

*Original Research Article***Behavioural and physiological responses of West African Dwarf Goat dams and kids subjected to short-term separation**

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Abstract

Nineteen West African Dwarf (WAD) goats were used to investigate the physiological and behavioural responses of dams and kids to short-term separation. The dams were naturally mated with bucks and after parturition the kids remained with their respective dams for 5 weeks. Thereafter, the dams were separated from their kids for 10 minutes/week for three weeks (week 5–7). Physiological indicators, namely, eye temperature (ET), heart rate (HRT) and blood glucose (GLUC) were taken from each dam, while the ET and HRT were taken from the kids before and after the separation. The behaviours of the dams and kids were recorded during the separation period at the 7th week. Changes (before minus after) in the physiological parameters (ET, HRT and GLU) for the three weeks were analysed using repeated measures ANOVA while the behavioural data were analysed using non parametric test (SPSS statistical package). The Δ GLUC of WAD dams was greater at the 5th than 7th week. At the 5th week also, the Δ ET was greater in dams with single kids than those with twins. Litter size did not influence the behaviour of the dams during separation. A significant correlation was established between Δ HRT and urination in dams. Although sex of the kids had no significant effect on both the physiological and behavioural indicators monitored, negative correlations were established between vocalization bouts and escape attempts ($r = -0.516, P < 0.01$), duration of vocalisation and escape attempts ($r = -0.427, P < 0.05$). In conclusion, only WAD dams showed physiological responses indicative of stress during the period of separation.

Keywords: *Capra hircus*; maternal stress; eye temperature; blood glucose; heart rate; urination; separation.

INTRODUCTION

Goats are the most important domesticated small ruminants with a population of about 53.8 million in Nigeria (FAOSTAT, 2009). The flock size is small and the main breeds are the West African Dwarf (WAD) goat, Red Sokoto (RS) or Maradi and the Sahel. These breeds are mainly meat producers and are well adapted to humid tropical zone of West Africa with inherent trait of being trypano-tolerant. With the increasing awareness of the nutritional, health and therapeutic benefits of goat milk (Ribeiro and Ribeiro, 2010), the demand for goat milk and its products is yet to be met in developing countries. The potentials and values of Nigerian indigenous breeds, especially WAD dams, for milk production has begun to be investigated (James et al., 2009; James et al., 2010). For optimal milk

collection, kids are weaned early, at about 2 weeks of age (Shittu et al., 2011), or separated from their dams for some period of time (Egbowon et al., 2007).

The quality of mother-infant relationships and the juvenile's subsequent social milieu are considered to be crucial for adjustment and social competence in adulthood (Ferdman et al., 2007). In goats, an exclusive bond between mother and young is established soon after birth (Miranda-de la Lama and Mattiello, 2010), hence maternal-offspring separation disrupts the bond between mother and offspring and this could result in welfare problems such as stress or rejection by the dams (Hersher and Richmond, 1958). Dams whose kids were separated from them early in life (1 hour after kidding) nursed alien kids more than their own kids two months after the separation (Hersher and Richmond,

Table 1. Composition of concentrate feed

Ingredients	Composition (%)
Corn bran	35
Wheat offal	27
Palm kernel cake(PKC)	30
Limestone	1
Premix	1
Beans offal	5
Salt	1
Bone meal	1
Total	100

1958). Recently, Iyasere et al. (2015) reported that the separation of kids from their dams for the first time triggered an increase in blood glucose of the WAD dams which is an indication of stress.

Hence, stress caused by commercial farm practices such as separation of kids from dams for increased milk yield is a major component of animal welfare assessment. Infrared thermography (IRT) has been developed as a non-invasive technology to detect stress in several farm and companion animal species. Mother hens witnessing her chicks undergoing distress showed physiological responses such as increase in heart rate and decline in eye temperature (Edgar et al., 2011). Stress leads to a change in blood flow resulting in a net influx of blood to internal organs thus causing a drop in surface temperature; this phenomenon is referred to as stress-induced hyperthermia (Jerem et al., 2015). Therefore, IRT offers advantages over many other non-invasive systems because of its capability in measuring stress irrespective of the stress axis (acute sympathetic and hypothalamic-pituitary-adrenocortical responses) triggered (Stewart et al., 2005).

