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Can facial expressions and infrared thermography be used to measure positive emotions in goats?

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Abstract

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No study yet is undertaken to measure positive emotions in goats by stroking their body. Therefore, the present study was aimed to investigate the effect of stroking goats' body as high valence and low arousal emotional state on facial grimace scale, ear postures and surface temperatures. The study lasted 10 months from September 2021 to May 2022. Thirty-two healthy goats were used in this study. Goats were stroked in three areas including forehead, neck and withers. The process was divided into three stages, which were pre-stroking, stroking, and post-stroking with five minutes for each stage. Results indicated that there were significant differences ($P < 0.01$) between all face units measured, except the ear position. In addition, significant differences ($P < 0.05$) were found in the positions of forward, backward and asymmetrical ears, while time spent with plane ears was not significant. Similarly, there were significantly ($P < 0.05$) higher ear position changes during both stroking and post-stroking periods, compared to pre-stroking stage. The stroking procedure had a significant effect ($P < 0.05$) only on eye and nasal temperatures during stroking and post-stroking stages compared to the stage before stroking, whereas no significant effect was found on the ear temperature. It was concluded that facial expressions and peripheral temperatures are vital indicators in measuring positive emotional valence in goats.

Keywords: Facial expressions; peripheral temperatures; positive emotions; ear position

Introduction

For many decades, scientists' primary goal was focusing on how to measure and mitigate distress and pain in animals, including farm animals (Hussein and Hidayet, 2019; Turner, 2019; Zebari et al., 2021). Recently, there is a growing interest on measuring positive animal welfare and emotions (Proctor and Carder, 2016; Meshabaz et al., 2017; Hussein, 2019; Turner, 2019). Researchers use different methods to determine the emotional state to measure its valence and arousal; for instance, feeding was used as high emotional arousal and valence, whereas stroking animals' body as high valence and low arousal state (Machado and da Silva, 2019).

Stroking farm animal body, including sheep and cattle, is widely been used by researchers. While little research is undertaken on stroking goats' body. Tactile contact and stroking were used in improving the human-animal interaction. In addition, gentle handling in cattle had been linked to lower the fear of human as well as reduces cortisol hormone levels in subjects (Proctor et al. Carder- Please revise this citation, 2014; 2015; Lambert and Carder, 2019). In addition, using different stroking styles in cattle was used to measure animal behavior and facial expressions (Lange et al., 2020).

Recently, facial expressions have been widely used to measure negative states such as pain and diseases in sheep (McLennan et al., 2016), rats (Sotocinal et al., 2011), mice

(Langford et al., 2010), rabbits (Keating et al., 2014), and horses (Dalla Costa et al., 2014). In contrast, limited number of research had been applied to indicate positive emotions using face units of animals (Proctor and Carder, 2014). Measuring facial expressions, in animals, might have benefits over the using of other measures of pain. Facial grimace scales are made in real time and are more practical (Leach et al., 2012). Facial movements in animals are involuntary and this leads them to be easier to be identified by human; thus, facial expressions are easily scored (Descovich et al., 2017). Some faces were used in positive emotional states such as play faces, orbital tightening, as well as ear position and movement had been used (Proctor and Carder, 2014; 2015; 2016; Descovich et al., 2017). However, nose and cheek regions have not been used as positive indicators in animals (Descovich et al., 2017), in which had only been measured in human (Langner et al., 2010).

The reliability of facial grimace scale measurement relies on some assumptions. For instance, the species that is used must have enough face mobility to produce observable face expressions. In addition, changes in face areas must be noticeable that may be seen by direct observations. Moreover, different faces must be generated during different affective states (Descovich et al., 2017). In developing facial grimace scale for mice, some similarities were seen in both sleeping and illness states (Langford et al., 2010). It was suggested that sheep would show different facial expressions when experiencing pain. As a result, sheep showed different scales of faces during diseases (McLennan et al., 2016). Goats, similar to sheep as a small ruminant, also showed different faces during positive emotions (Bellegarde et al., 2017). Bellegarde et al. (2017) mainly concentrated on ear postures in addition to face state as positive or negative face. Hence, no particular or standard face grimace scale was established for goats. In addition to facial expressions, measuring peripheral temperatures has been a vital tool in indicating positive emotions in animals.

