Identity profiles based on social strategies, morphology, physiology, and cognitive abilities in goats

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Abstract

The aim of this study was to analyze the structure of identity profiles based on social strategies, morphology, physiology, and cognitive abilities in domestic goats. Social interactions of 33 goats were recorded over a period of 16 days for 96 hours. Blood samples and morphological measurements were taken from each animal, and they were each put through a T-maze test. Using the test of factor analysis, 3 of 7 types of social interactions concentrated 76.6% of the variance. They were named the "avoider" factor (21.20%), "nonagonistic" factor (16.30%), and "agonistic" factor (39.10%). Subsequently, a hierarchical cluster analysis was performed to characterize identity profiles (groups of similar animals), which could help to explain the possible association between social strategies (obtained using the factor analysis) and index of success, social and individual behaviors, and morphological, physiological, and cognitive char-acteristics. The results suggest the existence of 4 clusters or identity profiles, which were termed "aggressive,""affiliative,""passive," and "avoider." When they were compared between clusters, each identity profile had significant differences regarding all social variables, feeding and resting variables, most of the physiological measures, and all the morphological characteristics. The resolution time for the T-maze was significantly different between clusters and days. In conclusion, associating social strategies with details of behavior, physiology, and morphology provides a more robust idea of identity profiles adopted by goats under intensive farm conditions and suggests a richer diversity of strategies used by goats.

Keywords: individual differences; social strategies; identity profiles; cognitive abilities; goats

Introduction

Differences among individuals are the substrate for natural selection. Behavioral variation reflects the individual's capacity to cope with social and physical environmental demands (Carere et al., 2003). Individual behavioral differences have also been viewed as an adaptation in themselves, because of either social advantages or frequency-dependent selection that operates to maintain variation. Consistent individual differences in behavior have now been documented in a broad range of animals over a variety of contexts.

However, individual differences in social contexts have received less attention (Morand-Ferron et al., 2011). The behavioral ecology theory of alternative strategies raises the possibility that individuals of different rank may be following alternative and perhaps equally successful social strategies. Recent behavioral research in farm animals has focused on identifying consistent relationship between social strategies and identity profiles. An identity profile can be defined as a coherent set of social strategies as well as behavioral and morphological adaptations, which are consistent over time and characteristic of certain social groups (Miranda-de la Lama et al., 2011).

Farm animals under intensive production systems are housed in barns under conditions that differ substantially from their natural habitat, with limited space and herd sizes. Under these conditions, social relationships also imply a higher competition for resources and conflict of interest. Particularly in groups with unstable social structures, an increase in conflicts of interest may increase aggression and jeopardize future cooperation (Aureli et al., 2002). As a consequence, individuals are forced to build

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adequate social strategies to respond to the social challenges posed (Miranda-de la Lama et al., 2011). Maintenance of a social hierarchy partly depends on social recognition and learning ability as animals must be able to discriminate between conspecifics to establish and maintain the social order (Croney et al., 2007).

Social stress caused by intensive production disrupts cognitive processes like learning and memory. Stress appears to affect the degree of attention and the speed of decision making, whereas chronic stress may affect cognitive abilities (Mendl, 1999). Animals with higher cognitive abilities should be more capable of producing new, modified, or innovative behaviors as this ability would allow them to cope better with unpredictable social and physical envi-ronmental changes, both in terms of improving survival and fitness and in terms of trying to achieve positive emotional states and avoid suffering (Wechsler and Lea, 2007). Agitated animals are less effective at making clear decisions in choice tests. Cognitive per-formance is improved when an individual is within a range of optimal stress, above or below which this performance decreases (Mendl et al., 1997). There are relatively few studies on personality or identity in domestic animals, and those that have been carried out have been concerned with understanding the effect of identity on behavior and physiology (pigs, Ruis et al., 2000; dairy cows, Van Reenen et al., 2002), social strategies and physiology (beef cows, Mülleder et al., 2003), as well as social strategies and morphology (dairy goats, Miranda-de la Lama et al., 2011). Studies of identity traits in domestic animals are important, not only from an evolu-tionary perspective but also in relation to practical situations such as handling in intensive production systems. Clarification of this relationship might provide insight into how and why goats of different social ranks are able to survive, particularly when resources, such as food, water, shelter, and space, are limited. The present article aims to analyze the structure of identity profiles, with the hypothesis that there is a high interrelation of social strategies, morphology, physiology, and cognitive abilities in goats that characterize types of individuals.

