Goat farming and landscape management: From controlled research to controlled grazing

T.A. Glasser[1], S.Y. Landau[2], E. Ungar[2], H. Muklada[2], A. Perevolotsky[2]

[1]Ramat Hanadiv Nature Park, P.O. Box 325, Zichron Ya'akov, 30900, Israel

[2] Department of Natural Resources and Agronomy, Institute of Plant Sciences, Agricultural Research Organization –Volcani Center, P.O. Box 6, Bet Dagan 50250, Israel

Abstract

In May, 2002 fourteen Damascus goats were bought and held at the Ramat-Hanadiv Nature Park on Mt. Carmel, in central Israel. The main purpose of purchasing the goats was to collect scientific information regarding grazing behaviour of different goat breeds and seasons and apply it in the management of the nature park. The research aimed at bridging the agricultural and ecological aspects of grazing in Mediterranean shrubland and reconciling the needs of both farmers and landscape managers. Fecal NIRS calibrations were developed using the MPLS routine of the Win-ISI II software (ISI, 1999) in order to determine dietary quality and botanical composition of free-grazing goats' diets. Reference values for calibration were obtained by a NIRS-oriented observation method that combined focal observation, digital recording and computerized "reconstruction" of the diet. Further on, the equations were used for determining dietary composition of three goat breeds (Damascus, Boer & Mamber) in different seasons.

This data was implemented in the context of a yearly grazing program at the park. Due to the relatively poor results of the Boer goats, they were excluded and the herd has expanded (to150 head) with Mamber and Damascus goats. The herd forages daily at specific locations in the park with specific management goals, such as suppression of *P. lentiscus* (approx. 20% tannins) or consumption of forest understory vegetation. Most scientific results are implemented in the park and herd management. The herd serves as a semi-commercial herd, since milk and cheese are produced, as well as for agro-tourism activities.

Keywords: goat, grazing, near-infrared reflectance spectroscopy, observations, behaviour

Introduction

Since goat domestication about 10,000 years ago (Zeder and Hesse, 2000), some 180 different breeds of goats have evolved (Porter, 1996). Many of these breeds developed more through genetic isolation and natural selection rather than through deliberate intervention by man (Devendra and Burns, 1983). Nevertheless, human selection has encouraged specific attributes and some breeds have become specialized. For example, Saanen and Alpine goats are bred for milk, the Boer goat is bred exclusively for meat, and the Angora and Cashmere goats are bred for fiber.

When using goats for landscape management (i.e. combating shrub encroachment, fire prevention, biodiversity conservation), the breed used must also be taken into consideration. There are significant differences among goat breeds in grazing behaviour attributes, such as dietary preferences (Dziba *et al.,* 2003) and propensity to consume specific plant species (Glasser *et al.,* 2009). Furthermore, herds that are used for landscape management must create a sustainable income. This income is usually gained by the production and sales of milk, cheese and meat.

In order to introduce goat herds to nature parks, forests and/or areas that need grazing services, there must be a profound understanding of the components involved, both from the ecological aspect and from the agricultural aspect. The main factors affecting livestock production are genetic potential and nutrition. In order to combine agricultural production goals with those of landscape management, it is most important to choose the breed that will consume the desired plant species as well as being able to produce under the limiting conditions of landscape-use restrictions (herd size, grazing pressure, limited supplementation, etc.).

The objective of this project is to develop a sustainable goat farm combining shrub control, fire prevention and self-sufficient economic production. In order to achieve these objectives, the park authorities have decided to implement a research, carried out in cooperation with the Volcani Center, for identifying the breed that will consume tannin-rich plants, which are very abundant in the park and are encroaching and covering most of the park area.