Measuring core body temperature was mostly used in animals as an invasive method, which causes stress to subjects (Omobowale et al., 2017; Farrar et al., 2020). Infrared thermal technology is a quick method and described as effective technology of measuring temperature (Qu et al., 2020). The temperature is presented as images of detected areas and can be easily compared in software between target places (Tattersall, 2016). Infrared thermal technology is beneficial as being fast, real-time, non-invasive as well as does not lead to exposing subjects to a harmful and strong radiations such as X-rays (Harrap et al., 2018). Infrared thermal technology can detect changes that occur in peripheral circulation of the blood without any direct contact to animals, hence, it improves animal well-being (Radigonda et al., 2017; Weimer et al., 2020; Isola et al., 2020). As a result, this method is considered a vital technique in animal production (Schmitt and O'Driscoll, 2021).

In previous research, infrared temperature was used to measure pain in kid goats during normal husbandry procedures such as ear tagging (Zebari et al., 2021). In addition, it was also used to measure positive emotional states in sheep by stroking body of animals (Hussein, 2019). There is, yet, little information on using peripheral temperatures as an emotion indicator of goats. Therefore, the aim of this research was to investigate the effect of stroking goats' body as high valence and low arousal emotional state on facial grimace scale, ear postures and surface temperatures.

Materials and Methods

Study Site and Animals

This research was undertaken on Batufa district, Zakho city, Kurdistan Region of Iraq. The study lasted from September 2021 to May 2022. Thirty-two healthy goats, aging from 2.5 to 4 years, were used in the present study.

Ethical Statement

All the procedures of the current study were considered non-harmful to animals and it was ethically approved by the Animal Ethics Committee of the Faculty of Sciences, University of Zakho, Kurdistan Region of Iraq with its code of approval: ARC012.

Stroking Procedure

Focal sampling was used to stroke animals body individually. Subjects were stroked in three areas including forehead, neck and withers. The process was divided into three stages, which were before stroking (pre-stroking), stroking, and after stroking (post-stroking) with five minutes for each stage, and a total of fifteen minutes for each animal. Before the stroking begins, animal was left unstressed by the owner and then was stroked by the owner as a familiar person. For each stage of the study, data were collected two times which were: 0:00, 4:30 pre-stroking, 5:00, 9:30 stroking, 10:00, 14:30 post-stroking (minutes: seconds).

Sample collection

Facial Expressions

For each stopwatch point, two images were captured in which one was from the side and the other was from front of animal's head. A high resolution camera was used to capture images (SONY, Cyber-Shot, DSC-H20, Japan). A total of 12

pictures were captured from each goat and the total obtained images from all studied goats were 384 pictures. For every face unit, the score was 0, 1 and 2. For 0, it means no changes, for 1, moderate change and for 2, obvious changes were seen in the face expressions.

Ear Postures

To measure ear location and movements, the frequency of ear changes per 30 seconds interval was used. In a total of 15 minutes, 30 ear postures were recorded for each goat. The total ear postures for all goats were 960 postures. (Fig. 1). The frequency of ear position change in addition to four ear positions were measured, which were plane, backward, asymmetrical and forward ears (for details see: Boissy et al., 2011; Hussein and Hidayet, 2019).

Fig. 1. Cropped image captured for goats to detect facial expressions

Peripheral Temperatures

Three body areas were detected to obtain surface temperature. These areas were eyes, ears and nose. FLIR infrared thermal camera was used in this study (FLIR E4, FLIR Systems, OU, Estonia). Eighteen thermal images were captured for each goat, in which the total captured thermal images were 576 (Fig. 2).

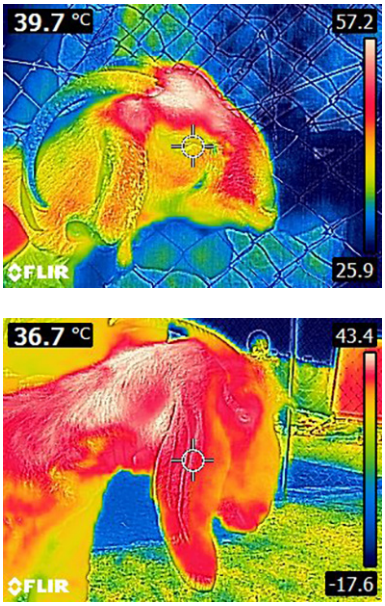

Fig. 2. Thermal images of goats for ear, eye and nasal as shown in the top-left corner in the images

Statistical Analysis

All the collected data were placed in Microsoft Excel spreadsheet. Data were prepared then sent to GenStat software program (17th edition, VSN International) to be analyzed. According to Shapiro-Wilk normality test, it was discovered that peripheral temperature data to be parametric, while all other data including face action units, ear postures were non-parametric. As a result, for temperature data, ANOVA one-way repeated measures was used with Fisher's Unprotected LSD test for comparing means with different periods. For non-parametric data, Kruskal Wallis test was used following by Mann-Whitney U-test for post hoc comparisons.

