

Allergic dermatitis caused by *Culicoides* in Texel sheep in the state of Pará, Brazil¹

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ABSTRACT.- Oliveira C.A., Silva A.O.F., Cerqueira V.D., Amaral A.S., Almeida A.B., Riet-Correa F., Felippe-Bauer M.L. & Riet-Correa G. 2017. **Allergic dermatitis caused by *Culicoides* in Texel sheep in the state of Pará, Brazil.** *Pesquisa Veterinária Brasileira* 37(4):301-306. Programa de Pós-graduação em Saúde Animal na Amazônia, Universidade Federal do Pará, BR-316, Castanhal, PA 68740-000, Brazil. E-mail: griet@ufpa.br

Allergic dermatitis was studied at a farm located in the municipality of Castanhal in the state of Pará, Brazil, from December 2009 to December 2012. Clinical and epidemiological data were obtained during monthly visits to the farm. Skin biopsies were performed for histopathological examinations, and insects were captured with Centers for Disease Control and Prevention (CDC) traps and live-bait entomological vacuum devices. The property housed a herd of both genders, with 45 Santa Inês sheep of different ages and 72 Texel adults. Of the 72 Texel sheep, 56 were affected. Of these, 24 exhibited alopecia, erythema, edema, and crust in the ears, on top of the head, and less often, around the eyes. In addition to the lesions described above, 14 animals exhibited hyperpigmentation of the ears and/or around the eyes and crust in the nose. Another 18 animals exhibited chronic lesions characterized by deformed and thickened ears, alopecia with hyperpigmentation, and in most cases, secondary bacterial infections with abscesses and/or myiasis. Some of these animals had lost part of their ears. Histologically, the lesions were characterized as orthokeratotic hyperkeratosis, acanthosis, vacuolization, and necrosis of epidermal cells. An inflammatory infiltrate was present in the dermis, which was composed mainly of eosinophils and macrophages, some lymphocytes and mast cells, and few neutrophils, in addition to edema and collagen deposition. The Santa Inês sheep were not affected. Among the captured insects, 294 specimens of *Culicoides* (*Hoffmania*) *plaumanni* Spinelli, 57 specimens of *C. (Hoffmania)* *insignis* Lutz, and 27 specimens of other *Culicoides* species were identified. We conclude that *C. plaumanni*, *C. insignis*, and possibly other *Culicoides* species are involved in the etiology of allergic dermatitis in Texel sheep in the state of Pará. Santa Inês sheep in the same region and under the same conditions were not affected, which suggests lower susceptibility of these animals.

INDEX TERMS: Allergic dermatitis, *Culicoides*, Texel sheep, hypersensitivity, seasonal dermatitis, Brazilian Amazon.

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RESUMO.- [Dermatite alérgica causada por *Culicoides* em ovinos Texel no estado do Pará.] A doença foi estudada em uma propriedade localizada no município de Castanhal, Pará, no período de dezembro de 2009 a dezembro de 2012. A propriedade possuía um plantel de 117 ovinos, 45 da raça Santa Inês e 72 Texel. Dos 72 ovinos da raça Texel, 56 estavam afetados. Os principais sinais clínicos observados foram alopecia, eritema, edema, hiperpigmentação e crostas nas orelhas, parte superior da cabeça e ao redor dos olhos. Em alguns animais as orelhas estavam deforma-

das, espessadas e com abscessos e/ou miíase. Histologicamente, as lesões caracterizavam-se por hiperqueratose ortoqueratótica, acantose, vacuolização e necrose das células da epiderme. Na derme havia infiltrado inflamatório composto principalmente por eosinófilos e macrófagos, edema e deposição de colágeno. Entre os insetos capturados foram identificados 294 exemplares de *Culicoides (Hoffmania) plaumanni* Spinelli, 57 de *Culicoides (Hoffmania) insignis* Lutz e 27 exemplares pertencentes a outras espécies de *Culicoides*. Conclui-se que *C. plaumanni*, *C. insignis* e, possivelmente, outras espécies de *Culicoides* estejam envolvidos na etiologia da dermatite alérgica nos ovinos da raça Texel no estado do Pará. Ovinos da raça Santa Inês que se encontravam na mesma área e nas mesmas condições não foram afetados, sugerindo menor susceptibilidade.

