Ciência Rural, Santa Maria, v.45, n.9, p.1634-1640, set, 2015 http://dx.doi.org/10.1590/0103-8478cr20141668
ISSN 0103-8478 PATHOLOGY

Feeding preferences of experienced and naïve goats and sheep for the toxic plant *Ipomoea carnea* subsp. *fistulosa*

Comportamento ingestivo de caprinos e ovinos habituados e não habituados a ingerir *Ipomoea carnea* subsp. *fistulosa*

Carlos Alberto Oliveira Júnior[I*] Gabriela Riet-Correa[II] Everton Lima[I] Danilo Maia Leite[I] James A. Pfister[III] Daniel Cook[III] Franklin Riet-Correa[I]

ABSTRACT

Ipomoea carnea *is a toxic plant that grazing goats and cattle may learn to ingest with repeated exposure. The objective of this study was to evaluate the feeding preferences of experienced and non-experienced (naïve) goats and sheep for* ***I. carnea****. The study used 3 groups of 5 goats (Group 1, experienced that were previously poisoned by the plant; group 2, naïve; Group 3, experienced eaters, composed of animals adapted to eat the fresh plant) and 2 groups of sheep (group 4, experienced that were previously poisoned by the plant; and group 5, naïve). For the test, the animals were placed daily for 10 minutes and 4 days in a rectangular stall (5x7m) with 4 feeders, each with 200g of a different food (****Ipomoea carnea****, commercial concentrate food, recently harvested green grass (mainly* ***Brachiaria*** *spp.), and* ***Cynodon dactylon*** *hay. The intake of concentrate food was significantly higher (P<0.05) than the consumption of green grass, hay and* ***I. carnea****. In a second 4 day trial, in which the commercial concentrate food was replaced by freshly harvested* ***Amorimia septentrionalis****, the ingestion of green grass (****Brachiaria*** *spp.) was significantly higher (P<0.05) than the consumption of other foods. In both trials there was no significant difference in food consumption between eaters and naïve animals. The results suggest that experienced or naïve sheep and goats do not prefer* ***I. carnea*** *when it is offered with other foods or forages, suggesting that animals will avoid the plant and not become poisoned if other food options are available.*

Key words: *feeding behavior,* ***Ipomoea*** *spp., poisonous plants, swainsonine-containing plants.*

RESUMO

Ipomoea carnea *é uma planta tóxica para caprinos e bovinos, que podem desenvolver o hábito de ingeri-la de forma compulsiva. O objetivo deste estudo foi avaliar o comportamento ingestivo de caprinos e ovinos habituados e não habituados a ingerir* ***I. carnea****. O estudo utilizou três grupos de cinco caprinos (Grupo 1, animais previamente intoxicados pela planta; Grupo 2, controle; Grupo 3, animais adaptados a ingerir a planta fresca) e dois grupos de cinco ovinos (Grupo 4, animais previamente intoxicados pela planta; e Grupo 5, controle). Para o teste, os animais foram introduzidos por 10 minutos, durante 4 dias consecutivos, em uma baia retangular (5x7m), com 4 caixas de alimentação, cada uma com 200g de um alimento diferente (****Ipomoea carnea****; concentrado comercial; capim verde recém colhido, principalmente* ***Brachiaria*** *spp.; e feno de* ***Cynodon dactylon****). A ingestão de concentrado foi significativamente maior (P<0,05) do que o consumo de capim verde, feno e* ***I. carnea****. Em um segundo ensaio de 4 dias, em que o concentrado foi substituído por* ***Amorimia septentrionalis*** *recém-colhida, a ingestão de capim verde (****Brachiaria*** *spp.) foi significativamente maior (P<0,05) do que o consumo dos outros alimentos. Em nenhuma das duas espécies, houve diferenças no comportamento ingestivo entre animais habituados e não habituados a ingerir* ***I. carnea****. Os resultados sugerem que ovinos e caprinos habituados e não habituados a ingerir* ***I. carnea*** *não preferem a planta quando é oferecida com outros alimentos ou forragens, o que sugere que os animais irão evitar a planta e não haverá intoxicação se outras opções de alimentos estão disponíveis.*

Palavras-chave: *comportamento ingestivo,* ***Ipomoea*** *spp., plantas tóxicas, plantas que contêm swainsonina.*