Materials and methods

The study was carried out in the Autonomous Community of Aragon (northern Spain) in June and July 2011, at the experimental research farm of the Food Technology and Research Centre, CITA, Zaragoza province (41 430 N, 0 480 W; 225 m above the sea level). All protocols were approved by the Animal Experimentation Ethics Committee of the University of Zaragoza.

Animals and housing

We used 33 female Angora goats (5-8 years of age, nonlactating, nonpregnant, multiparous, and horned) that had been housed in a 27 10 m pen (stocking density 8 m2 per goat) for 3 years before the observations were carried out. The goats were fed twice a day, in the morning between 08.00 and 08.30 hours and in the afternoon between 15.00 and 15.30 hours. All the animals were fed pellet concentrate (11.5 MJ metabolisable energy/kg dry matter and 15.5%crude protein; approximately 0.3 kg per goat), and Lucerne chaff (Medica gosativa) ad libitum. The pen was equipped with a metallic water trough (1.5 x 0.60 m) and 2 metallic feeders (4.5 x 0.80 m, 27 cm per goat), and a lick stone for minerals.

Behavioral measurements

Direct observations, with a combination of scan and behavior sampling, were carried out to collect information on individual and social behaviors, respectively. All goats were individually identified and marked with 30-cm-high numbers and letters painted on the sides and rump with washable paint for sheep marking (Peinture Marquage Mouton; Laboratoires Natura A platform with a seat 3 m above the ground was used to observe the goats from a dis-tance. The goats were observed 6 hours daily, from 7:00 to 9:00, 11:00 to 13:00, and 17:00 to 19:00 for 16 consecutive days (96 hours of observation) by the same trained observer.

Social behavior

A behavior sampling technique was used to record all agonistic and nonagonistic interactions, both with and without physical contact. Agonistic interactions with contact included butts, when the goat used the front of her head to make contact with another goat; pushes, when a goat used other parts of her body to make contact with another goat; and bites, when one goat bit another goat's body using her teeth. Agonistic interactions without contact included threats, when a goat turned toward or approached another individual with her head down and then lunged without making contact; chase, when a goat actively moved toward another individual, causing the latter to walk or run away; and avoidance, when a goat actively moved away from another individual whether or not previous interaction had occurred between the 2 individuals. Nonagonistic interactions with contact included licking, when a goat passed her tongue over the body of another individual; grooming, when a goat groomed another goat's body using her teeth. Nonagonistic interactions without contact included sniffing, when a goat sniffed another goat's body and the flehmen response, when a goat retracted the upper lip, wrinkled the nose, and bared the gums in the presence of another goat.

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For each animal, the total number of times engaged in each of those social interactions was calculated. Indices of success were calculated using the data collected on interactive behaviors to reflect the social status of each goat according to her experiences in agonistic interactions with any other member of the herd. Taking into account those interactions that resulted in a displacement of the receptor goat, the index of each goat could therefore range from 0 to 1 and was calculated according to Mendl et al. (1992). Index of success (IS) = number of individual goats the goat is able to displace/(number of individual goats she is able to displace þ number of individual goats able to displace her). The goats were then placed, as in the study by Alvarez et al. (2003), into 3 ranking categories according to their IS: low (IS = 0.0-0.33), medium (IS = 0.34-0.66), and high ranks (IS = 0.67-1.0).

Individual behavior

On each of the observation days, a scan sampling was carried out every 10 minutes (576 samples) to obtain information on the total time spent lying down (goat resting with eyes open or closed); drinking (goat with head inside the water trough); feeding (goat with head inside the feeder trough); and walking (goat moving from one place to another). Individual goats were observed at different times of the day so that, when averaged across the study, each part of the day was equally represented. For each goat, the time spent in nonsocial behaviors during the study was expressed as a proportion of observations calculated as follows: number of observations of a behavior/total number of scan samplings.