TERMOS DE INDEXAÇÃO: Dermatite alérgica, *Culicoides*, ovinos Texel, hipersensibilidade, dermatite sazonal, maruim, Amazônia brasileira.

INTRODUCTION

Seasonal allergic dermatitis is a skin disease that is associated with insect bites and affects several animal species, including horses (Henry & Bory 1937, Baker & Quinn 1978, Fadok & Greiner 1990, Schild et al. 2003, Oliveira-Filho et al. 2012), sheep (Connan & Lloyd 1988, Schild et al. 2003, Corrêa et al. 2007, Souza et al. 2005, Barbosa et al. 2011, Portela et al. 2012), cattle (Yeruham et al. 1993), mules, goats (Yeruham et al. 1997, Macêdo et al. 2008), felines (Mason & Evans 1991), and man (Penneys et al. 1989, Brummer-Korvenkontio et al. 1994).

In Brazil, the disease was reported for the first time in the state of Rio Grande do Sul (Corrêa et al. 2007) in sheep from different breeds, including Ideal, Corriedale, Texel, Hampshire Down, and Crioula. The morbidity ranges from 10 to 80%. The first cases occur from October to December, with morbidity reaching 60 to 80% from January to March, and markedly decreasing from March to the end of April, during which some chronic cases are observed (Souza et al. 2005, Corrêa et al. 2007).

In the semiarid region of the state of Paraíba, two cases of the disease were diagnosed in sheep (Macêdo et al. 2008). In the state of Rio Grande do Norte, Portela et al. (2012) described the disease in a herd with 40 Santa Inês sheep that were raised extensively on natural pasture. The morbidity rate reached 32.5%. Lesions were observed during the rainy season and completely or partially receded during the drought, reappearing in the next rainy season. The disease was associated with bites from *Culicoides insignis* Lutz.

In the North region, the disease was diagnosed at 15 farms in the state of Pará and at one farm in the state of Roraima, affecting Santa Inês and mixed-breed sheep from both genders. The most affected animals were aged from 2 to 4 years, and it was suggested that the allergic dermatitis was associated with insects from the genera *Simulium* and *Hippelates* (Barbosa et al. 2011).

The present study aimed to describe allergic dermatitis in Texel sheep in the municipality of Castanhal, in the

state of Pará, at a farm with Santa Inês sheep that were not affected. The epidemiological aspects of the disease and the clinical-pathological condition of the animals were studied, and the biting midges species possibly associated with the disease etiology were identified.

MATERIALS AND METHODS

The disease was studied at a farm located in the municipality of Castanhal, state of Pará, monthly from December 2009 to December 2012. The Castanhal region is composed of secondary forest with a humid equatorial megathermal climate, which corresponds to the Ami type in the classification by Köppen, with high temperatures and relative humidity between 85 and 90%. The average annual rainfall ranges from 2,500 mm to 3,000 mm and is concentrated mainly in the rainy period, which occurs from November to May (Santos et al. 2006).

Clinical and epidemiological data were obtained during monthly visits to the farm. A skin biopsy was performed in the dorsal region of the ear of four sheep for histopathological examination. The samples obtained were fixed in 10% formalin, embedded in paraffin, cut at a thickness of 5 µm, hematoxylin-eosin stained, and evaluated with an optical microscope.

The insects were captured twice, in December 2009 and December 2012. The first capture was performed with three CDC light traps placed at a 120 to 150 cm distance from the ground, which functioned continuously from 5:00 pm to 6:00 am of the next day for three consecutive days. The second capture was performed with an entomological vacuum device using three mixed-breed Texel sheep as live bait from 5:00 am to 7:00 am and from 5:00 pm to 7:00 pm for three consecutive days. At the time of the first capture, there were 72 Texel sheep on the farm, of which 56 were affected. At the time of the second capture, Santa Inês and mixed-breed Texel sheep were housed on the farm, and two predominantly white mixed-breed animals had lesions that were suggestive of allergic dermatitis. After capture, the insects were placed in containers containing 70% ethanol and sent to the Ceratopogonidae Collection (CCER) of the Laboratory of Diptera of the Oswaldo Cruz Foundation for mounting, identification and deposit. Part of the specimens were preserved in Kahle-Dietrich solution and part was slide-mounted in phenol-balsam in the manner described by Wirth & Marston (1968). The identification was based on the key and descriptions of species found in Spinelli et al. (1993).