The majority of research on WAD goats has been designed to investigate their milk yield, milk composition, udder characteristics and growth (James et al., 2009) and recently their suckling behaviour (Iyasere et al., 2017). With the increasing awareness of the greater value of goat milk over cow milk, there is high possibility of farmers to disrupt the mother-offspring bond with the intention of increasing their milk production but neglecting the welfare of the dams and kids during the separation period. Very few experiments have focussed on the degree of stress experienced by goat dams and their kids during separation prior to milking, and to the best of our knowledge, no information in literature is available on WAD goat dams and their kids. Hence, the purpose of this study was to determine the extent to which short-term separation affects behaviour and physiology of WAD dams and their kids. We hypothesise that short-term separation of goat dams

and kids would be accompanied by changes in behaviour and physiology indicative of stress.

MATERIALS AND METHODS

Experimental site and animals

The experiment was conducted at a smallholder goat farm, Abeokuta. The area is located in the southwestern part of Nigeria and lies at latitude 7°25'N and longitude 3°25'E. The area is characterized by an annual rainfall of about 1037 mm. The average temperature and relative humidity are 34 °C and 82%, respectively.

A total of 19 pregnant West African Dwarf does were used for this experiment. They were reared at a smallholder dairy goat farm unit. The weight of the dams ranged from 18–22 kg before mating them naturally and pregnancy was confirmed by non-return to oestrus. The dams were reared intensively on wooden slatted floor. Two dams were housed together in a pen (1.52 × 1.22 m), provided with water *ad libitum* and fed with concentrates (composition is presented in Table 1) in the morning and freshly chopped forage grasses such as elephant grass (*Pennisetum purpureum*) and guinea grass (*Panicum maximum*) in the afternoon.

Experimental procedure

After parturition, eleven dams had single kids while eight dams had twin births. Of the eleven single birth kids, six were males and five were females. Of the twin birth kids, three sets of twins were males and females, one set of twin were both males and four sets of twins were both females. After parturition, dams and kids were left undisturbed for 5 weeks so that the maternal-offspring bond would have been fully established. At the end of the fifth week after parturition, the kids were separated from their respective dams for a period of 10 min once a week for 3 wks (i.e. 5, 6 and 7 weeks after parturition). Prior to the separation, the baseline levels of heart rate (using a stethoscope), eye temperature (using infra-red digital thermometer) and blood glucose (ACCUCHEK glucometer) of the dam was measured. About 0.5 ml of blood was collected from the jugular vein of the dam and a drop

Table 2. Distress behaviour of WAD dams and kids during separation

Behaviour	Description
Dams	
Duration of vocalization	Total duration of bleating within the 10 minutes period
Vocalization bouts	Number of times dam bleats
Escape attempt	Number of times the dam attempted to escape from their pen
Urination	Number of times the animal urinates
Kids	
Duration of vocalization	Total duration of bleating within the 10 minutes period
Vocalization bouts	Number of times the kid bleats
Escape attempt	Number of times the kid attempted to escape from their pen

of blood was immediately placed on the glucose strip already inserted into the glucose meter and showing a red light, which indicates its readiness for blood. For the kids, only the eye temperature and heart rate were measured. Subsequently, the kids were visually separated from their dams by taking them away from their dams to an empty pen about 1 meter away (dams and kids could only communicate through vocalisation but could not see each other). The dams and kids were recorded separately with two Camcoders (Fujifilm, FinePix, S2980, China) for 10 minutes. The behaviour was analysed subsequently by watching the playback of the videos. During the playback, a yes/no were recorded for the presence or absence of behaviours such as escape attempt and urination. For the vocalisation, the number of times the animals performed a complete bleating was recorded as vocalisation bout. The total time during the 10-minute period when the animal was vocalising was recorded as the duration of vocalisation. The behavioural indices of distress during separation monitored in the dams and kids as described in Table 2 were only recorded on the 7th week. After the 10 min separation period, the heart rate, eye temperature and blood glucose of the WAD dams and the eye temperature and heart rate of kids were measured again.

Statistical Analysis

Data were analysed using the SPSS statistical package (version 21). Data collected on physiological parameters from the dams and kids satisfied the normality test (Shapiro-Wilks), hence data on change (before-after separation) in eye temperature (ΔET), blood glucose ($\Delta GLUC$) and heart rate (ΔHRT), were subjected to ANOVA with week of separation (week 5–7) and litter size (single or twin) and their interaction as fixed factors. If the Mauchly’s test of sphericity was significant, Greenhouse-Geisser tests of within-subjects effects was used. The level of significance was set at $P < 0.05$.

For the kids, data on ΔET and ΔHRT were subjected to ANOVA with week of separation (week 5–7), sex and their interactions as fixed factors.

Behavioural data collected did not satisfy the normal distribution test (Shapiro-Wilks) and

hence were subjected to separate non-parametric test (Mann-Whitney U test) having litter size and sex as fixed factor for data collected from the dam and kids, respectively.