Physiological measurements

Blood samples were taken by jugular venipuncture per goat between 18:00 and 19:00 hours a day after behavioral observations ended (two 10-mL tubes were collected per animal, with and without anticoagulant, EDTA-K3). Approximately an hour before blood sampling, the site of venipuncture was clipped and covered with an anesthetizing cream to minimize the response to the initial puncturing of the skin. Restraint during blood sampling was kept to a minimum, and the total duration of the procedure did not exceed 1 minute. The handler grasped the halter with 1 hand and with the other groomed the goat's neck to direct attention away from the blood sampling procedure. Samples were kept on ice for less than 1 hour and taken to the laboratory for routine hematological measurements. The EDTA plasma and serum were centrifuged at 3000 rpm for 10 minutes, and aliquots were frozen and kept at 30 C until analyzed.

The concentration of cortisol was determined from plasma (EDTA-K3) by enzyme immunoassay using an "in-home kit." Each sample was determined in duplicate from 50 mL of plasma, and the results were expressed in ngnL 1, with the corresponding controls. Variation coefficients of the analysis, interassay and intraassay, were 7% and 8%, respectively. The concentration of lactate was deter-mined using a SigmaeAldrich Diagnostic kit (lactate no. 735-10; SigmaeAldrich, St Louis, MI) and spectrophotometer (Lambda 5; Perkin Elmer, Waltham, MA). Serum samples were analyzed with a Multichannel Technicon Analyser (RA-500; Bayer, Barcelona, Spain) using reagents from Bayer diagnostics (SA, Barcelona, Catalonia, Spain) for RA technicon systems to determine the concentration of glucose (mg dL·L) (Ref. T01-1492-56) and the activity of creatine kinase (CK) (CI<), EC 2.7.3.2 (UI L·L) (Ref. T01-1885-01). Serum concentration of nonesterified fatty acid (NEFA) levels was analyzed by a multianalyser ACE (Clinical Chemistry System; Alfa Wasser-man, Woerden, The Netherlands), with commercial kits (NEFA C Ref. 994-75409 of the Wako). Finally, the leukocyte formula was estimated from blood swabs on clean slides. Staining was performed by the rapid panoptic method using dyes from Química Clinica Aplicada, Inc. (Aposta, Catalonia, Spain). With an optic immersion microscope, we counted and identified 100 leukocytes per sample (neutrophils, lymphocytes, eosinophils, basophils, and monocytes). The neutrophil/lymphocyte (N/L) ratio was used as a stress indicator in goats according to Kannan et al. (2000) and Rajion et al. (2001).

Morphological measurements

Morphological traits were measured 1 day after blood sampling, using a measuring tape. Body measurements included body length (BL), height at withers (HW), and thorax circumference (TC). Additionally, each goat was weighed using a portable digital weighing scale.

Cognitive test

We used a T-maze built with 1.40-m high plastic panels (Figure 1). It consisted of a start box, isolation chamber (2   2 m) joined on 1 of its sides to a T-corridor. The start box was fully closed but large enough to enable an individual to move around. The T-corridor consisted of a 4   0.80 m path linked to 2 perpendicular arms (1.65   1.65 m each). A mirror (70   30 cm), loudspeaker, and plastic feeder (with feed pellets) were located in the target zone on the left arm. An observation platformwas located on a 3-m high platform so as not to influence animal movement, adjacent to the T-maze apparatus. The apparatus was kept in a soundproof room (9   6 m) held at constant temperature and humidity during the trial.

The sounds used in the experiment were a playback of sounds present during the feeding time. The stimulating sound consisted of different components, such as metallic noise of the feeder when the goats are feeding, handling noise of the concentrate feed paper bag, and the noise of pellets falling onto the feeder. We recorded at a distance of 50 cm from the noise source using a Handy Recorder H1 (Zoom Corporation, Tokyo, Japan) numeric recorder (sampling rate: 44.1 kHz). Sounds were then imported into a computer at a sam-pling rate of 44.1 kHz and saved in WAV format at 16-bit amplitude resolution. We used Audacity□ 2.0 (General Public Licence) audio software for the preparation of sound sequences that were played back. A sample of each of these sounds was combined into a 5-minute segment, and a random portion of this segment was played at each trial. The noise was played and measured using a Bioblock Scientific Sound Level Meter type 50517 (Thermo Fisher Scientific Inc.), at a set volume that ensured goats were exposed to 81 dB of intensity through most of the T-maze. For each trial, the sounds were played back by a Handy Recorder H1 connected to a loud-speaker located at floor level in left arm in the target zone.