RESULTS

The farm housed a herd with 117 sheep of both genders, with 45 Santa Inês sheep from diverse categories (sheep, lambs, ewes, and rams) and 72 Texel adults. The animals were extensively managed with *Panicum maximum* cv. Massai grazing during the day. At night, they were kept in two collective pens of approximately 100 m² each, with 6 m between them. The Texel sheep remained in one of the pens, whereas the Santa Inês sheep remained in the other. The pens had a cement floor, and accumulation of fecal matter and urine occurred. Of the 72 Texel sheep, 56 had lesions suggestive of allergic dermatitis. Of these, 24 had alopecia, edema, and crust in the ears, on top of the head (Fig. 1A), and less often, around the eyes. In addition to the lesions described above, 14 animals exhibited hyperpigmentation of the ears and/or around the eyes and crust on the nose. Another 18 animals had chronic lesions (Fig.1B) characterized by deformed thicker ears, with alopecia, hyperpig-

mentation, and in most cases, secondary bacterial infection with formation of abscesses at the base of the ears and myiasis. Some of these animals had lost part of their ears.

According to the keepers, the Texel animals were restless in the pens due to attacks of "biting midges". The Santa Inês sheep were not affected. The two herds were observed periodically during a three-year period, and most of the Texel sheep affected exhibited lesions that partially receded during the drought and worsened during the rainy season. As a result of the disease severity, in October 2012, the pure Texel sheep were transferred to another farm, and only the Santa Inês sheep and some crossbred Texel sheep remained at the farm. In December 2012, two predominantly white crossbred animals exhibited allergic dermatitis lesions.

Histologically, the lesions were characterized by orthokeratotic hyperkeratosis, acanthosis, vacuolization, and necrosis of epidermal cells. An inflammatory infiltrate was present in the dermis, which was composed mainly of eosinophils and macrophages, some lymphocytes and mast cells, and few neutrophils, in addition to edema and collagen deposition (Fig.2).