INTRODUCTION

Ipomoea carnea subsp. ***fistulosa*** (Figure 1) is a swainsonine-containing plant that induces glycoprotein storage disease in ruminants characterized by neurologic signs that cause the death of numerous goats in Northeastern and Northern Brazil (ARMIÉN et al., 2007; OLIVEIRA et al.,

[I]Hospital Veterinário, Universidade Federal de Campina Grande (UFCG), 50700-000, Patos, PB, Brasil. E-mail: carlosjr@ufpa.br. *Corresponding author.
[II]Programa de Pós-graduação em Saúde Animal na Amazônia, Universidade Federal do Pará (UFPA), Saudade - Castanhal, PA, Brasil.
[III]Poisonous Plant Research Laboratory, Agricultural Research Service, United States Department of Agriculture, Logan, USA.

Received 11.17.14 Approved 01.24.15 Returned by the author 04.07.15
CR-2014-1668.R1

Figure 1 - ***Ipomoea carnea*** var. ***fistulosa***. Municipality of Castanhal, state of Pará.

2009). Swainsonine causes cellular accumulation of oligosaccharides due to inhibition of several important enzymes, resulting in cellular vacuolization and death in the central nervous system and in other systems (DE BALOGH et al., 1999). Consumption of the plant is an important cause of losses in goats in the north and northeastern Brazilian regions (ARMIÉN et al., 2007; OLIVEIRA et al., 2009; PIMENTEL et al., 2012) and has been also diagnosed in cattle in the Pantanal region of Mato Grosso (ANTONIASSI et al., 2007). Normally, grazing livestock do not ingest ***I. carnea***, but anecdotal accounts by livestock producers suggest that goats and cattle that start to consume the plant develop the habit to ingest it compulsively, even with sufficient alternative forage (ARMIÉN et al., 2007; TOKARNIA et al., 2007; OLIVEIRA et al., 2009, 2011). This behavior, defined by farmers as addiction (or strong preference), is not observed in sheep (ADRIEN et al., 2013b).

There is no treatment for the poisoning, and control methods include the development of conditioned food aversions (ADRIEN et al., 2013a; OLIVEIRA et al., 2013, 2014; PIMENTEL et al., 2012, 2013). Studies have shown that goats that were naïve but exposed to the plant, then conditioned to avoid eating it, did not ingest the plant for at least 2 years and 8 months. However, aversion was not effective in goats that have developed the habit of consuming the plant for long periods of time (OLIVEIRA et al., 2014). There are indications that the maintenance of the conditioned aversion in goats is favored by the availability of other forages (OLIVEIRA et al., 2014). The aversive treatment reduced goats' consumption of the plant during the rainy season, but during the dry season the goats again consumed the plant, as it was the only green forage available (PIMENTEL et al., 2013). It appears that hunger due to shortage of forage, associated with large amounts of the plant in the field, are the main factors leading goats and cattle to ingest ***I. carnea*** (ANTONIASSI et al., 2007; ARMIÉN et al., 2007; OLIVEIRA et al., 2009). However, young goats may consume ***I. carnea*** even with good forage availability (OLIVEIRA et al., 2014).

Sheep may be intoxicated spontaneously (TOKARNIA et al., 1960) or experimentally (ARMIÉN et al., 2011) with high doses of ***I. carnea***. However, on farms where sheep are raised together with goats the poisoning occurs in goats, but not in sheep (TORTELLI et al., 2008). The difference in the occurrence of the poisoning in the two species may be explained by their different eating habits, food preferences or susceptibility to the poisoning. An increased understanding of goats' and sheep preferences for ***I. carnea***, and how those preferences may vary with previous experience with the plant, is important to develop grazing management options to reduce animal losses. Thus, the objective of this study was to evaluate the feeding preference of experienced and non-experienced (naïve) goats and sheep for ***I. carnea***, and to determine if there was learned compulsive eating or preference of this plant by experienced goats and sheep.

