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# Reproductive characterization of hair ewe in the American tropics: a review part 1

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**ABSTRACT**

**Objective**: To carry out a reproductive characterization of the breeds of hair ewe in the tropical region of the Americas.

**Design/Methodology/Approach**: A search of scientific information about the reproductive variables of breeds of hair ewe was carried out and the results were analyzed in the Web of Science, Redalyc, Dialnet, PubMed, SciELO, and Latindex databases.

**Results**: We described and discussed the highly-variable onset of puberty in ewe lambs. Similar results were found in adult ewes regarding the duration and occurrence of the estrus, estrus cycle length, seasonal anestrus, ovulation rate, fertility, gestation, and prolificacy.

**Study Limitations/Implications**: Information about the reproductive variables of breeds of hair ewe is poorly known or non-existent.

**Findings/Conclusions**: The onset of puberty in 15-43 kg ewe lambs ranges from 175 to 335 d of age. The estrus cycle of hair ewe in Mexico lasts 17 d in autumn-winter and 21 d in spring-summer. In Brazil, this cycle lasts 17 d in spring-summer and 18 d in autumn-winter. In the United States of America and Venezuela, the estrus cycle length was similar in both periods of the year. The occurrence of the estrus reached 97.1% in autumn-winter and 76.5% in spring-summer. The duration of the estrus ranges from 16 to 52 hours. Seasonal anestrus occurs from May to July. The ovulation rate ranges from 1 to 3 oocytes. The percentage of fertility fluctuates between 80 and 100% in temperate months and reaches 37% in warm ones. Gestation lasts from 144 to 152 d. Prolificacy ranges from 1.0 to 2.2 offspring per ewe. The lambing interval ranges from 244 to 294 d.

**Keywords**: Puberty, estrous, estrous cycle, ovulation rate.

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## INTRODUCTION

The success of a sheep production unit depends mainly on nutritional, reproductive, and health management, as well as on welfare, biosecurity, and other factors (Rojas-Rodríguez *et al.*, 2001). Reproduction is a fundamentally important factor, since it determines the ability to increase the size of the herd in each period. Therefore, an efficient reproductive management will allow the production unit to be profitable (Plakkot *et al.*, 2020). Because of their reproductive and adaptation characteristics, hair sheep are very important in the tropical regions of the Americas, the Caribbean, and certain warm and humid environments in the United States; some hair breeds and breeds crossbred with wool sheep have shown their potential for lamb production under marginal conditions (Wildeus,

1997). With the increase in sheep production, other hair breeds have become present in recent years, including Katahdin, Dorper, Santa Inés, and Saint Croix. Although they have a greater productive capacity, especially regarding weight gain, their reproductive characteristics are still largely unknown. Therefore, the objective of this work was to review the scientific data bases, in order to carry out a reproductive characterization of the main breeds of hair sheep in the American tropic.

**Puberty in ewe lambs**

Puberty is defined as the beginning of reproductive activity and is evidenced by the first ovulation and the presence of >0.5 ng $mL^{-1}$ plasma progesterone (López-Sebastián *et al.*, 1985). In ewe lambs with a body weight ranging from 15 to 43 kg, the first estrous has been observed between 8 and 13 months of age (Camacho-Ronquillo *et al.*, 2008). Likewise, it has been established that ewe lambs begin puberty when they reach 60 to 75% of the live weight of the adult ewe (Simplicio and Santos, 2005). This reproductive process is strongly influenced on the one hand, by age and live weight (Table 1), and, on the other hand, by birth season and type of lambing (Table 2), as well as food availability and health (Valasi *et al.*, 2012).

Table 1 shows that Saint Croix, Pelibuey, and Blackbelly ewes began puberty at an earlier age (218 d average) and with a live weight of 29.4 kg. However, West African, Katahdin, Dorper, Morada Nova, Santa Inés, and Brazilian Somali ewes start their reproductive process later (292 d average) and with a live weight of 28 kg.

On the other hand, the ewe lambs born in September-October began puberty earlier than those born in July-August. For their part, the ewe lambs born in January-March and April-June took longer to begin their reproductive activity (Table 2).