Materials and methods

Study site

The study was conducted at the Ramat-Hanadiv Nature Park, located on the southern tip of the South Carmel mountain ridge, in central Israel (32° 25' N, 34° 52' E), characterized by an average yearly rainfall of 600 mm and a 180-d rainy season from October to April. The size of the nature park is 450 Ha. In the center of the park are the mamorial gardens which sprawl across approximately seven hectares, surrounding the Baron and Baroness Rothschild's crypt. The nature park borders on two populated communities (one on the north and one on the south), which increases fire hazards. The ecosystem is a disturbed Mediterranean woodland (garrigue) featuring steep rocky slopes with rare patches of shallow soil. The vegetation is dominated by low trees (mainly *Phillyrea latifolia* L.) and tall shrubs (*Pistacia lentiscus* L. and *Calicotome villosa* L.) which form 2- to 3-m high round coppice islets that are sometimes covered with climbing *Rubia tenuifolia* Dum.-Urville, *Clematis cirrhosa* L., *Smilax aspera* L., Isolated Kermes (*Quercus calliprinos* Webb) and Thabor (*Q. ithaburensis* Decaisne) oak trees. Carob (*Ceratonia siliqua* L.) and buckthorn (*Rhamnus alaterna* L.) trees can also be found. Occasional bushes of *Ephedra foemina* Forskk., *Asparagus stipularis* Forskk., *Sarcopoterium spinosum* L. Spach are located between the coppices. From January to mid-May, green annual herbaceous vegetation covers the soil patches.

The main woody species that dominate the park are *Pistacia lentiscus,* which contains more than 20% PEG-binding tannins (on DM basis), and *Phillyrea latifolia,* which contains only 3% PEG-binding tannins (on DM basis). For this reason goat breeds that are considered suitable for landscape management are breeds that can cope with the physical conditions of the terrain and the shrubs that are thorny, sclerophyllous, and contain high concentrations of tannins.

During the spring (January-May) a cattle herd (~200 head) is introduced into the park. The herd enters the park when average herbaceous vegetation exceeds 1,200 kg (DM)/ha and leaves the park when it is lower than 700 kg (DM)/ha. This leads to an average of 88.5 grazing days per year. The cattle herd is then turned off from the park until the next grazing season. The cattle herd exploits 77% of the whole park area.

Goat herd

The initial herd was composed of three goat breeds, Boer, Damascus and Mamber (12, 11, 11 head, respectively). After studies regarding grazing behaviour and dietary attributes of the goats under free-grazing conditions, Boer goats were excluded and the herd was expanded by the introduction of Damascus and Mamber bucks. Controlled mating within breeds took place and since 2004 the herd has expanded to comprise 100 goats and 50 yearlings (50% of each breed).

Determination of dietary composition

Goats' dietary quality and botanical composition was determined by the fecal NIRS (Near Infrared Reflectance Spectroscopy) method (Lyons and Stuth, 1992). Calibration equations were developed using the MPLS routine of the Win-ISI II software (ISI, 1999). Fecal NIRS calibrations had reasonable precision for predicting dietary percentages of the three main botanical components: herbaceous vegetation (as one category), *Phillyrea latifolia*; and tannin-rich *Pistacia lentiscus*, (R^2 = 0.85, 0.89 and 0.77, respectively) with SE of cross-validation (SECV) of 7.8, 6.3, and 5.6% of DM, respectively. R^2 values for the prediction of CP (Crude Protein), NDF (Natural Detergent Fiber, IVDMD (In Vitro Dry-Matter Digestibility), and polyethylene glycol-binding tannins were 0.93, 0.88, 0.91, and 0.74, respectively, with SECV values of 0.9, 2.1, 4.3, and 0.9% of DM, respectively. The predictive ability of intake values was generally lower, with R^2 values for intakes of herbaceous vegetation, *P. latifolia*, and *P. lentiscus* of 0.80, 0.75, and 0.65, with SECV values of 71, 64, and 46 g of DM/d, respectively. The R^2 values for the daily nutrient intakes were below 0.60 (Glasser et al, 2008).

Reference values for calibration were obtained by a NIRS oriented observation method (Glasser *et al.*, 2008) that included 45 focal observation sessions (total of 360 observation hours), accompanied by digital recording and computerized "reconstruction" of the diet. Twenty-five observations were carried out during the spring when woody vegetation was lush and herbaceous vegetation was green and of high nutritional quality. Twenty observations were carried out during the fall, when herbaceous vegetation was dry. Equations were then developed from spectra of observed goats' fecal matter and implemented on fecal samples (n=147) from all grazing goats for determining dietary composition of the three goat breeds (Damascus, Boer & Mamber) at the different seasons (Glasser *et al.*, 2009).