MATERIAL AND METHODS

Animals

Fifteen goats and 10 sheep were divided into 5 groups: Group 1 was formed by 5 goats that were intoxicated by swainsonine in a previous experiment (OLIVEIRA et al., 2015, unpublished); they had received ground ***I. carnea*** equivalent to 3mg/kg bw of swainsonine (four goats) for 41-43 days, or 1mg kg^{-1} of swainsonine for 61 days (one goat). The administration of the plant was suspended after the first clinical signs of poisoning were observed (rough hair coat, weight loss, and nervous signs associated mainly with cerebellar and brain stem lesions as difficulties in standing, ataxia, hypermetria, wide-

based stance, lateral gait, intention tremors, spastic paresis or weakness, abnormal postural reactions, nystagmus, loss of equilibrium and falling to the side or backward). In Group 1, animals were allowed to recover from clinical signs for 31 to 51 days after the end of the administration, and then the animals ingested 200g of green leaves of ***I. carnea*** for 15 days to reinforce the experience. Group 2 was formed by 5 naïve goats that never ingested ***I. carnea***; these animals were raised on a pasture of native vegetation (*caatinga*) of the Brazilian semiarid. Group 3 was formed by 5 goats that grazed 3 days a week for 2 hours daily, for at least 2 months, in an area severely invaded by ***I. carnea*** (PIMENTEL et al., 2013) and they all consumed the plant regularly. No clinical signs were observed in this group; Group 4 was formed by 4 sheep that received ground ***I. carnea*** from days 43 to 93 at the daily dose equivalent to 3mg kg^{-1} bw of swainsonine plus one sheep that received 1mg kg^{-1} bw for 107 days (OLIVEIRA et al., 2015, unpublished). The administration of the plant was suspended after the observation of the first clinical signs of poisoning. After the recovery from clinical signs, 1 to 49 days after the end of the administration, the animals ingested, daily, 200g of green leaves of ***I. carnea*** for 15 days to reinforce the experience. Group 5 was formed by 5 naïve sheep that never ingested ***I. carnea***. In groups 1 and 4, dry ***I. carnea*** was administrated by mixing the plant with commercial concentrate ration, which was given in an amount equivalent to 1.5% of body weight and was ingested spontaneously by all animals.

Test pen and foods offered

For the test, the animals were individually placed in a rectangular pen (5x7m) with 4 feeders, identified from 1 to 4, distributed equidistant from one another, on each side of the pen, positioned so that the animal entering the pen could initially choose any of the feeders.

Before the start of the experiment, all animals were trained for 25 days to become familiar with the location of the feeders in the stall and to consume the various foods offered in the feeder. To this end, after an overnight fast, each food was offered to each animal individually for 5 days by putting 50g of the food in each one of the four feeders and allowing the animal access for ten minutes a day. Animals quickly learned to investigate each feeder.

During the first preference test, the following 4 foods were tested: freshly harvested leaves of ***I. carnea***; a commercial concentrate food; recently harvested green grass (mainly ***Brachiaria*** spp.); and ***Cynodon dactylon*** (variety Tifton) hay. During the second 4 day period, 4 foods were again offered except the commercial concentrate food that was not offered and freshly harvested ***Amorimia*** (***Mascagnia***) ***septentrionalis*** was substituted in its place.

Preference test

The animals were fasted for at least 12 hours before the test. During the first four days test, 4 different foods were tested (commercial concentrate, fresh grass, hay, and ***I. carnea***), by putting 200g of each food in each feeder. Every day each food was rotated to a different feeder, and each animal was introduced into the stall for 10 minutes, and the order they examined the different feeders was noted. At the end of the 10 minutes the amount of each food that remained in the feeders was weighed to determine the amount consumed. During the second test from day 5 to day 8 the most palatable food (commercial concentrate food) was removed and substituted by green leaves of ***A. septentrionalis***. ***Amorimia septentrionalis*** is a native plant that contains relatively low amounts of monofluoroacetate (LEE et al., 2012), and is considered moderately palatable to grazing livestock (DUARTE et al., 2013). The amount offered to animals in these preference trials, even if totally consumed, was not sufficient to intoxicate the animals (DUARTE et al., 2013).

Swainsonine concentrations of freshly harvested leaves of ***I. carnea*** were determined by liquid chromatography and mass spectrometry (GARDNER et al., 2001).

Statistical analysis

The fixed effects of position, day, treatment (i.e., different foods), and the day × treatment interaction on proportion consumed (% of offered) were assessed using a generalized linear mixed model with a β distribution, a logit link, and Laplace estimation. Pen (i.e., different animals) was a random effects blocking factor. Pair wise comparisons among treatment means within a given day were adjusted for family wise Type I error ($\alpha = 0.05$) using the Tukey-Kramer method. The analysis was done using the GLIMMIX procedure in SAS/STAT 12.1 (SAS Inst. Inc., Cary, NC).