Table 2 shows that the type of lambing (single or multiple) has a significant effect on the onset of puberty. In Mexico, multiple-birth ewe lambs began puberty 24 d earlier than ewe lambs that had single birth; meanwhile in Brazil, single-birth ewe lambs began puberty 16.8 d earlier than their multiple-birth counterparts. It is important to note that, in both

**Table 1**. Age (a) and live weight (LW) in ewe lambs of different hair breeds at the onset of puberty.

| Breed | Place | Age (d) | PV (kg) | Reference |
|---|---|---|---|---|
| DR | Yucatán, México | 291.2±7.2 | 43.1±0.93 | Zavala *et al.* (2008) |
| KN | Yucatán, México | 272.6±1.6 | 36.5±0.2 | Zavala *et al.* (2008) |
| BY | Yucatán, México | 250.1±1.8 | 24.7±0.4 | Zavala *et al.* (2008) |
| PY | Yucatán, México | 231.8±1.5 | 27.5±0.2 | Zavala *et al.* (2008) |
| SC | Virginia, USA | 175±17.7 | 36.0±0.7 | Wildeus, (1997) |
| SI | Piauí, Brasil | 294.6±13.8 | 28.0±0.7 | Girão y Medeiros, (1988) |
| SB | Caerá, Brasil | 335.4±12.8 | 21.8±0.6 | Silva *et al.* (1987) |
| MN | Caerá, Brasil | 292.1±11.7 | 23.8±0.6 | Silva *et al.* (1987) |
| WA | Zulia, Venenezuela | 268. 1±35.5 | 15.3±1.0 | Rodríguez-Urbina *et al.* (2001) |

DR=Dorper; KN=Katahdin; BY=Blackbelly; PY=Pelibuey; SC=Saint Croix; SI=Santa Inés; SB=Brazilian Somali; MN=Morada Nova; WA=West African.

**Table 2**. Effect of season and type of lambing on the onset of puberty in hair ewe lambs.

| Time of birth | Place | Age (d) | Live weight (kg) | Reference |
|---|---|---|---|---|
| Jul-Aug | Yucatán, México | 262.5±0.6 | 31.0±0.6 | Zavala *et al.* (2008) |
| Sep-Oct | | 233.8±1.2 | 30.6±0.1 | |
| Jan- Mar | Maracay, Venezuela | 420.1±126.3 | 30.1±2.0 | Rondón *et al.* (2002) |
| Apr-Jun | | 439.3±149.4 | 30.4±2.2 | |
| Type of lambing | | | | |
| Single | Yucatán, México | 266.6±1.0 | 34.1±0.1 | Zavala *et al.* (2008) |
| Multiple | | 242.5±0.7 | 28.6±0.1 | |
| Single | Noreste de Brasil | 290.3±9.9 | 26.2±0.5 | Dias *et al.* (1988) |
| Multiple | | 313.1±9.8 | 24.2±0.5 | |
| Single | Piauí, Brasil | 291.8±17.7 | 28.5±1.0 | Girão y Medeiros (1988) |
| Multiple | | 302.5±26.0 | 23.3±1.5 | |

countries, single-birth ewe lambs were 4.2 kg heavier than multiple-birth ewe lambs. The low body weight of the latter could be associated with a lower intake of liquid feed during rearing. Finally, the differences in the onset of puberty between breeds are associated with their genetic structure, since the genetic factor influences the ability to adapt to the environment (Zavala *et al.*, 2008).

**Estrus in ewes**

Estrus is the period in which the ewe is receptive to the ram. When the ewe manifests the estrus behavior, it presents changes in its behavior and emphasize the constant urination, inappetence, nervousness, and changes in the coloration of the vulva (pink to red) (Rojas-Rodríguez *et al.*, 2001). Generally, the estrus lasts 25 to 28 hours; however, some ewes have a 30 to 48 h estrus (Table 3, Macías-Cruz *et al.*, 2015). It is important to mention that, when the estrus takes place, ewes do not mount each other, as it happens with cows and does; the only way to know which female is in estrus is with the help of a marker ram (Muñoz-García *et al.*, 2021).

**Estrus cycle**

The estrus cycle is the period that elapses from one estrus to another or the successive repetition of behavioral events that begins and ends with estrus behavior in adult ewes. Table 3 shows the estrus cycle length (Rojas-Rodríguez *et al.*, 2001).