Each goat underwent the cognitive test on 2 consecutive days. Each goat entered the testing equipment 2 times in total, once on each day of test, without receiving prior training. Each animal stayed in the start box for 20 seconds before a guillotine door was lifted to allow entrance into the maze. After the goat left the start box, the guillotine door was quietly closed. At the same time, recorded playback was played and the test was started. The test was considered to be successfully passed when the individual found the target zone (which was always located in the left arm) where there was a mirror (social clue), the sound source (sound clue), and concentrate feed to reinforce behavior. Each animal was given a maximum time of 5 minutes to solve the T-corridor. No animal exceeded this time limit. The test was filmed, and the time taken by each goat to solve the T-corridor was recorded.

Reactivity to handling test

Each goat was subjected to reactivity to handling test in 2 stages: restraint by handler and restraint by squeeze chute. Each stage took place at an interval of 1 week. The first stage consisted of the random capture and restraint of an animal by a handler. Restraint continued for 1 minute, during which a photograph was taken with an infrared thermography camera. In the second stage, the animals were randomly led into a squeeze chute where each animal was restrained for 1 minute and an infrared photograph was taken. An infrared thermography camera (Testo 880 Thermal Imaging Cam-era; Testo AG, Lenzkirch, Germany) was used to collect images of the eye during both restriction practices to evaluate acute stress response. All images were collected from the left side of the goat (approximate distance of 1.5 m). The built-in lens (24) was used, and the camera was calibrated for the current room temperature and relative humidity. The emissivity value used was 0.98, which is the recommendation of the camera manufacturer for biological tissues. A good-quality infrared image (precise location and perfect focus) was chosen for each animal. Image analysis software (IRSoft software; Testo AG, Lenzkirch, Germany) was used to determine the maximum temperature within an oval area traced around the eye, including the eyeball and approximately 1 cm surrounding the outside of the eyelids (Stewart et al., 2007).

Statistical analysis

All statistical analyses were carried out with the SPSS (IBM□ SPSS□), version 14.0 software package. As an initial measurement, univariate analyses were carried out for all the variables studied to understand individual behavior and to detect atypical data.

Factor analysis

A factor analysis was used to summarize the data of 7 social behavioral variables and to understand their correlational struc-ture. Agonistic and nonagonistic behaviors were grouped in the classes described in behavioral sampling to analyze them: no. of times each goat initiates an agonistic interaction with physical contact; no. of times each goat initiates an agonistic interaction without physical contact; no. of times each goat receives an agonistic interaction with physical contact; no. of times each goat receives an agonistic interaction without physical contact; no. of times each goat initiates a nonagonistic interaction with physical contact; no. of times each goat receives a nonagonistic interaction with physical contact; and no. of times avoiding another goat.

The factors were extracted using principal components. The KaisereMeyereOlkin index and Bartlett test of sphericity were used as a measure of high correlation between variables. The factors selected had eigenvalues greater than 1. To gain a better under-standing of the factors obtained, a Varimax method of orthogonal rotation was carried out. Accordingly, the factor scores in the analysis were estimated by means of the regression method and were consequently used to carry cluster analysis.

Cluster analysis

A hierarchical cluster analysis was performed to identify dif-ferences in social interactions. The cluster analysis enables segments of individuals to be identified, so that the characteristics of individuals that belong to the same group are as similar as possible, although, when compared with other groups, they are as different as possible. The distance used was the squared Euclidean distance, and the Ward method was used for agglomeration. The variables used to calculate the squared Euclidean distances were the scores of the 3 factors obtained and the 2 variables corre-sponding to conflict resolution. To reduce the effects of scale when forming the clusters, both groups of variables were standardized. The graphic solution used was the dendogram (Figure 2). Once the membership to cluster variables had been created, they were then characterized using different variables, such as IS, classes of behavior (factorial scores), individual behavior variables, physio-logical, morphological traits, cognitive abilities, and acute response to 2 methods of physical restriction. To select the most significant variables that would enable differentiation between clusters ob-tained, a nonparametric KruskaleWallis test and several nonpara-metric paired ManneWhitney tests were carried out, bearing in mind the characteristics of the study and variables.