RESULTS

In 8 samples of the leaves of ***I. carnea*** used in this experiment, the mean concentration of swainsonine was 0.05%±0.05 with a range from non-detected to 0.155%. During the assessment of feeding preferences in the first trial, when the foods

tested were ***I. carnea***, concentrate food, green grass and hay, the intake of the concentrate food was significantly higher (P<0.05) that the consumption of green grass, hay and ***I. carnea*** (Figure 2). The second most consumed food by animals in all groups was green grass, with a significant difference (P<0.05) with the amounts of hay and ***I. carnea*** consumed by Group 4 (sheep poisoned previously by dry ***I. carnea***) and 5 (control sheep) (Figure 2 D and E).

In trial 2 when the most preferred food (concentrate) was substituted by ***Amorimia*** (***Mascagnia***) ***septentrionalis***, the ingestion of green grass (***Brachiaria*** spp.) was significantly higher (P<0.05) than the consumption of the other foods (***A. septentrionalis***, ***I. carnea***, and hay) in the 5 groups (Figure 3), with no differences (P>0.05) among the hay, ***I. carnea*** and ***A. septentrionalis***.

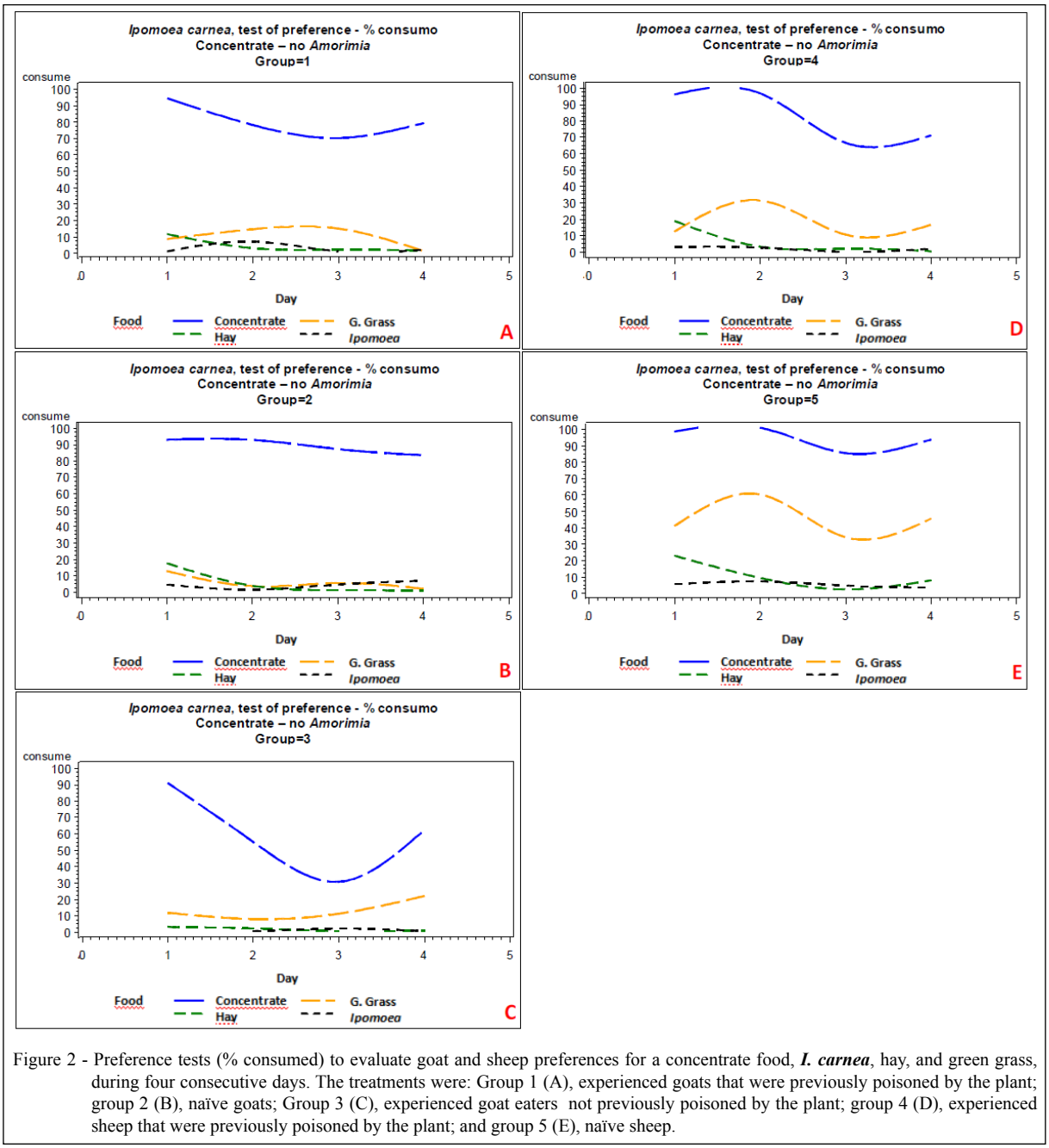

Figure 2 - Preference tests (% consumed) to evaluate goat and sheep preferences for a concentrate food, ***I. carnea***, hay, and green grass, during four consecutive days. The treatments were: Group 1 (A), experienced goats that were previously poisoned by the plant; group 2 (B), naïve goats; Group 3 (C), experienced goat eaters not previously poisoned by the plant; group 4 (D), experienced sheep that were previously poisoned by the plant; and group 5 (E), naïve sheep.

In both trials no significant differences in food consumption were observed between eaters and naïve animals.

DISCUSSION

Previous reports suggested that after starting to eat ***I. carnea***, goats develop a preference or even strong preference to the plant (ARMIÉN et al., 2007; TOKARNIA et al., 2007; OLIVEIRA et al., 2009). In this experiment goats and sheep from all treatment groups, including those with substantial prior experience with the plant to the point of intoxication, consumed ***I. carnea*** in a lesser amount than the highly palatable concentrate food and green grass, indicating that the animals do not develop a preference for ***I. carnea*** under these experimental conditions. These results suggest that if goats and sheep have sufficient high quality concentrate food or green grasses, they will not eat ***I. carnea*** in high enough quantities to become intoxicated. To occur intoxication, animals must ingest relatively large amounts of ***I. carnea***. TOKARNIA et al.