Results

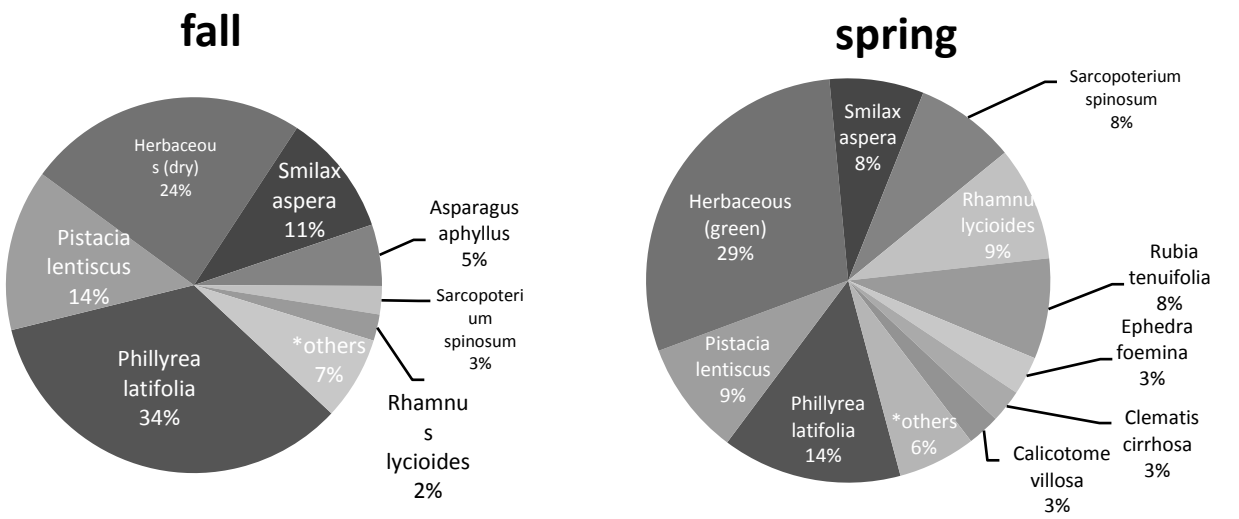
Dietary differences among goat breeds

During the fall, Damascus goats consumed an average of 14.8% of *P. lentiscus* in their diet (on DM basis); Mamber goats consumed 5.5% and Boer goats only 5.0%. Therefore, Damascus goats ingested diets richer in tannins than did Mambers or Boers (Damascus > Mambers = Boers, $P < 0.0001$). On the other hand, Mamber goats' diets' contained a higher

percentage of herbaceous species in the spring than did the other two breeds (38.4 vs. 27.7%, respectively). Boer goats selected the most nutritious diets in terms of CP content and IVDMD. In spite of their differences in foraging selectivity, the local Damascus and Mamber goats had similar dietary percentages of CP and similar IVDMD (Glasser *et al*., 2009)

Dietary differences between seasons

Data regarding dietary botanical composition between seasons is based on 45 focal observations (Glasser *et al.*, 2008), with data averaged over all three breeds. The number of plant species (Herbaceous vegetation grouped) was higher during the spring vs. fall (21 vs. 14). Herbaceous vegetation, *P. lentiscus* and *P. latifolia* comprised more than 50% and 70% of the diet during the spring and fall, respectively. Total woody vegetation (including climbers) consisted of 65.7% and 75.3% of the diet (on DM basis) during the spring and fall, respectively (Figure 1). Thorny and tanniferous species (i.e. *Calicotome vilosa, Sarcopoterium spinosum*) were eaten more readily during the spring than fall. It is important to note that species such as *Asphodelus ramosus, Euphorbia sp., Asparagus aphyllus, Scabiosa prolifera, Tamus communis, Allium sp., Eryngium creticum and Sinapis arvensis* are not present over ground surface during the fall.