Correlation between the physiological and behavioural variables of the kids and dams were analysed using Pearson correlation.

RESULTS

Physiological and behavioural responses of dams

Overall (average for week 5–7), there was tendency ($P = 0.081$) for an effect of litter size on the ΔHRT of dams separated from their kids, with dams with single kids showing a higher increase in heart rate than those with twins. There was neither a significant ($P > 0.05$) effect of week of separation nor week of separation \times litter size on the ΔHRT of WAD dams (Figure 1A).

Overall, there was no significant ($P > 0.05$) effect of litter size on the $\Delta GLUC$. However, there was a significant effect of week of separation on the $\Delta GLUC$ ($F_{2,34} = 4.964, P = 0.013$), post hoc test shows that the $\Delta GLUC$ was greater at week 5 than 7 with the 6th week being intermediate (Figure 1B). There was no significant interaction between week of separation \times litter size.

Overall, there was no significant ($P > 0.05$) effect of litter size on the ΔET of WAD dams separated from their kids. Although there was no significant ($P > 0.05$) effect of week of separation on the ΔET , there was a significant effect of week of separation \times litter size on ΔET of WAD dams ($F_{2,24} = 3.432, P = 0.044$), post hoc test shows that the ΔET declined in dams with single compared to twin kids only at the 5th week (Figure 1C).

There was a positive correlation between ΔHRT and dam urination ($r = 0.613, P < 0.01$) during the period of separation at the 7th week. There was no significant effect of litter size on the behaviour (urination, duration of vocalisation, escape attempt and vocalisation bouts), see Table 3.

Physiological and behavioural indicators of kids

Overall, there was no significant ($P > 0.05$) effect of sex on the ΔET of WAD kids separated from their dams.