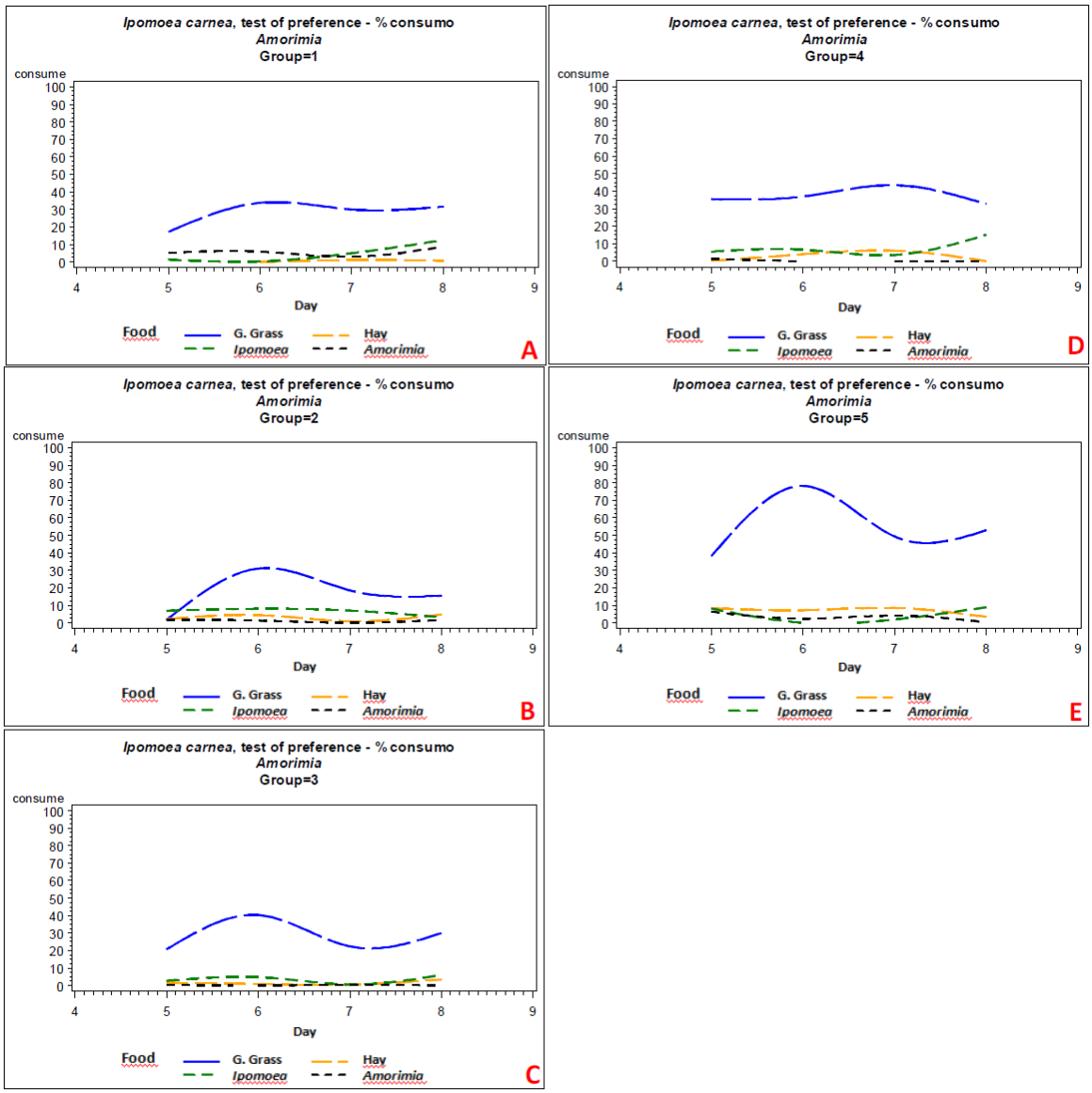

Figure 3 - Preference test to evaluate the preference for the consumption of ***I. carnea***, ***A. septentrionalis***, hay, and green grass, during four consecutive days in groups 1 (A), 2 (B), 3 (C) 4 (D), and 5 (E).

(1960) observed the first clinical signs of poisoning in two goats after they had been ingesting the plant as sole food source for 35 and 46 days, respectively.In another experiment, goats showed the first clinical signs 21 to 42 days after the ingestion of daily doses of 24 to 96g of the green plant kg^{-1} bw (ARMIÉN et al., 2007). In Mozambique, 2 goats ingesting daily doses of 50g of green plant/kg bw showed first clinical signs after 39 and 54 days, respectively (DE BALOGH et al., 1999).

The swainsonine concentration in the plant is no doubt a factor in whether animals become intoxicated; however, despite the variations found between different samples from the same location, the mean swainsonine concentrations of plants from different places showed little variation. In the state of Paraíba, samples of ***I. carnea*** causing outbreaks in the northeastern region contained 0.07±0.06% swainsonine (PIMENTEL et al., 2012) and samples collected in the same experimental area where the plant was collected for this preference experiment contained 0.05±0.05% swainsonine (PIMENTEL et al., 2013). In the Northern region, concentrations of swainsonine in ***I. carnea*** from different places were 0.05±0.01% (ADRIEN et al., 2013a), 0.05±0.03% (OLIVEIRA et al., 2014), and 0.07±0.08% (OLIVEIRA et al., 2015). Samples collected in the Southern region contained 0.06±0.004% swainsonine (ADRIEN et al., 2013b).