Results

Factor analysis

Three factors explained 76.6% of the variance. The parameters loaded high on those factors (Table 1). The first factor accounted for 21.2% of the total variance and was characterized by 2 of the 7 vari-ables that were used: number of times each goat received an agonistic interaction with physical contact and number of times it avoided another goat. These variables had a very significant loading (0.7), and this factor was labeled as the “avoidance factor.” The second factor accounted for 16.30% of the total variance and was character-ized by 2 variables: number of times each goat initiated a nonagonistic interaction with physical contact and number of times each goat received a nonagonistic interaction with physical contact. These var-iables had a very significant loading (0.7), and this factor was labeled as the “nonagonistic factor.” Factor 3 accounted for the remaining 39.10% of the total of variance. It was characterized by 2 variables, which had very significant loadings (0.9): number of times each goat initiated an agonistic interaction without physical contact and number of times each goat initiated an agonistic interaction with physical contact. Factor 3 was labeled the “agonistic factor.”

Cluster analysis

This multivariate analysis suggests the existence of 4 clusters or identity profiles that explain their association with behavioral, physiological, and morphological traits as well as the acute response to 2 methods of physical restriction (Table 2) and cogni-tive abilities (Table 3). The distribution of animals by strata is not homogeneous (cluster 1: 11 goats, cluster 2: 2 goats, cluster 3: 15 goats, and cluster 4: 5 goats). Given the associations that were found in each cluster, 1 was termed “aggressive,” 2 “affiliative,” 3 “passive,” and 4 “avoider,” according to the social strategy prefer-entially used for each profile.

Social and individual behaviors

As expected, all the social variables were different among clus-ters. The aggressive profile was characterized by highly dominant individuals (IS ¼ 0.70) with highly agonistic behavior values. The affiliative profile was characterized by animals of average domi-nance (0.41), with nonagonistic behavior. The passive profile group was made up of low-dominance individuals (0.33) that displayed negative values toward the 3 social strategies. Finally, the avoider profile had low-dominance individuals (0.31), with high evasive factor scores.

In the case of individual behaviors, only the feeding and resting variables were statistically significant. In the aggressive profile, more time was spent feeding compared with the other profiles ($P<= 0.001$), whereas the least amount of time was spent resting. Individuals of the affiliative profile spent the most amount of time resting, along with the passive profile ($P<=0.013$). Like the affiliative animals, passive goats spent less time feeding and intermediate values for resting. Avoider animals had intermediate values for feeding and resting.

Physiological measurements

Physiological measures had a significant effect on all variables, except for lactate, CK, and N/L ratio. Aggressive goats had the lowest levels of cortisol and NEFA but the highest glucose levels. Affiliative goats had the highest cortisol and NEFA levels and the second highest glucose levels. Passive animals had intermediate values of cortisol and NEFA. Cortisol levels of the avoider profile were the lowest in the study (along with the aggressive profile), and glucose levels were similar to those of the affiliative and the passive profile, but they had the highest NEFA levels along with the affiliative profile.

Morphological measurements

For the morphological characteristics, significant differences were observed within all the variables studied. Morphologically, aggressive goats were the largest and heaviest individuals. The affiliative profile had the smallest BLs and an intermediate height, compared with the rest of the profiles. TC and body weight were statistically similar to evasive and passive profiles but smaller than the aggressive goats ($P <=0.01$). Passive goats had a lower HW ($P <=0.05$) and the second shortest BL in the study. TC and body weight were statistically the same as evasive and affiliative goats but less than that of the aggressive animals. Avoider goats had the longest body and greatest HW, after the aggressive goats. Their TC and body weight were statistically similar to those of the affiliative and passive profiles but less than the aggressive profile.