Results

Facial Expressions

Facial action units of all the three stroking stages are shown in Table 1. There were significant differences ($P < 0.01$) between all face units measured, except the ear position. Regarding the orbital tightening, the eyes were more closed in stroking and post-stroking in comparison to pre-stroking stage. Nostril was more V-shaped in both stroking and post-stroking. The jaw was less straightened in the stage of pre-stroking, compared to other stages. In addition, cheek muscle was more tensed and obvious in stroking and post-stroking phases (Table 1).

Table 1. The mean of facial expressions obtained in different stroking stages

Face Areas	Stage of Stroking			
	Before	Stroking	After	P value
Orbital Tightening	0.43 ± 0.06a	1.37 ± 0.06b	0.75 ± 0.08c	0.01
Lip and Jaw Profile	0.18 ± 0.04a	1.19 ± 0.09b	0.81 ± 0.06c	0.01
Nostril shape	0.0 ± 0.0a	0.56 ± 0.06b	0.25 ± 0.05c	0.01
Ear Position	0.75 ± 0.05a	0.69 ± 0.05a	0.75 ± 0.05a	n.s
Cheek masseter muscle	0.02 ± 0.01a	0.63 ± 0.06b	0.38 ± 0.06c	0.01

Note: different letter in the same row means a significant difference.

Ear Postures

The time spent with each position of ear by goats during stroking stages is shown in Table 2. The significant differences ($P < 0.05$) were found in the positions of forward, backward and asymmetrical ears, while time spent with plane ears was not significant.

The frequency of ear position changes is shown in Fig. 3. There were significantly ($P < 0.05$) higher ear changes during both stroking and post-stroking periods, compared to pre-stroking stage.

Table 2. Time (seconds) spent with each ear position for all the stroking periods

Ear Position	Stroking Stages			P value
	Pre-stroking	Stroking	Post-stroking	
Plane	28.3a	23.6a	28.1a	n.s
Forward	1.5a	4.4b	1.5a	0.05
Backward	0.0a	1.5b	0.4ab	0.05
Asymmetrical	0.1ab	0.5b	0.0a	0.05

Note: different letter in the same row means a significant difference.

Peripheral Temperatures

The stroking procedure had a significant effect ($P < 0.05$) only on eye and nasal temperatures during stroking and post-stroking compared to the stage before stroking, whereas no significant effect was found on ear temperature (Table 3).

The mean peripheral temperatures measured in this study over 15 minutes' period in 6 stopwatches are shown in Table 3. The significant differences ($P < 0.05$) were found between the stages of stroking over time. The peripheral temperatures were significantly dropped during stroking and post-stroking stages (Table 4).

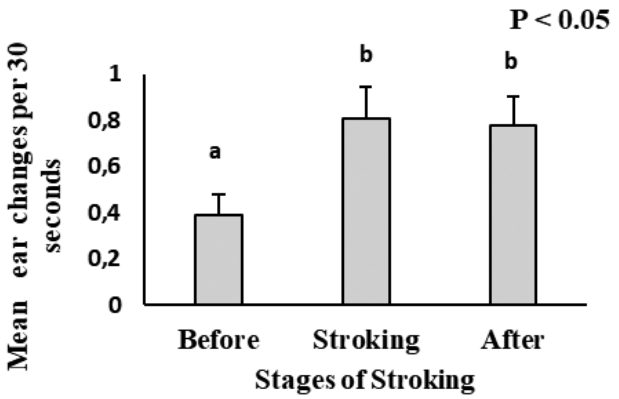

Fig. 3. Mean changes of ear position in 30 seconds intervals over 15 minutes for all the three stroking stages
Note: Different letters mean they are significantly different

Discussion

The objective of the present study was determining the effect of stroking goats' body on their positive emotional state. The temperatures of both eye and nose were significantly lower during the process of stroking, whereas the ear temperature was not affected. Noticeable changes were shown on the face of goats during stroking. In addition,

Table 3. The mean temperature of ear, nasal and eyes of goats for the stages of before, during and after stroking procedure

Peripheral Temperatures	Stage of Stroking			P value
	Before	Stroking	After	
Eye	36.7 ± 0.4a	35.5 ± 0.3b	35.8 ± 0.3b	0.05
Ear	33.7 ± 0.6a	32.6 ± 0.5a	33.6 ± 0.5a	n.s
Nasal	33.7 ± 0.4	31.8 ± 0.4	32.7 ± 0.3	0.05