In goats, another factor determining the occurrence of the disease is year-round availability of the plant. The plant is always growing in wet areas (e.g., edges of ponds), and stays green for the whole year including during the dry season when there is a shortage of other forage (ANTONIASSI et al., 2007; OLIVEIRA et al., 2009; PIMENTEL et al., 2012). Hunger due to shortage of forage is obviously the main factor to induce grazing goats to ingest ***I. carnea***, and consumption by some individuals within a herd will induce others to ingest the plant through social facilitation; however, young, inexperienced goats may initiate ingestion even with ample forage availability (OLIVEIRA et al., 2014). Nevertheless, as these pen trials have demonstrated, goats show little preference for ***I. carnea*** when given a choice of other foods, and thus it seems unlikely that with sufficient availability of other forage, goats will ingest enough of the plant to become intoxicated.

Poisoning by ***I. carnea*** is frequent in goats in northern and northeastern regions of Brazil, but not in sheep. Even though some livestock producers raising animals along the borders of the São Francisco river (states of Pernambuco, Bahia, and Alagoas) mention the occurrence of the disease in sheep (personal communication), there is only one report of two cases of poisoning in sheep (TOKARNIA et al., 1960), which suggests that sheep may be more resistant to the poisoning than goats or that they typically avoid the plant. ADRIEN et al. (2013b) in experiments to induce a conditioned aversion in sheep to the plant, observed that even sheep adapted to consume ***I. carnea***, ingested limited amounts of plant when placed into invaded areas with large amounts of ***I. carnea***. In the present experiment, the only difference noted between goats and sheep was when the foods tested were a highly palatable concentrate food, green grass and hay. In this case, the intake of green grass by sheep from groups 4 and 5 was significantly greater than their intake of ***I. carnea***, whereas there was no difference in the consumption of green grass and ***I. carnea*** in the goats.