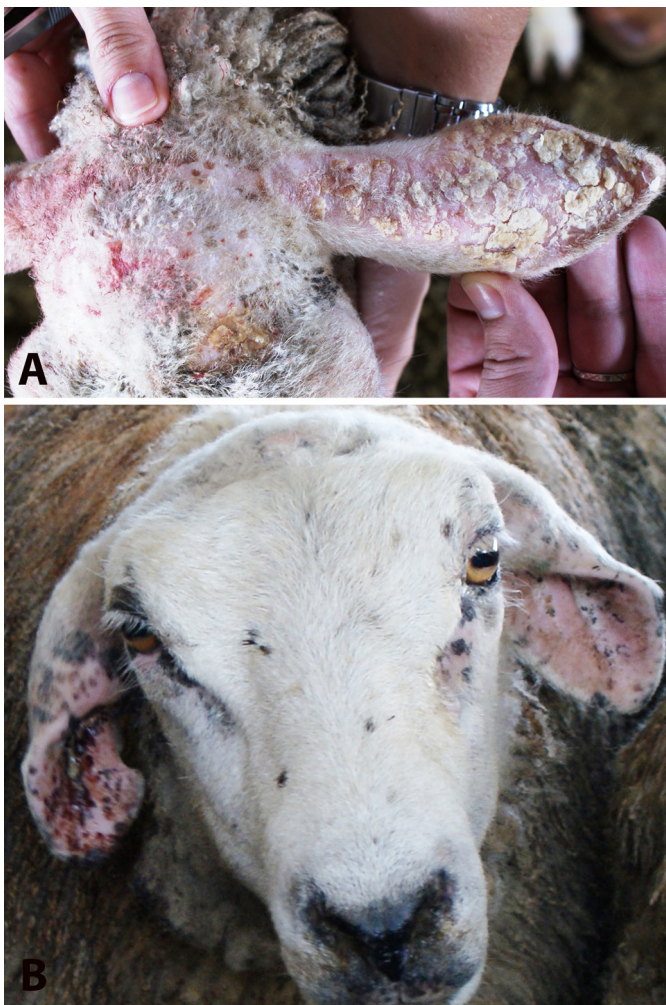


Fig.1. Texel sheep. Allergic dermatitis. (A) Redness, alopecia, edema, and crust are observed in the skin of the head and (B) ears. Alopecia, hyperpigmentation, thickness and crusts are observed in the ears.

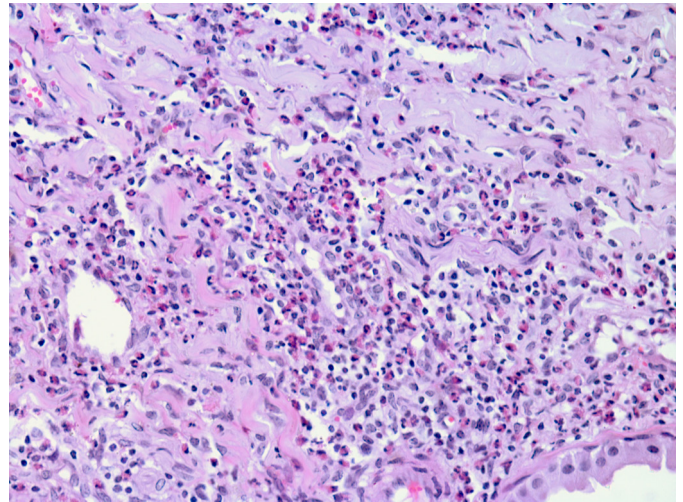


Fig.2. Texel sheep. Skin of the ear. Allergic dermatitis. Severe infiltrate by eosinophils, macrophages, some lymphocytes and collagen deposition are observed in the dermis. HE, obj.20x.

In total, 378 female specimens of biting midges were captured both in the CDC light traps and in the live-bait traps. Of the trapped material, 179 specimens of *C. (Hoffmania) plaumanni* Spinelli, 47 specimens of *C. (Hoffmania) insignis* Lutz and 14 specimens of *Culicoides (Hoffmania)* spp. were identified. Of the insects captured on the sheep, 115 *C. (Hoffmania) plaumanni*, 10 *C. (Hoffmania) insignis*, eight *Culicoides (Hoffmania)* spp., one *C. (Hoffmania) foxi* Ortiz, one *C. (Hoffmania) maruim* Lutz, one *C. (Hoffmania) ocumarensis* Ortiz, one *C. carsiomelas* Wirth & Blanton and one *Culicoides* sp. were identified. *Culicoides insignis* and *C. plaumanni* are the most abundant species and belong to the *Culicoides guttatus* group of the subgenus *Hoffmania*. They can be distinguished from the other species of the group by the following combination of morphological characters (Fig.3): wing with contrasting pattern of dark and pale spots; r-m crossvein dark; cell r_3 with one distal pale spot; third palpal segment with irregular palpal pit; cell m_1 with one distal pale spot (in *C. insignis*) or two distal pale spots (in *C. plaumanni*); vein R_3 pale (in *C. plaumanni*) or dark up to the point where it turns abruptly forward to meet costa (in *C. insignis*); mandible with 13-15 teeth (in *C. plaumanni*) or 21-23 teeth (in *C. insignis*); palpal head ratio 0.83-0.93 (in *C. plaumanni*) or 0.98-1.08 (in *C. insignis*); antennal ratio 1.09-1.20 (in *C. plaumanni*) or 1.19-1.38 (in *C. insignis*).