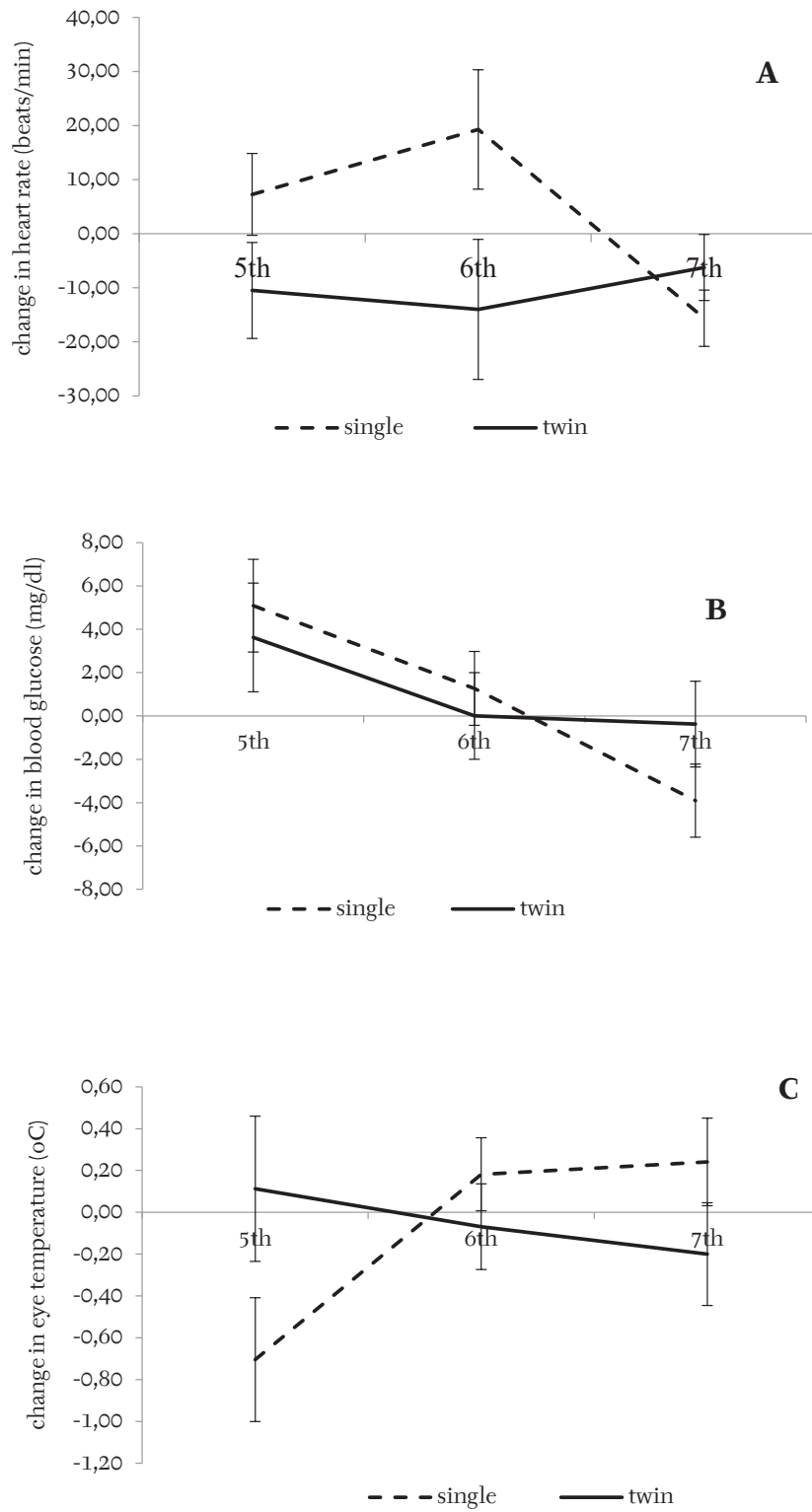


Figure 1. Effect of separation time and litter size interaction on changes in heart rate (A), blood glucose (B) and eye temperature (C) of WAD dams. Values are Means \pm SEM.

Table 3. Behavioural responses of WAD kids and dams during separation as affected by sex and litter size, respectively, at the 7th week

	Duration of vocalisation (min)	Vocalisation bouts	Display of escape attempt	Display of urination
WAD Dam				
Single	9.55	11.45	10.14	9.55
Twin	10.63	8.00	9.81	10.63
WAD Kids				
Male	14.41	13.86	13.36	N/A
Female	13.72	14.09	14.44	N/A

Values are Mean Ranks, N/A = not applicable to the kids

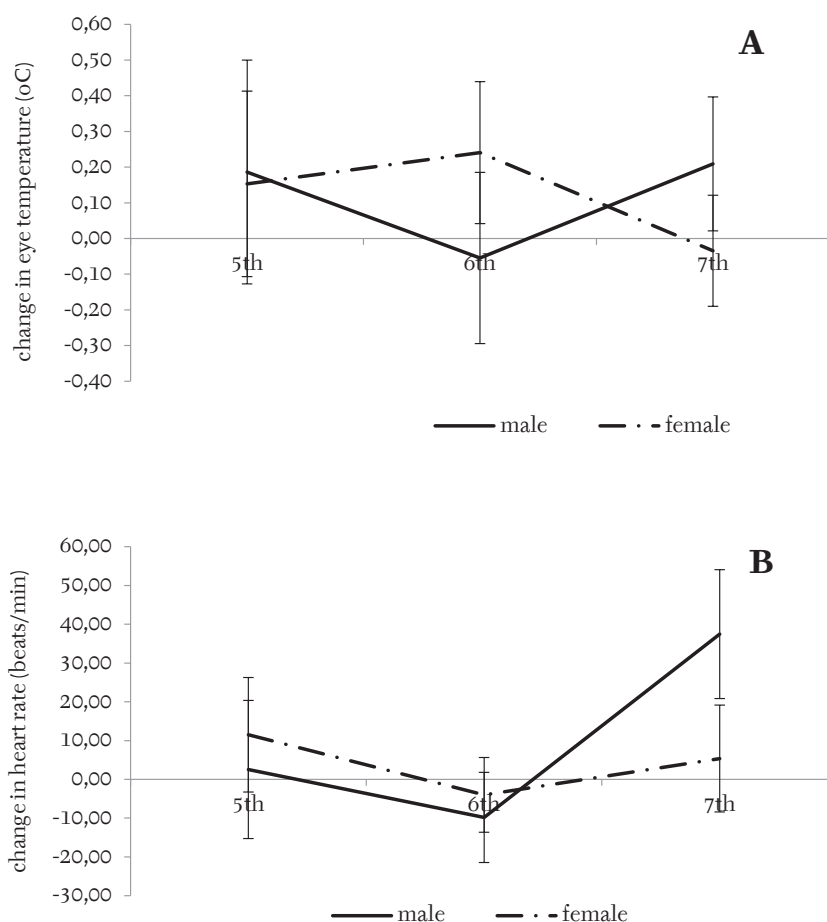


Figure 2. Effect of separation time and kid sex interaction on changes in eye temperature (A) and heart rate (B) of WAD goat kids. Values are means ± SEM.