The anecdotal accounts of strong preference by grazing animals to swainsonine-containing plants have not been verified in experimental settings (RALPHS et al., 1990; PFISTER et al., 1992). However, strong preference to foods are a complex interaction of many factors, difficult to study even in highly controlled research settings with rodents (CORWIN et al., 2011). To answer this question definitively will likely require research in which rodents self administer purified swainsonine, similar to strong preference studies with compounds of abuse in which rats are first trained to press a lever for intravenous infusions (e.g., QUICK et al., 2011).

CONCLUSION

In conclusion sheep and goats with extensive experience in consuming ***I. carnea*** showed no preference for fresh plant when it was offered with other foods. These results suggest that grazing animals will not become poisoned if other foods or forages are available.

ETHICS COMMITTEE

The experiment was approved be the ethical committee on animal experimentation on the Universidade Federal de Campina Grande (UFCG), process CEP 69-2013.

ACKNOWLEDMENTS

This research was supported by the National Institute for Science and Technology for the Control of Plant Poisonings, Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), grant 573534/2008-0.

REFERENCES

ADRIEN, M.L. et al. Conditioned food aversion to ***Ipomoea carnea*** var. ***fistulosa*** induced by ***Baccharis coridifolia*** in goats. **Pesquisa Veterinária Brasileira**, v.33, n.8, p.999-1003, 2013a. Available from: <http://www.scielo.br/scielo.php?pid=S0100-736X2013000800009&script=sci_arttext>. Accessed: May 19, 2014. doi: 10.1590/S0100-736X2013000800009.

ADRIEN, M.L. et al. Conditioned food aversion to ***Ipomoea carnea*** var. ***fistulosa*** in sheep. **Ciência Rural**, v.44, n.2, p.362-367, 2014. Available from: <http://www.scielo.br/scielo.php?pid=S0103-84782014000200027&script=sci_arttext>. Accessed: May 19, 2014. doi: 10.1590/S0103-84782013005000156.

ANTONIASSI, N.A.B. et al. Spontaneous ***Ipomoea carnea*** subsp. ***fistulosa*** (***Convolvulaceae***) poisoning of cattle in the Brazilian Pantanal. **Pesquisa Veterinária Brasileira**, v.27, n.10, p.415-418, 2007. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-736X2007001000005>. Accessed: May 19. 2014. doi: 10.1590/ S0100-736X2007001000005.

ARMIÉN, A.G. et al. Spontaneous and experimental glycoprotein storage disease of goats induced by ***Ipomoea carnea*** subsp. ***fistulosa*** (***Convolvulaceae***). **Veterinary Pathology**, v.44, p.170-184, 2007. Available from: <http://vet.sagepub.com/content/44/2/170.short>. Accessed: May 19, 2014. doi: 10.1354/vp.44-2-170.

ARMIÉN, A.G. et al. Clinical and morphologic changes in ewes and fetuses poisoned by ***Ipomoea carnea*** subspecies ***fistulosa***. **Journal of Veterinary Diagnostic Investigation**, v.23, n.221-232, 2011. Available from: <http://vdi.sagepub.com/ content/23/2/221.long>. Accessed: May 19, 2014. doi: 10.1177/104063871102300205.

CORWIN, R.L. et al. Feeding and reward: Perspectives from three rat models of binge eating. **Physiology & behavior**, v.104, p.87-97, 2011. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/21549136>. Accessed: May 19, 2014. doi: 10.1016/j.physbeh.2011.04.041.

DE BALOGH, K.K.I.M. et al. A lysosomal storage disease induced by ***Ipomoea carnea*** in goats in Mozambique. **Journal of Veterinary Diagnostic Investigation**, v.11, p.266-273, 1999. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/10353359>. Accessed: May 19, 2014.

DUARTE, A.L. et al. Poisoning by ***Amorimia*** spp. in ruminants. **Ciência Rural**, v.43, p.1294-1301, 2013. Available from: <http://www.scielo.br/scielo.php?pid=S0103-84782013000700024&script=sci_arttext>. Accessed: May 19, 2014. doi: 10.1590/S0103-84782013005000081.

