. It is required to determine the morphological, physiological, and behavioral characteristics of these animals; to examine which environments and aspects they need to be utilized in; and to identify ways of integrating this species into the red meat sector.

References

1. Dawkins MS. Using behaviour to assess animal welfare. Anim Welf 2004; 13: 3-7.

2. Spinka M. How important is natural behaviour in animal farming systems? Appl Anim Behav Sci 2006; 100: 117-128.

3. Koyuncu M. Keçi yetiştiriciliğinin dünya ve Türkiye stratejileri. In: Proceedings of the National Congress of Dairy Goat, İzmir, Turkey; 2005. pp. 59-65 (in Turkish).

4. Bateman HG, White TW, Williams CC, Alford S. Case study: goat preference for concentrates or forages is influenced by physical and chemical characteristics of the feed. Professional Animal Scientist 2004; 20: 198-204.

5. Morand-Fehr P. Dietary choices of goats at the trough. Small Rumin Res 2003; 49: 231-239.

6. Silanikove N. The physiological basis of adaptation in goats to harsh environments. Small Rumin Res 2000; 35: 181-193.

7. Landau S, Silanikove N, Nitsan Z, Barkai D, Baram H, Provenza FD, Perevolotsky A. Short-term changes in eating patterns explain the effects of condensed tannins on feed ıntake in heifers. Appl Anim Behav Sci 2000; 69: 199-213.

8. Lu CD. Grazing behaviour and diet selection of goats. Small Rumin Res 1988; 1: 205-216.

9. Solanki GS. Feeding habits and grazing behaviour of goats in a semi-arid region of India. Small Rumin Res 1994; 14: 39-43.

10. Leopold Center Grass-based Livestock Working Group. Graze Goats to Clean Up Trees, Brush, Weeds and Other Unwanted Plants. Ames, IA, USA: Leopold Center; 2009.

11. Le Houerou HN. Environmental Aspects of Fodder Trees and Shrubs Plantation in the Mediterranean Basin. Brussels, Belgium: Agriculture, Agrimed Research Programme, Commission of the European Communities; 1993.

12. Schlecht E, Hiernaux P, Kadaoure I, Hülsebusch C, Mahler F. Spatio-temporal analysis of forage availability and grazing and excretion behaviour of herded and free grazing cattle, sheep and goats in Western Niger. Agric Ecosyst Environ 2006; 113: 226-242.

13. Barrows EM. Animal Behavior Desk Reference: A Dictionary of Animal Behavior, Ecology and Evolution. 2nd ed. Boca Raton, FL, USA: CRC Press; 2001.

14. Minitab Inc. Minitab 16.1.1 for Windows. State College, PA, USA: Minitab Inc.; 2011.

15. Cisse M, Ly I, Nianogo AJ, Sane I, Sawadogo JG, N'Diaye M, Awad C, Fall Y. Grazing behavior and milk yield of Senegalese Sahel goat. Small Rumin Res 2002; 43: 85-95.

16. El Aich A, El Assouli N, Fathi A, Morand-Fehr P, Bourbouze A. Ingestive behavior of goats grazing in the Southwestern Argan (*Argania spinosa*) forest of Morocco. Small Rumin Res 2007; 70: 248-256.

17. Dziba LE, Scogings PF, Gordon IJ, Raats JG. The feeding height preferences of two goat breeds fed *Grewia occidentalis* L. (Tiliaceae) in the Eastern Cape, South Africa. Small Rumin Res 2003; 47: 31-38.

18. Morand-Fehr P. Nutrition and feeding of goats: application to temperate climatic conditions. In: Gall C, editor. Goat Production. New York, NY, USA: Academic Pres; 1981. pp. 192-232.

19. Demment MW, Van Soest PJ. A nutritional explanation for body size patterns of ruminant and non-ruminant herbivores. Am Nat 1985; 125: 640-671.

20. Yayneshet T, Eik LO, Moe SR. Influences of fallow age and season on the foraging behavior and diet selection pattern of goats (*Capra hircus* L.). Small Rumin Res 2008; 77: 25-37.

21. Galina M, Palma JM, Morales R, Aguilar A, Hummel J. Voluntary dry matter intake by dairy goats grazing on rangeland or on agricultural by-products in Mexico. Small Rumin Res 1995; 15: 127-137.

22. Ortega-Reyes L, Provenza FD. Experience with blackbrush affects ingestion of shrub live oak by goats. J Anim Sci 1993; 71: 380-383.

23. Beker A, Gipson TA, Puchala R, Askar A, Tesfai K, Detweiler GD, Asmare A, Goetsch AL. Effects of stocking rate, breed, and stage of production on energy expenditure and activity of meat goat does on pasture. J Appl Anim Res 2009; 36: 159-174.

24. Fedele V, Pizzillo M, Claps S, Morand-Fehr P, Rubino R. Grazing behavior and diet selection of goats on native pasture in Southern Italy. Small Rumin Res 1993; 11: 305-322.

25. Tölü C. Studies on behaviour, health and performance traits of different goat genotypes. PhD, Çanakkale Onsekiz Mart University, Çanakkale, Turkey, 2009 (in Turkish with an English summary).

26. Ventura MR, Castanon JIR, Pieltain MC, Flores MP. Nutritive value of forage shrubs: *Bituminaria bituminosa*, *Rumex lunaria*, *Acacia salicina*, *Cassia sturtii* and *Adenocorpus foliosu*. Small Rumin Res 2004; 52: 13-18.

27. Orihuela A, Solano JJ. Grazing and browsing times of goats with three levels of herbage allowance. Appl Anim Behav Sci 1999; 61: 335-339.

28. Papachristou TG. Foraging behaviour of goats and sheep on Mediterranean oak shrublands. Small Rumin Res 1997: 24: 85-93.

29. Mill E. Investigation into the grazing of the Mediterranean shrub vegetation of North-West Tunisia by goats, particularly in relation to stocking density. Anim Res Dev 1990; 32: 7-40.

30. Lebopa CK, Boomker EA, Chimonyo M, Mulugeta SD. Factors affecting the feeding behaviour of free ranging Tswana and Boer goats in the False Thornveld of the Eastern Cape, South Africa. Life Sci J 2011; 8: 70-80.