The estrous cycle length ranges from 14 to 24 days (17 d average), depending on the time of year in which it takes place. However, in the case of Pelibuey ewes in Veracruz, Mexico, their estrus cycle was longer during the spring. In general, the occurrence of the estrous in the reproductive season is higher (95.4%, autumn-winter) than in the seasonal anestrus period (29%, spring-summer). The duration of the estrus ranges from 16 to 52 h, depending on the production system (intensive or extensive), as can be seen in Table 3. Both the estrus cycle length and the occurrence of the estrus will be strongly influenced by

**Table 3**. Influence of the season of the year on the cycle length, occurrence, and duration of the estrus in hair ewes.

| Breed | Place | Estrus cycle (d) and % incidence of oestrus | | | | Duration of oestrus (h) | Reference |
|---|---|---|---|---|---|---|---|
| | | P | V | O | I | | |
| PY | Baja California, México | 24.2<br>95.2 | 17.8<br>95.2 | 17.3<br>100 | 20.1<br>100 | 24 to 36 | Macías-Cruz *et al.* (2015) |
| PY | Veracruz, México | 22.3<br>84.6 | 22.3<br>82.3 | 17.8<br>92.0 | 17.8<br>96.0 | 16 to 52 en pastoreo | Cruz-Lazo *et al.* (1994) |
| PY | Habana, Cuba | 19<br>- | 17<br>- | 17<br>- | 19<br>- | -<br>- | Herrera *et al.* (2010) |
| KN | Baja California, México | -<br>- | -<br>- | -<br>95.8 | -<br>95.8 | -<br>- | Macías-Cruz *et al.* (2017) |
| KN | Durango, México | -<br>72.2 | -<br>29.7 | -<br>- | -<br>- | -<br>- | González-Godínez *et al.* (2014) |
| DR | Yucatán, México | 17.4±0.3<br>82.1 | 17.3±0.3<br>82.1 | 17.4±0.3<br>97.4 | 17.4±0.3<br>97.4 | 17.3±1.8 to 36.6±1.7 | Aké-López *et al.* (2017), Aké-López *et al.* (2019) |
| SI | Ceará, Brasil | 14 a 19*<br>- | 14 a 19*<br>- | 18.4±0.4 **<br>90.2 | 18.4±0.4 **<br>90.2 | 29.1±1.0 | Simplício *et al.* (1981) |
| MN | Caerá, Brasil | 18.5±0.3 | 18.5±0.3 | 18.0±0.3 | 18.0±0.3 | 24 to 36 | Sousa *et al.* (2015) |
| SB | Caerá, Brasil | 18.5±0.3 | 18.5±0.3 | 18.0±0.3 | 18.0±0.3 | 30.2±0.80 | Simplício *et al.* (1981) |
| WA | Maracaibo, Venezuela | -<br>17 | 16.8±0.9<br>84 | 16.8±0.9<br>87 | 17.2±0.7<br>89 | 26.7±2.4 | González-Stagnaro (1993) |
| SC | Idaho, USA. | 19<br>51 | -<br>- | 19<br>74 | -<br>25 | - | Pope *et al.* (1989) |

PY=Pelibuey; KN=Katahdin; DR=Dorper; SI=Santa Inés; MN=Morada Nova; BS (SB)=Brazilian Somali; WA=West African; SC=Saint Croix; *Rainy season (January to June) in Brazil; **Dry season (July to December) in Brazil; SP (P)=spring, SU (V)=summer, AU (O)=autumn, WI (I)=winter.

the rainy season and forage availability, since this food source will be used to feed the ewes and improve their body condition.

**Seasonal anestrus**

It is defined as the period of ovarian inactivity and it is characterized by the absence of sexual activity (Rosa and Bryant, 2003). The ewes of certain breeds have well-defined seasonal reproductive cycles, as in the case of wool ewes from temperate and cold climates (far from the equator); these ewes have a period of ovarian inactivity in spring-summer, heavily impacted by the photoperiod (Ortavant *et al.*, 1988). However, some hair breeds developed in equatorial regions have periods of reduced estrous activity during spring and early summer; such is the case of the Pelibuey ewes in Mexico, which have a reproductive inactivity of 36.1±8.1 d (Valencia *et al.*, 2006). However, Arroyo *et al.* (2007) reported a 67.5 d absence of sexual activity (spring-summer). The behaviour of the Saint Croix ewe had a similar pattern: reproductive inactivity in May, June, and July (Wildeus, 1997). Likewise, Balaro *et al.* (2014) reported that 85.7% of the Santa Inés ewes had a short seasonal anestrous in the spring (September to December), while González-Stagnaro (1993) determined that the West African ewe reduced its reproductive activity in the December-March season to 7.5%. At this time, the limited availability of forage has a reduced nutritional quality, which

fails to meet the nutritional requirements, as reported for the Cuban Pelibuey sheep by Herrera *et al.* (2008).