*Others include plant species that compose less than 2% (each) in the diet. These are: *Ephedra foemina; Quercus calliprinos; Rubia tenuifolia; Ceratonia siliqua; Asphodelus ramosus; Quercus ithaburensis; Calicotome villosa*

*Others include plant species that compose less than 2%(each) in the diet. These are: *Asphodelus ramosus; Euphorbia sp.; Herbaceous (dry); Asparagus aphyllus; Prasium majus; Scabiosa prolifera; Olea Europaea;Tamus communis; Allium sp.; Eryngium creticum; Sinapis arvensis*

Figure 1. Botanical composition of goats' diets' in Mediterranean shrubland during fall and spring.

Grazing plan

The grazing plan is based mainly on research results regarding grazing behaviour of the goats in the different seasons, combining park management goals. Park managers have designated specific areas/polygons (Figure 2) that need specific treatment (Table 1). The grazing plan is based on a herd size of 100 goats. The total area of the polygons adds up to 57.6 hectares. Grazing takes place in more than one polygon in parallel, according to feed availability, shrub

species and management objectives. Synchronized grazing in more than one polygon enables greater consumption of the vegetation by the goats and is, therefore, more efficient.

Table 1. Grazing plan objective for the different polygons.

Polygon no.	Main management objective	Proposed plan
1) olive groves (exclusively goats)	Landscape opening, reconstructing the groves for the benefit of visitors and nicer scenery	Grazing in winter and spring (higher intake of herbaceous vegetation)
2) "Cabara" stream (goats & cattle)	Preventing fire hazards by creating a firebreak between the neighboring village and the park, as well as continuing opening of the ancient olive groves	Grazing at the end of the cattle grazing season or after they leave this area; completion of clearing by the goats
3) Northeast of memorial gardens	Diminishing woody vegetation volume in favor of the herbaceous vegetation	Entering after cattle leave the area at the end of spring
4) Water spring & archeological site	Reducing fire hazards	Grazing at the beginning of vegetative season
5) Areas dominated by *Calicotome vilosa* and thickets	Diminishing the cover of *Calicotome vilosa* shrubs	Grazing in spring and summer mainly to reduce the cover of *Calicotome vilosa*; in the spring this species is eaten willingly by the goats.
6) Thickets over "Timsach" stream	Treatment of understory, including dense shrubs and climbers	As in 5 (above); however the understory in this area differs from 5 and the rotation between them during the day is recommended
7) Pine thickets at southeast side of the park	Treatment of understory with high cover of *Calicotome vilosa* and climbers and enabling this thicket to be attractive for hikers coming up from the water spring area	Entering this area when *calicotome vilosa* shrubs are blooming; during this period they are eaten willingly by the goats
8) Long-Term Ecological Research (LTER) plots	The objective of grazing in these plots is for research and education purposes	Grazing upon request of researchers. Due to the small size of the plots (0.1 ha each; total of 10 grazed plots) there is no problem to allow the goats to graze for short periods throughout the year