There was neither a significant ($P > 0.05$) effect of week of separation nor week of separation × sex on the ΔET (Figure 2A) of WAD kids.

Overall, there was no significant ($P > 0.05$) effect of sex on the ΔHRT of WAD kids separated from their dams. There was neither a significant ($P > 0.05$) effect of week of separation nor week of separation × sex on the ΔHRT (Figure 2B) of WAD kids.

There was a negative correlation between number of vocalization bouts and attempts to escape ($r = -0.516$,

$P < 0.01$), and between duration of vocalisation and escape attempt ($r = -0.427$, $P < 0.05$). Finally, there was no significant ($P > 0.05$) effect of sex on the behaviour of WAD kids during separation (Table 3).

DISCUSSION

Heart rate measurement has been proven to be a useful measure of stress in ruminants, although there are inconsistencies in the literature. In the current study, separation of dam from kids did not affect

the heart rate of either the dam or their kids. This could probably be due to the short period of separation or the age of the kids prior to separation, or auditory contact between dams and kids during the separation period. Even a period of one hour daily separation of lambs from ewes (between 13–20th day and 20–27th day of age) did not cause any significant change in the heart rate of the lambs (Simitzis et al., 2012). In a study, using one week old Djallonke lambs separated from their dams (lambs were left behind when dams were grazing) for three consecutive days, Abdul-Rahman et al. (2012) reported a consistent increase in respiratory rate, heart rate, rectal temperature and blood glucose. This indicates that maternal separation within the first few days after parturition could be more stressful in lambs. Compared to the current study where kids and dams could communicate through vocalisation, in the study of (Abdul-Rahman et al., 2012), there was no communication between the lambs and the ewes during the period of separation and this could aggravate the level of stress experienced by the lambs. Goat kids that were partially isolated from conspecifics displayed higher rates of locomotion, jumping and bleating and motivated efforts to reunite with their mates than completely isolated kids (Siebert et al., 2011).

However, von Walter et al. (2010) investigated separation of goat kids 4–6 days after parturition and reported no change in heart rate and cortisol levels. This suggests that an increase in heart rate to offspring separation was dependent on farm animal species and age of kids when the separation was undertaken. In the current study, the positive correlation between change in heart rate and urination implies that the greater the change in the heart rates of the dams the higher the increase in the frequency of urination. A previous study has shown that social isolation of Holstein cows increased the incidence of high-frequency vocalization, defecation/urination, heart rate and cortisol concentrations (Rushen et al., 1999). The greater increase in Δ GLUC of WAD dams at the 5th week (which corresponds to the first separation time) than the 7th week (3rd separation time) suggests that WAD dams experienced more stress when their kids were separated from them for the 1st time after which the dams became adapted to the separation from their kids. Stressful events induce physio-pathological responses through the activation of sympatho-adrenal medullary and hypothalamic-pituitary-adrenal (HPA) system (Sanders and Anticevic, 2007). Increase in blood glucose level is associated with the activation of the adrenal gland to prepare animals for fight, flight or fright (von Walter et al., 2010). Mother-offspring separation affects the emotion of dairy animals. After 2.5 days of separation of dairy calves from dams, the calves showed a negative judgement bias, which is indicative of being in a negative emotional state (Daros et al., 2014).

WAD dams with single kids showed a decline in ET after 10 min separation period compared to those with twin kids, and this implies that WAD dams' with single kids experience greater level of stress than those with twin kids. The use of eye temperature to assess stress has been used in different animals ranging from hens to horses. For instance, eye temperature was useful in assessing stress during jumping competition in horses (Bartolomé et al., 2013), while Edgar et al. (2011) reported that mother hens displayed a decrease in eye temperature when they were subjected to a stressful condition (air puff directed at hen or its chicks at 30 seconds interval).

In the current study, increased vocalization response during isolation or separation has been ascribed to either an adaptive and active attempt to communicate with each other or as a sign of distress and fear (Siebert et al., 2011). We were able to establish a negative correlation between number of escape attempts and vocalization bouts in goat kids. This implies that goat kids that displayed greater attempt to escape vocalized less frequently than those that showed fewer attempts to escape.

CONCLUSION

WAD dams subjected to short-term separation from their kids experienced stress due to the changes in their blood glucose level and eye temperature. In addition, the stress experienced by WAD dams to kid separation was related to the number of kids delivered by the dam and the separation time (first, second or third). Finally, there was a significant correlation between frequency of urination and Δ HRT of the WAD dam. WAD kids showed no physiological response in terms of their change in heart rate and eye temperature.

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