DISCUSSION

The diagnosis of seasonal allergic dermatitis was based on the epidemiology, clinical signs, pathological changes, and identification of Ceratopogonidae insects from the genus *Culicoides*. Reports of seasonal allergic dermatitis outbreaks in sheep caused by *Culicoides* spp. have been documented by several authors (Schild et al. 1993, Yeruham & Braverman 2000, Corrêa et al. 2007, Portela et al. 2012). In Israel, *C. obsoletus* is responsible for all cases of this disease in sheep (Yeruham & Braverman 2000). *C. insignis* was indicated as the cause of this disease in Hampshire Down sheep in Rio Grande do Sul (Corrêa et al. 2007). In the pre-

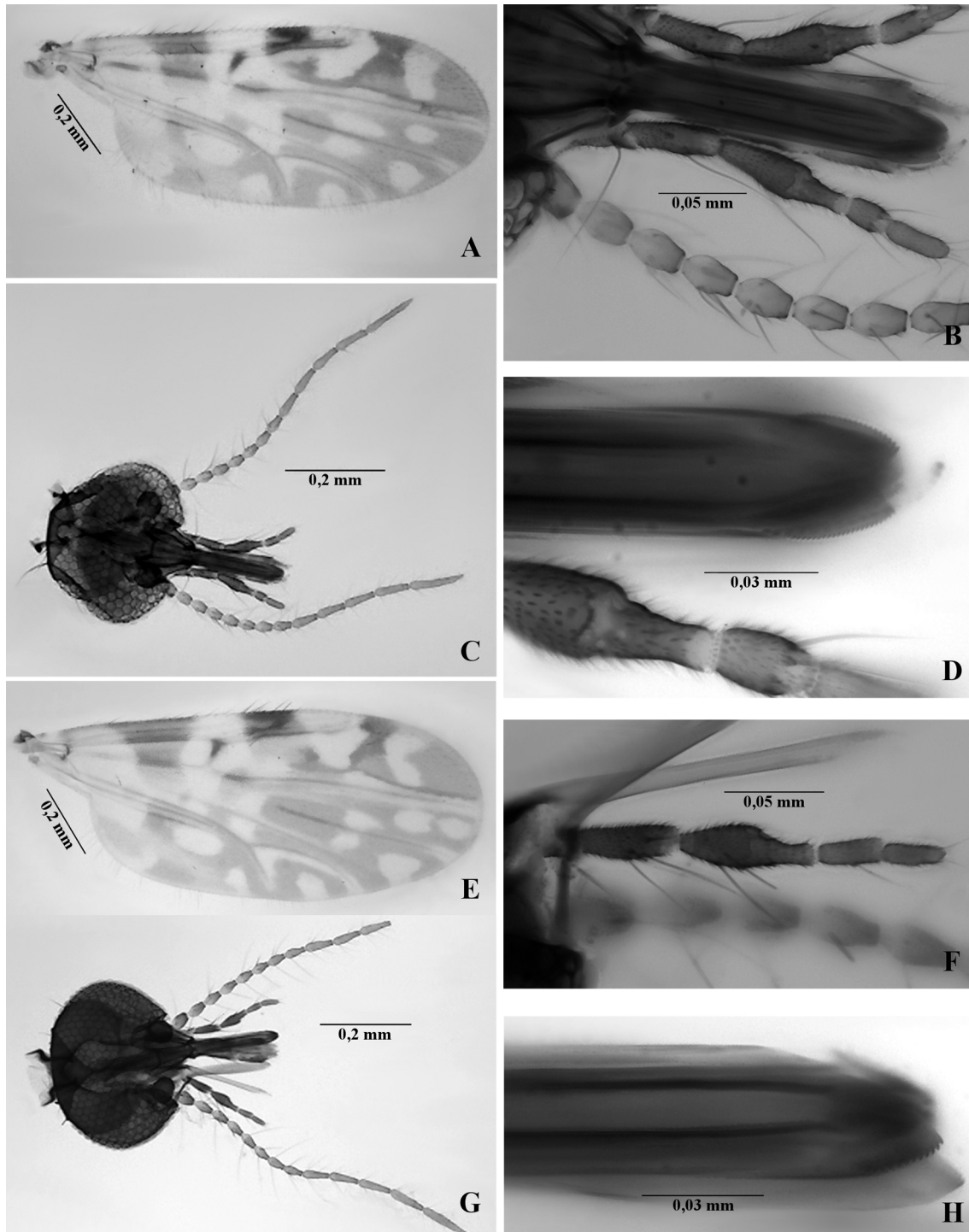


Fig.3. (A-D) *Culicoides insignis*, female. (E-H) *C. plaumanni*, female. (A,E) Wing photograph. (B,F) Palpus. (C,G) Head, ventral view. (D,H) Mandible.