Cognitive test

In the case of the cognitive test, resolution time was statistically significant between clusters and also days. Aggressive goats took the second longest time in solving the T-corridor during the first exposure ($P <=0.01$) and the longest time during the second expo-sure ($P <= 0.05$). However, comparing the difference between days, this profile did not show any significant difference and took the same time to solve the T-corridor on day 1 and 2. Affiliative goats spent the longest time to solve the T-corridor during the first exposure and an intermediate time for the second exposure. When compared between days, this profile solved the T-corridor in less time ($P <=0.001$). Passive profile solved the T-corridor in less time than the rest of the profiles in the study during the first exposure. When the difference between days was compared, this profile was the quickest of all the groups, reducing the time by half on day 2 with respect to day 1 ($P <= 0.01$). Avoider goats behaved similarly to the passive profile.

Reactivity to handling test

Finally, for the reactivity to handling test, only restriction by squeeze chute had a significant effect ($P <=0.05$). The aggressive goats obtained intermediate temperature values along with the passive profile. The temperature of the affiliative goats was the lowest of all profiles after the squeeze chute restraint phase. Passive goats had intermediate temperature values, similar to those of the aggressive profile. Body temperature of the avoider goats after the handling reactivity test was the highest of the study (squeeze chute restraint phase).

Discussion

In our study, a series of behavioral and morphological traits suggest the existence of 4 types of profiles: aggressive, affiliative, passive, and evasive. We have furthermore found an association between physiological and cognitive characteristics that strengthen the identity profiles. Although the characterization of each profile is closely related with social strategies and dominance order, we have found that there are certain differences in individual behaviors and morphological characteristics vary from the study by Miranda-de la Lama et al. (2011), who worked with dairy goats using methodology similar to ours. These differences may indicate that although social strategies may be stable in a species, individual behavior and morphology may reveal adaptive variations. Differences between animals with different levels of dominance may increase in more demanding environments in production terms (Andersen and Bøe, 2007). In this context, dairy production systems are more demanding productively than goat meat or goat hair production systems, and this stimulates each profile to make behavioral and morphological adjustments to improve inclusive fitness that will allow the animals to survive. This would explain the differences between the results of observations in hair production goats in this study and dairy goats in that of Miranda-de la Lama et al. (2011).

Feeding and resting behaviors are clearly 2 traits that are affected by the identity profile. This relationship may be because of the fact that both behaviors are influenced by social facilitation (Nicol, 1995) and dominance order (Barroso et al., 2000), so that it is reasonable to assume that highly dominant individuals obtain more benefits from their social status because they have priority access to resources such as food and resting places (Robitaille and Prescott, 1993). Our results show that the animals in the aggressive profile spent more time feeding, followed by the evasive animals. This is perhaps because both profiles constantly compete for food. Although the time devoted to this activity is not necessarily pro-portional to a large intake of food, perhaps the aggressive individuals selectively consume good-quality forage (Matsuzawa and Hagiya, 1991), in comparison with affiliative and passive animals that probably consume the food that remains, with different thresholds of selective efficiency (Miranda-de la Lama et al., 2011).

Several measures can be used to evaluate the animal welfare, including behavior and biological functions related to stress physiology. These evaluations should be based on multicriteria ap-proaches because no single measure can unequivocally be related to the level of welfare. Among those, neuroendocrine parameters are probably the most widely used because corticosteroid hormone secretion by the adrenal cortex has been equated with stress level since the very beginning of the stress concept. Indeed, circulating levels of corticosteroid hormones are very sensitive to a wide range of stimuli including low level of emotional activation such as induced by social stress (Mormède et al., 2007). Various studies of domestic ruminants indicate that highly dominant animals have lower levels of cortisol than animals of average and low dominance in socially stable groups (Galindo et al., 2000). However, in our study, the animals with an affiliative profile (average dominance) had the highest levels of cortisol in the study. In intensive farming systems, affiliation as a strategy is not useful; when competing for resources, an aggressive strategy is more effective (Miranda-de la Lama et al., 2012). On average, dominant animals are highlighted as being more efficient in metabolic terms, with greater production yields (Barroso et al., 2000). However, it is possible that this inclusive fitness is impaired in competitive social environments (Conway et al., 1996). In this context, the affiliative and evasive profiles had higher levels of NEFA and lower values of glucose, although they were within the reference values for the species (Piccione et al., 2010).