GARDNER D.R. et al. Analysis of swainsonine: extraction methods, detection and measurement in populations of locoweeds (***Oxytropis*** spp.). **Journal of Agricultural and Food Chemistry**, 49:4573-4580, 2001. Available from: <http://pubs.acs.org/doi/abs/10.1021/jf010596p>. Accessed: May 19, 2014. doi: 10.1021/jf010596p.

LEE, S.T. et al. Detection of monofluoracetate in ***Palicourea*** and ***Amorimia*** species. **Toxicon**, v.60, p.791-796, 2012. Available from: <http://www.ncbi.nlm.nih.gov/pubmed/22699106>. Accessed: May 19, 2014. doi: 10.1016/j.toxicon.2012.05.029.

OLIVEIRA C.A. et al. Poisoning by ***Ipomoea carnea*** subsp. ***fistulosa*** in goats in Marajó Island. **Pesquisa Veterinária Brasileira**, v.29, n.7, p. 583-588, 2009. Available from: <http://www.scielo.br/scielo.php?script=sci_arttext&pid=S0100-736X2009000700014>. Accessed: May 19, 2014. doi: 10.1590/S0100-736X2009000700014.

OLIVEIRA, C.A. et al. Clinical signs, lesions and productive and reproductive changes in goats poisoned by ***Ipomoea carnea*** subsp. ***fistulosa*** (***Convolvulaceae***) that discontinued to ingest the plant. **Pesquisa Veterinária Brasileira**, v.31, n.11, p.953-960, 2011. Available from: <http://www.scielo.br/scielo.php?pid=S0100-736X2011001100003&script=sci_artte>. Accessed: May 19, 2014. doi: 10.1590/S0100-736X2011001100003.

OLIVEIRA, C.A. et al. Poisoning by swainsonine-containing plants in Brazil. **Ciência Rural**, v.43, n.4, p.653-661. 2013. Available from: <http://www.scielo.br/pdf/cr/v43n4/a10013cr2012-0516.pdf >. Accessed: May 19, 2014. doi: 10.1590/S0103-84782013000400014.

OLIVEIRA, C.A. et al. Conditioned food aversion to control poisoning by ***Ipomoea carnea*** subsp. ***fistulosa*** in goats. **Ciencia Rural**, v.44, n.7, p.1240-1245. 2014.

PFISTER, J.A. et al. Behavioral toxicology of livestock ingesting plant toxins. **Journal of Range Management**, v.45, p.30-36, 1992. Available from: <http://digitalcommons.usu.edu/behave/111/>. Accessed: May 19, 2014.

PIMENTEL, L.A. et al. Conditioned food aversion to control outbreaks of poisoning by ***Ipomoea carnea*** subsp. ***fistulosa*** and ***Turbina cordata*** in goats. **Pesquisa Veterinária Brasileira**, v.32, n.8, p.707-714, 2012. Available from: <http://dx.doi.org/10.1590/S0100-736X2012000800005>. Accessed: May 19, 2014.

PIMENTEL, L.A. et al. Conditioned food aversion for the control of poisoning by ***Ipomoea carnea*** subsp. ***fistulosa***. **Pesquisa Veterinária Brasileira**, v.33, n,6, p.719-723, 2013. Available from: <http://dx.doi.org/10.1590/S0100-736X2012000800005>. Accessed: May 19, 2014.

QUICK, S.L. et al. Loss of alternative non-drug reinforcement induces relapse of cocaine-seeking in rats: role of dopamine D_1 receptors. **Neuropsychopharmacology**, v.36, p.1015-1020, 2011. Available from: <http://www.nature.com/npp/journal/v36/n5/full/npp2010239a.html>. Accessed: May 19, 2014. doi: 10.1038/npp.2010.239.

RALPHS, M.H. et al. Feed preferences and habituation of sheep poisoned by locoweed. **Journal of Animal Science**, v.68, p.1354-1362. 1990. Available from: <http://www.journalofanimalscience.org/content/68/5/1354.long>. Accessed: May 19, 2014.

TOKARNIA, C.H. et al. Experimental studies in the toxicity of ***Ipomoea fistulosa*** Mart in ruminants. **Arquivo Instituto Biologia Animal**, v.3, p.59-71, 1960.