sent study, many specimens of *C. plaumanni* were captured using both the CDC traps and live bait, and they are most likely the main agents responsible for the emergence of the disease. The occurrence of this insect has been reported in Brazil (in the state of Amazonas), Argentina, Peru (Felippe-Bauer et al. 2008), Bolivia, and Colombia (Spinelli et al. 2009). However, there are no case reports of allergic dermatitis in domestic animals associated with this species, although a few insects have previously been collected close

to sheep and poultry in Peru (Felippe-Bauer – unpublished data). *C. insignis* and *Culicoides (Hoffmania) spp.*, which were captured in low number, may be also associated with the etiology of the disease. In allergic dermatitis outbreaks diagnosed in Santa Inês sheep in the same region of the state of Pará, the disease was attributed to insects from the genera *Simulium* and *Hippelates*, and no insects from the genus *Culicoides* were found (Barbosa et al. 2011).

The skin lesions observed, characterized by alopecia,

erythema, hyperpigmentation, crust, thickening and deformity of the ears, and the presence of secondary bacterial infection with the formation of abscesses at the base of the ears, are similar to those described in sheep attacked by insects from the genus *Culicoides* (Schild et al. 1993, Yeruham & Braverman 2000, Corrêa et al. 2007). These lesions were also described in horses and have been associated with Ceratopogonidae insects from this genus (Connan & Lloyd 1988, Schild et al. 1993, Yeruham & Braverman 2000, Ferreira 2001, Yeruham et al. 2004, Oliveira-Filho et al. 2012).

In the present study, the lesions were located in the ears, around the eyes, on the top of the head, and in the nose, which is similar to the observations in other outbreaks (Connan & Lloyd 1988, Yeruham & Braverman 2000, Yeruham et al. 2004, Corrêa et al. 2007, Souza et al. 2005, Portela et al. 2012). Lesions in the lower abdomen (Corrêa et al. 2007, Souza et al. 2005), dorsal region of the body, rump (Portela et al. 2012), udder, and distal portion of the limbs (Souza et al. 2005) have also been described but were not observed in the present study. The location of these lesions matches the regions chosen by insects during blood feeding. According to Corrêa et al. (2007), *Anopheles albittarsis* attacks the distal portion of animals' limbs, whereas *C. insignis* prefers the face, ears, and ventral portion of the abdomen. Souza et al. (2005) described allergic dermatitis lesions in the distal portion of limbs of affected sheep, but the insect that causes the disease was not identified.

The histological lesions observed in the present study are also similar to those described in sheep with this disease in the states of Rio Grande do Sul (Corrêa et al. 2007, Souza et al. 2005), Rio Grande do Norte (Portela et al. 2012), Pará, and Roraima (Barbosa et al. 2011) and are characterized by an immediate hypersensitivity reaction associated with the introduction of antigens through the bite of Ceratopogonidae insects from the genus *Culicoides*. A similar finding was observed in sheep and horses bit by insects (Connan & Lloyd 1988, Yeruham et al. 2004, Oliveira-Filho et al. 2012). Lesions that characterize type IV hypersensitivity, such as orthokeratotic hypersensitivity, acanthosis, vacuolization, and necrosis of epidermal cells, observed in some animals, are similar to those described by Corrêa et al. (2007).

A clinical sign reported by the keepers was restlessness of animals during attacks of biting midges when they were in the pens. Restlessness was also described in sheep that were used as live bait to capture *A. albittarsis* and *C. insignis* during blood feeding (Corrêa et al. 2007) and was also observed in the present study when the insects were captured on sheep.