NEFA is considered a biomarker of the negative energy balance when glucose supply is insufficient to satisfy energy requirements (Adewuyi et al., 2005). In the case of the evasive animals, the relationship of high cortisol and NEFA values and low glucose values is not fulfilled. One possible explanation could be related to evasive animals that had a higher threshold of susceptibility to social stress than the affiliative profile because they would be used to social stress, although they would suffer some energy repercussions in adjusting to the social environment.

Morphological traits may be honest signals that communicate a certain genetic value (Smith et al., 2009), biological efficacy (Rowe, 1999), and information for social recognition, providing, for example, information on the age, sex, and individual identity

(Keil et al., 2012). From our results, these signals are linked to the char-acterization of the identity profiles. Although some have a greater power of discrimination (such as BL and HW compared with TC and weight), with the exception of the aggressive profile, all the other profiles were statistically similar. In this respect, the aggressive profile was found to be heaviest and have the greatest measure-ments. That confirms what has already been described by other authors in the case of highly dominant goats (Barroso et al., 2000). However, body sizes are not proportional to the dominance scale, and some of the measurements of evasive animals were higher than the affiliate and passive profiles. It is probable that in meat and hair production goats, morphological variables are distributed differ-ently because the selection programs are less strict when compared with dairy animals in intensive production systems.

The time taken by goats to solve the T-corridor was interpreted as the ability to learn from specific stimuli, actions, and results to be able to solve a challenge (Morton and Avanzo, 2011). Our results indicate that aggressive goats took longer to locate the sound source the first and second day of exposure, unlike the other pro-files which, even on the second day of exposure, significantly reduced the time it took to solve the T-corridor by more than half. It is possible that the low-dominance goats have to learn quickly how to relate socially (compared with the high-dominant goats), to avoid aggressions (Croney and Newberry, 2007). Thus, they must be more flexible to adopt alternative strategies to obtain valuable resources such as food (Croney et al., 2007). This mental flexibility would mean that the association between the stimulus used and food would be more attractive for animals that have restricted access to it.

The handling practices to which animals are subjected can cause fear, anxiety, and reactivity to humans as well as affect the way in which animals adapt to production environments (Nordquist et al., 2011). These practices can be measured using noninvasive tech-niques such as infrared thermography, which can determine heat loss gradients in the ocular area caused by blood kinetics, as part as the sympatheticeadrenal response during acute stress (Stewart et al., 2007). Our results indicate that physical restraint by a handler does not significantly alter the response of the 4 profiles in our experimental conditions. This may be because the quality of the humaneanimal relationship has a greater influence on fear and reactivity during handling than the innate reactivity of the animal to humans (Waiblinger et al., 2006). Nevertheless, squeeze chute re-straint does increase temperature, and this indicates a heightened state of reactivity in the evasive profile. The evasive animals are those that actively participate in social interactions but with few results and they occupy a low position in the dominance order. This characteristic perhaps makes them prone to displaying a greater reactivity, as was seen in the physical restraint test. The infrared thermography camera is a useful tool for measuring handling reac-tivity in a noninvasive way and to evaluate acute responses to stress.

Conclusions and implications

The identity profiles of the group of stabled goats observed were characterized by social strategies, behavioral, physiological, morphological traits, as well as cognitive abilities. Four profiles were distinguished (aggressive, affiliative, passive, and evasive), which were associated with social strategies to create, adjust, and use a series of behavioral solutions to adapt to intensive productive systems. These adaptations are evidence of the behavioral adaptive strategies that the individuals develop to survive in a competitive and artificial environment such as the production system. Although social strategies are closely linked to the creation of each profile,there are variations in certain behavioral, physiological, or even morphological traits in animals of the same species but which are destined for different production purposes.

The identity profiles based on social strategies, morphology, physiology, and cognitive abilities may be a valuable tool to assessment of the animal welfare. Insight into this individuality can be used to carry out recommendations on changes in herd handling aimed at improving social cohesion and achieving more efficient management procedures. To characterize types of goats would permit to establish relationships between certain behavioral or morphological traits of interest and other traits of interest such as stress response or cognitive ability and thus the possible susceptibility to stress-related diseases and the efficacy of a given strategy for attaining fitness of the animals.

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