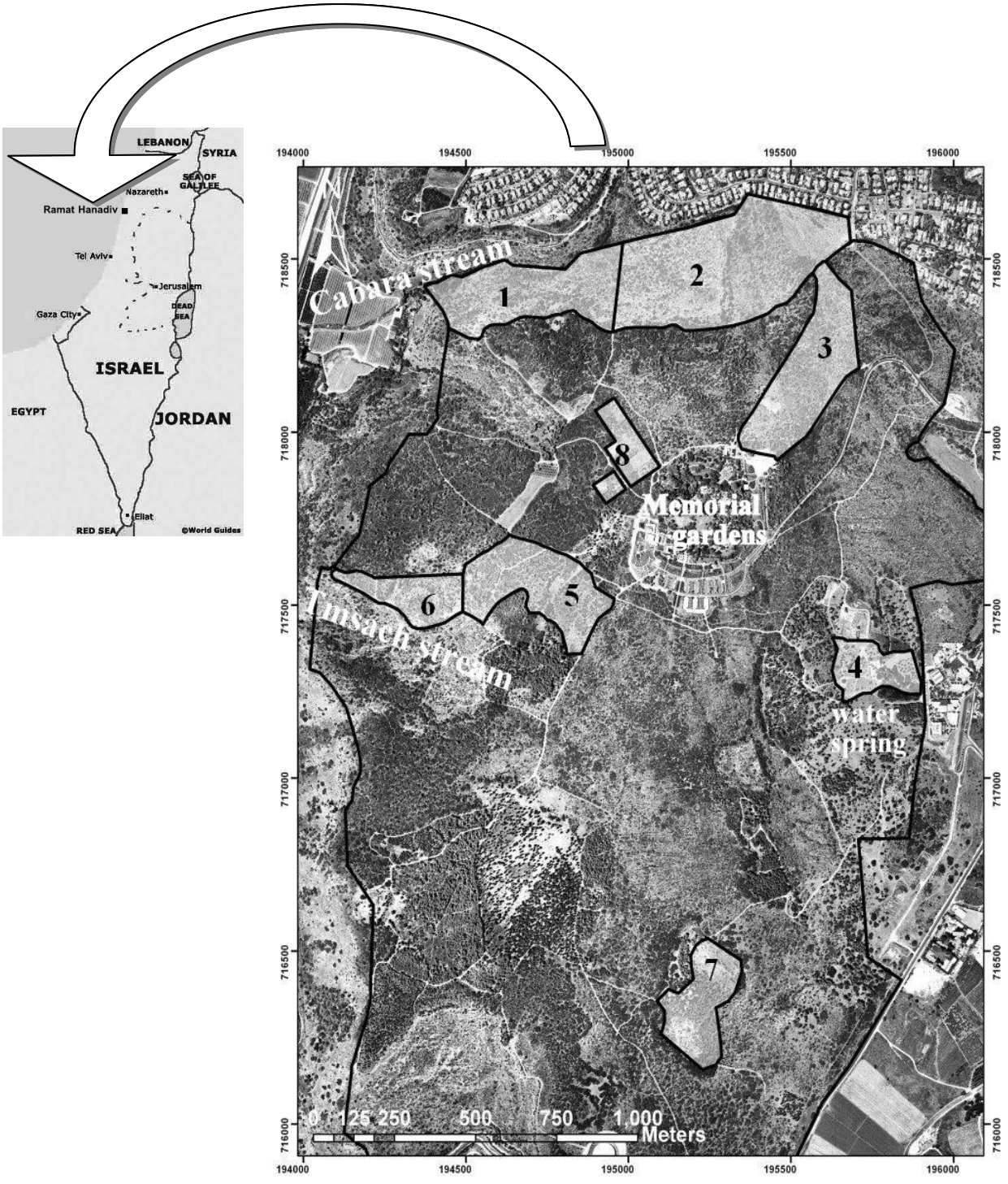


Figure 2: Ramat Hanadiv Nature park location and Goat grazing polygons.

Production

During 2008 the herd was registered as a bio-organic farm. Since then the farm is managed by the obligatory regulations for this type of management. During 2009, after parturition of the goats, a milking parlor was constructed and 60 goats were milked in parallel to kid suckling. A small cheese plant was rented and yogurt and cheese were produced and marketed for the local market.

Goat kids are sold yearly for meat consumption. All kids are naturally reared by mothers and are weaned at the age of 90 days. They are then raised, up to a weight of 30 kg, upon which males are all sold and females are sorted for replacement or sold for meat.

Several times a month special tours take place at the park, during which visitors join the goat herd and the shepherd. Tourists have a chance to learn about the Mediterranean landscape, fauna and flora, as well as learning about the history of livestock farming in the region, the importance of local farming and the use of goats as a tool for achieving landscape management goals. All tours are paid for by the participants.

Discussion

Determining dietary quality and botanical composition of a goat herd is a complex task. There are many methods that can be used (alkanes, microhistological analysis, focal observations, fecal NIRS, etc.). The only method that can be used under commercial farm conditions is the fecal NIRS method. After the development of calibration equations this method can be used for determining dietary quality of free-grazing livestock rapidly and at low cost (Foley *et al.*, 1998). This method is already in use for the determination of grazing cattle in the U.S.A (Stuth *et al.*, 2002).