The absence of lesions in the Santa Inês sheep in the present study may have occurred because these animals were not effectively attacked by the biting midges or these animals may have greater resistance than Texel animals, which could be related to a greater amount of Immunoglobulin E (IgE) on their skin, as described by Tizard (1998). Apparently, some breeds can be more sensitive than others, such as Merino (Yeruham & Braverman 2000). Another possible explanation is that there were no sensitive animals in this Santa Inês herd. In several properties in the same region, in which Santa Inês animals are raised, we observed that

only a few animals, particularly adult sheep, have allergic dermatitis lesions, with a morbidity rate ranging from 5 to 10%, which demonstrates different sensitivity among individuals of the same breed (Gabriela Riet-Correa, unpublished data). In the present study, the affected animals were adults of both genders because the owner was starting a herd and had purchased only adult Texel animals. It is unknown whether the morbidity rate of allergic dermatitis is associated with age.

The disease has a seasonal tendency, with a marked increase in the number of cases in periods with high rainfall and a decrease in periods with low rainfall. A study performed by Corrêa et al. (2007) showed that the period in which the disease occurred was ideal to maintain the breeding sites of the captured insects due to favorable environmental conditions for the reproduction of arthropods. In the present study, the number of cases was higher during December, which is a period of high rainfall, as the rain period in the studied region starts in November and continues until April, which favors the emergence of the disease. However, a three-year follow up of the animals found that even during dry periods, many animals remained sick, but the lesions became more discrete, worsening again in the next rainfall period. A possible explanation is that even in the dry period, rainfall still occurs in the region but with lower intensity and frequency than in the rainfall period.

CONCLUSIONS

Culicoides plaumanni, *Culicoides insignis*, and possibly other *Culicoides* species cause seasonal allergic dermatitis in sheep in the state of Pará.

Texel sheep are more affected than Santa Inês sheep, what suggests higher susceptibility.

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REFERENCES

- Baker K.P. & Quinn P.J. 1978. A report on clinical aspects and histopathology of sweet itch. *Equine Vet. J.* 10(4):243-248.
- Barbosa J.D., Albernaz T.T., Oliveira C.M.C., Duarte M.D., Oliveira C.H.S., Brito M.F. & Silva A.G.M. 2011. Dermatite alérgica à picada de insetos em ovinos no estado do Pará. *Pesq. Vet. Bras.* 31(2):117-120.
- Brummer-Korvenkontio H., Lappalainen P., Reunala T. & Palosuo T. 1994. Clinical aspects of allergic disease. Detection of mosquito saliva-specific IgE and IgG4 antibodies by immunoblotting. *J. Allergy Clin. Immunol.* 93(3):551-555.
- Connan R.M. & Lloyd S. 1988. Seasonal allergic dermatitis in sheep. *Vet. Rec.* 124:335-337.
- Corrêa T.G., Ferreira J.M., Riet-Correa G., Ruas J.L., Schild A.L., Riet-Correa F., Guimarães A. & Felipe-Bauer M.L. 2007. Seasonal allergic dermatitis in sheep in southern Brazil caused by *Culicoides insignis* (Diptera: Ceratopogonidae). *Vet. Parasitol.* 145:181-185.
- Fadok V.A. & Greiner E.C. 1990. Equine insect hypersensitivity: skin test and biopsy results correlated with clinical data. *Equine Vet. J.* 22(4):236-240.