**Ovulation rate**

The ovulation rate is defined as the number of oocytes released per estrus cycle (Nagdy *et al.*, 2018). The evaluation of the ovulation rate is determined by counting the corpora lutea (CL) present on the ovarian surface. CL can be counted in two ways: 1) with an ultrasound machine; and 2) by direct counting via laparoscopy. The choice of method will depend on the equipment available, and the staff trained to carry out the count. The ovulation rate has great variability between and within breed (Table 4). Generally, ewes ovulate between 24 and 27 h after the beginning of the estrus.

Table 4 shows that the Pelibuey ewe from San Luis Potosí, Mexico, had the highest ovulation rate, followed by the Morada Nova and Santa Inés ewes (both from Brazil), while the Dorper from Mexico had the lowest ovulation rate. It is important to highlight that the ovulation rate is strongly influenced by feeding, body condition, and age of the ewe.

**Fertility**

Fertility is defined as the number of ewes that get pregnant after services (natural mating or artificial insemination) multiplied by 100. Fertility can be affected by body condition, age, and health status. Table 5 shows that an acceptable fertility percentage ranges between 85 and 100% (Abecia-Martínez and Forcada-Miranda, 2010) and is strongly influenced by the time of year. Therefore, in the reproductive season (autumn-winter, 90.8%) ewes have a higher fertility than in the seasonal anestrus period (spring-summer, 84.8%).

**Gestation**

The gestation length in ewes is very similar between breeds; the gestation is 150 d average from the last service (natural mating or artificial insemination) to the lambing (Table 5).

**Table 4**. Ovulation rate in different breeds of hair ewe.

| Breed | Place | Ovulation rate | Reference |
|---|---|---|---|
| PY | San Luis Potosí, México. | 3.00±0.18 | Muñoz-García *et al.* (2021) |
| BY | California, USA. | 2.04 | Bradford y Quirke, (1986) |
| SI | Brasilia, Brasil. | 1.2±0.1 - 2.2±0.1 | Silva *et al.* (2010) |
| MN | Sobral, Brasil. | 1.4 - 2.3 | Silva *et al.* (1987) |
| SB | Sobral, Brasil. | 1.0 - 2.0 | Silva *et al.* (1987) |
| DR | Yucatán, México. | 1.2±0.0 - 1.4±0.1 | Aké-López (2019) |
| WA | Aragua, Venezuela. | 1.6±0.2 | Contreras-Solís (2008) |
| SC | Utah, USA. | 1.93-1.97 | (Wildeus, 1997) |

PY=Pelibuey; BY=Blackbelly; SI=Santa Inés; MN=Morada Nova; SB=Brazilian Somali; DR=Dorper; WA=West African; SC=Saint Croix.

**Table 5**. Fertility percentages by time of year and gestation length in hair ewes.

| Breed | Place | Fertily (%) | | | | Length of gestation (d) | Reference |
|---|---|---|---|---|---|---|---|
| | | P | V | O | I | | |
| PY | Baja California, México. | 81 | 81 | 100 | 100 | 150.0 | Macías-Cruz *et al.* (2009)<br>Macías-Cruz *et al.* (2017) |
| PY | Habana, Cuba. | 65 | 92 | 92 | 65 | 150 | Herrera *et al.* (2010) |
| DR | Baja California, México. | 93 | 93 | - | - | 146.7 | Macías-Cruz *et al.* (2009) |
| KN | Baja California, México. | 92 | 92 | - | - | 148.5 | Macías-Cruz *et al.* (2009) |
| BY | Yucatán, México. | 80.6±2.7 | 79.2±2.7 | - | 80.6±2.7 | - | Segura *et al.* (1996) |
| DR | Yucatán, México. | 84.4 | 84.4 | 85.3 | 85.3 | - | Aké-López *et al.* (2019) |
| SI | Sao Carlos, Brasil. | 100.0 | - | 100.0 | 100.0 | 148.3-150.1 | Machado y Simplício (1998) |
| SB | Ceará, Brasil | - | - | 90 | 90 | 144-152 | Sousa *et al.* (2015) |
| MN | Ceará, Brasil | - | - | 92 | 92 | 144-152 | Sousa *et al.* (2015) |
| WA | Maracaibo, Venezuela. | 80.5 | 94.3 | 94.3 | 80.5 | 150.9±2.8 | González-Stagnaro (1993) |
| SC | Arkansas, USA. | 37.7±7.6 | 71.2±7.3 | 88.6±7.4 | 86.7±8.3 | - | Brown y Jackson (1995) |