Note: different letter in the same row means a significant difference

Table 4. The mean eye, ear and nasal temperatures over the time of stroking stages

Stages	Time (min:sec)	Temperature (°C)		
		Eye	Ear	Nasal
Pre-stroking	00:00	36.6 ± 0.4a	33.7 ± 0.8a	34.0 ± 0.5a
	04:30	36.8 ± 0.5ab	33.6 ± 0.7a	33.4 ± 0.4a
Stroking	05:00	35.7 ± 0.4b	32.9 ± 0.6ab	31.2 ± 0.6bc
	09:30	35.3 ± 0.4bc	32.2 ± 0.8b	32.4 ± 0.6bd
Post-stroking	10:00	35.8 ± 0.4bc	33.2 ± 0.6ab	32.7 ± 0.3ad
	14:30	35.7 ± 0.5ac	34.1 ± 0.9ab	32.7 ± 0.4ad
P – value		0.05	0.05	0.05

Note: different letter in the same column means a significant difference.

mean frequency of ear changes were higher in both stroking and post-stroking stages.

Using infrared thermal technique, it was shown that the peripheral temperatures such as eye temperature is not affected with animal's coat color. In addition, animal sex did not affect the infrared readings (Vieira et al., 2022). Using infrared thermography as a non-invasive and easily-used technique had been previously used in animals. Vieira et al. (2022) used infrared thermography to evaluate heat tolerance in nine cattle breed in Brazil. They found it was a useful method to be used in farm. Staveley et al. (2022) used infrared technique to detect early shoulder sores in sows and piglets. They revealed that infrared thermography can detect 88% of shoulder sores before 7 days of its appearance. Hussein (2018) found stroking sheep body caused a drop in nasal and eye temperatures. Similarly, Proctor & Carder (2015) measured the eye temperature of cattle during stroking; it was revealed that eye temperature was decreased significantly during stroking. Similar results were found in the current study; thus, the results of this research are agreed with previous findings.

To consider the changes in face units, there are still little known about positive emotional valence in ruminants particularly in goats. In the previous studies, it was found that animals close (half or totally) their eyes during positive experience such as stroking their bodies (Proctor and Carder, 2015; Tamioso et al., 2018). Similar results were found in the current study in which goats had closed their eyes during and post-stroking stages. Other face places that were measured in the present study are yet not found in any other study. Studies of positive emotional states in animals mostly depend on play behavior, ear movements, or the percentage of visible eye white (Biossy et al., 2011; Bekoff, 2015; Proctor and Carder, 2014; 2016; Tamioso et al., 2018). More research is required to measure facial expressions of animals, mainly goats, during positive situations.

Several studies had measured ear position and postures in small ruminants. For instance, in a study of Boissy et al. (2011), they used three methods to indicate sheep status. Moving objects slowly and quickly in the first experiment, while decreasing the amount of feed reward; and scaring sheep with air blower in the second and third experiments, respectively. In their experiments, sheep were moving their ears more forward when experiencing positive states (Boissy et al., 2011). Similar results were found in another study when sheep spent more time with ears forward during the stroking procedure as a positive emotional valence (Tamioso et al., 2018). In the present study, goats spent significantly more time with ears forward, however, in the most of the experimental time, goats had plane ears (Table 2). In the present study, the frequency of ear posture change was significantly higher in not only the stroking stage, but also in the post-stroking stage in comparison with pre-stroking period. Similar results to this study were found in cows when they had a significant increase in ear position changing frequency (Proctor and Carder, 2014).

In all the obtained results from the present research, measuring positive emotional valence in goats is possible with both behavioral and physiological parameters. Previously, scientists were considering positive emotional statement of animals is impossible as a result of its subjective nature. Although many studies are concentrated on measuring positive emotions in different animals such as cattle, sheep, rats, mice, horses, whereas no study is yet undertaken in measuring goats' positive emotions (brushing or stroking body) using facial expressions and peripheral temperatures. Thus, more research is required similar to this study or using different methods on goats.

Conclusions

According to the findings of the present study, it, therefore, can be concluded that measuring peripheral temperatures in goats, mainly eye and nose, is vital to indicate positive emotional valence in goats. Similarly, facial expressions of goats during stroking were valuable in indicating positive

states with stroking their bodies. There is still need for further research to be conducted with positive emotions, both arousal and valence, in goats.

Authors Contribution

Both authors contributed equally.

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