- Felippe-Bauer M.L., Cáceres A., da Silva C.S., Valderrama-Bazan W., Gonzales-Perez A. & Costa J.M. 2008. New records of *Culicoides* Latreille (Diptera: Ceratopogonidae) from Peruvian Amazonian region. *Biota Neotrop.* 8:33-38.
- Ferreira J.L.M. 2001. Dermatite alérgica sazonal, p.505-507. In: Riet-Correa F, Schild A.L., Méndez M.C. & Lemos R.A.A. (Eds), *Doenças dos Ruminantes e Equinos*. Vo.2. 3ª ed. Varela Livraria e Editora, São Paulo.
- Henry A. & Bory L. 1937. Dermatose estivale recidivante du cheval: pathologie et therapeutique. *Rec. Méd. Vét.* 113:65-78.
- Macêdo J.T.S.A., Riet-Correa F., Dantas A.F.M. & Simões S.V.D. 2008. Doenças da pele em ovinos e caprinos no semi-árido brasileiro. *Pesq. Vet. Bras.* 28(12):633-642.
- Mason K.V. & Evans A.G. 1991. Mosquito bite-caused eosinophilic dermatitis in cats. *J. Am. Vet. Med. Assoc.* 12:2086-2088.
- Oliveira-Filho J.P., Fabris V.E., Gonçalves R.C., Amorim R.M., Chiacchio S.B. & Borges A.S. 2012. Clinical and histopathological aspects of the insect bite hypersensitivity in horses. *Semina, Ciênc. Agrárias* 33(3):1113-1122.
- Penneys N.S., Nayar J.K., Bernstein H., Knight J. W. & Leonardi C. 1989. Mosquito salivary gland antigens identified by circulating human antibodies. *Arch. Dermatol.* 125(2):219-222
- Portela R.A., Carvalho K.S., Ahid S.M.M., Felippe-Bauer M.L. & Riet-Correa F. 2012. Dermatite alérgica sazonal em ovinos deslanados no Nordeste do Brasil. *Pesq. Vet. Bras.* 32(6):471-476.
- Santos J.S., Silva L.M. & Costa G.B. 2006. Um estudo da precipitação pluviométrica no município de Castanhal/PA. Pós-Graduação do Curso de Ciências Ambientais da UFPA-MPEG-Embrapa. Disponível em <<http://www.cbmet.com/cbm-files/14-f5a6921597660e6fdcd87e5ca469f457.pdf>> Acesso em 8 nov. 2010.
- Schild A.L., Ferreira J.L. & Soares M.P. 2003. Boletim 23 do Laboratório Regional de Diagnóstico. Editora e Gráfica Universitária UFPEL, Pelotas. 40p.
- Schild A.L., Riet-Correa F., Ferreira J.L. & Méndez M.C. 1993. Boletim 13 do Laboratório Regional de Diagnóstico. Editora e Gráfica Universitária UFPEL, Pelotas. 45p.
- Souza T.M., Figuera R.A., Piazer J.V., Irigoyen L.F. & Barros C.S.L. 2005. Dermatite alérgica sazonal em ovinos. *Ciência Rural* 35(2):475-477.
- Spinelli G.R., Santamaría E., Cabrera O.L., Ronderos M.M. & Suárez M.F. 2009. Five new species of *Culicoides* Latreille described from Colombia, yielding a new species list and country records (Diptera: Ceratopogonidae). *Mem. Inst. Oswaldo Cruz* 104(1):81-92.
- Spinelli G.R., Greiner E.C. & Wirth W.W. 1993. The neotropical bloodsucking midges of the *Culicoides guttatus* group of the subgenus *Hoffmania* (Diptera: Ceratopogonidae). *Contrib. Am. Entomol. Inst.* 27(3):1-91.
- Tizard I.R. 19998. *Imunologia Veterinária*. 5ª ed. Roca, São Paulo. 545p.
- Wirth W.W. & Marston N. 1968. A method for mounting small insects on microscope slides in Canada balsam. *Ann. Entomol. Soc. Am.* 61:783-784.
- Yeruham I. & Braverman Y. 2000. Perl S. Study of apparent hypersensitivity to *Culicoides* species in sheep in Israel. *Vet. Rec.* 147:360-363.
- Yeruham I., Braverman Y. & Orgad U. 1993. Field observations in Israel on hypersensitivity in cattle, sheep and donkeys caused by *Culicoides*. *Aust. Vet. J.* 70(9):348-352.
- Yeruham I., Perl S. & Braverman Y. 2004. Seasonal allergic dermatitis in sheep associated with *Ctenocephalides* and *Culicoides* bites. *Vet. Dermatol.* 15:377-380.
- Yeruham I., Rosen S. & Perl S. 1997. An apparent flea-allergy dermatitis in kids and lambs. *J. Vet. Med.* 44:391-397.