The introduction of a goat herd into a nature park must be determined by the main goals of the park authorities as well as by the farmer. These may lead to some points of conflict, such as:

- Limitation of herd size by park authorities and landscape management professionals, which limits commercial production and efficiency by a small herd.
- Goat breeds that may be most productive may not be durable enough or productive under grazing conditions.
- Some parts of the land of high foraging quality may be suceptible to destruction under grazing or may lead to competition with wildlife or other livestock. These areas must be fenced and herds must be excluded from them. Fencing large parts of a nature park may not be favored by park managers or hikers.

These points and others must be discussed and resolved beforehand and well understood by the farm owner as well as by park management. In cases in which the herd is owned by park authorities and no production is expected, most conflicts can be resolved relatively easily.

Local breeds usually are very well adapted to local terrain and vegetation but not necessarily suitable for maximum production. This situation may lead to a conflict between the importance of conservation of genetic diversity and the importance of conservation of local farming units. One way to overcoming this conflict may be by compensation of farmers for breeding and conserving local breeds, as well as paying for landscape management services.

Using local breeds for landscape management requires that most of the roughage consumed by the livestock come from grazing. In many cases the nutritional quality of the grazed forage is low. This leads to an undesired situation in which the farmer must increase

concentrate feed supplementation, which is very costly and in some cases leads to lower consumption during the grazing bout.

In order to develop sustainable local farming that will meet the goals of landscape management as well as genetic conservation and economic sustainability, a plan that includes all ecological and agricultural aspects must be established. It is of great importance that the local public be aware and involved in such projects. This awareness may prevent antagonism and also serve to promote understanding of the importance of sustainable livestock farming for agricultural, ecological and social values.

Acknowledgments

The authors wish to thank the Ganei Ramat Hanadiv Nature Park staff for logistic help during the entire experimental period of this research.

References

Devendra, C., Burns, M., 1983. *Goat Production in the Tropics*. CAB Farnham House, Farnham Royal Slough, U.K.

Dziba, L.E., Scogings, P.F., Gordon, I.J., Raats, J.G., 2003. Effects of season and breed on browse species intake rates and diet selection by goats in the False Thornveld of the Eastern Cape, South Africa. *Small Rum. Res.* 47:17–30.

Foley, J.F., McIlwee, A., Lawler, I., Aragones, L.,Woolnough, A.P., Berding, N., 1998. Ecological implications of near-infrared reflectance spectroscopy - a tool for rapid, cost-effective prediction of the composition of plant and animal tissues and aspects of animal performance. *Oecologia* 116: 293–305.

Glasser, T.A., 2009. Maternal and breed effects on the consumption of *Pistacia lentiscus* by domestic goats: a fecal NIRS aided study. PhD Dissertation. The Hebrew University of Jerusalem.

Glasser, T., Landau, S. Y., Ungar, E.D., Perevolotsky, A., Dvash, L., Muklada, H., Kababya, D., Walker, J.W., 2008. A fecal NIRS-aided methodology to determine goat dietary composition in a Mediterranean shrubland. *J. Anim. Sci*. 86: 1345-1356.

Glasser, T., Ungar, E.D., Landau, S.Y., Perevolotsky, A., Dvash, L., Muklada, H., Kababya, D., Walker, J.W., 2009. Breed and maternal effects on the intake of tannin-rich browse by juvenile domestic goats (*Capra hircus*). *App. Anim. Behav. Sci*. 119: 71–77.

ISI. 1999. WinISI, the complete software solution for routine analysis, robust calibrations and networking. Version 1.02A. Infrasoft International, Port Matilda, PA.

Lyons, R.K & Stuth, J.W., 1992. Fecal NIRS equations for predicting diet quality of free-ranging cattle. *J. Range Manage.*, 45(3):238-244.

Porter, V. 1996. *Goats of the World*. Farming Press, Ipswich, U.K.

Stuth, J.W., Hamilton, W.T., Conner, R., 2002. Insights in development and deployment of the GLA and NUTBAL decision support systems for grazinglands. *Agricultural Systems* 74:99–113.

Zeder, M.A. & Hesse, B., 2000. The initial domestication of goats (*Capra hircus*) in the Zagros Mountains 10,000 years ago. *Science*. 287:2254-2257.