PY=Pelibuey; DR=Dorper; KN=Katahdin; BY=Blackbelly; DR=Dorper; SI=Santa Inés; SB=Brazilian Somali; MN=Morada Nova; WA=West African; SC=Santa Cruz; SP (P)=spring, SU (V)=summer, AU (O)=autumn, WI (I)=winter.

Table 5 shows that, on the one hand, fertility is variable during the year: it is highest in autumn-winter and lowest in spring-summer. On the other hand, the gestation length was similar in all breeds and ranges from 144 to 152 d.

**Prolificacy**

It is defined as the total number of offspring born divided by the total ewes that were born multiplied by 100 (Abecia-Martínez and Forcada-Miranda, 2010). Table 6 shows the prolificacy in different breeds of hair ewes.

Table 6 shows that both Mexican and Cuban Pelibuey ewes have great variability in prolificacy, with a range from 1.2 to 2.1 offspring per ewe. Similarly, the prolificacy of Santa Inés ewes ranged from 1.1 to 1.8 offspring per ewe. The Pelibuey, Santa Inés, and Blackbelly breeds had the most offspring per ewe, followed by Dorper and Katahdin. West African and Brazilian Somali ewes had the fewest offspring per ewes.

**Lambing interval**

The lambing interval (LI) is defined as the time that elapses between one birth and the next one. In the ewes, the LI can be affected by external and internal factors. The season in which the births occur (dry and rainy) stands out among the former, while the age and weight of the ewe at birth, type of lambing (single- or multiple-birth), and number of births stand out among the latter (nulliparous or multiparous) (Neto Rego *et al.*, 2012). Table 7 shows the average values of the LI of the hair breeds.

On the one hand, the previous table shows that the breeds that had the lowest LI were Dorper from Brazil, followed by Blackbelly from the Caribbean, Mexico, and Trinidad and Tobago. On the other hand, the ewes that had a higher LI were Pelibuey from Cuba,

**Table 6**. Prolificacy in different breeds of hair ewes.

| Breed | Place | Prolificity | Reference |
|---|---|---|---|
| PY | Baja California, México | 2.1 | Macías-Cruz *et al.* (2009) |
| PY | San Luis Potosí, México | 2.1 ± 0.1 | Muñoz-García *et al.* (2021) |
| PY | Yucatán, México | 1.2 | Segura *et al.* (1996) |
| PY | Yucatán, México | 1.46 ± 0.1 a 1.7 ± 0.0 | Cansino-Arroyo *et al.* (2009) |
| PY | Habana, Cuba | 1.2 - 1.7 | Herrera *et al.* (2010) |
| SI | Brasilia, Brasil | 1.11 - 1.87 | Silva *et al.* (2010) |
| SI | Minas Gerais, Brasil | 1.7 ± 0.3 – 2.2 ± 0.2 | Saunders *et al.* (2012) |
| MN | Caerá, Brasil | 1.51 | Sousa *et al.* (2015) |
| SB | Caerá, Brasil | 1.04 | Sousa *et al.* (2015) |
| DR | Yucatán, México | 1.2 ± 0.0 to 1.4 ± 0.1 | Aké-López *et al.* (2019) |
| BY | California, USA | 1.71 | Bradford y Quirke (1986) |
| BY | Trinidad y Tobago | 1.92 | Rastogi (2001) |
| KN | Durango, México. | 1.3 ± 0.3 | González-Godínez *et al.* (2014) |
| SC | Arkansas, USA | 1.4 ± 0.0 to 1.7 ± 0.0 | Brown y Jackson (1995) |
| WA | Maracaibo, Venezuela | 1.1 - 1.2 | González-Stagnaro (1993) |

PY=Pelibuey; SI=Santa Inés; MN=Morada Nova; BS (SB)=Brazilian Somali; DR=Dorper; BY=Blackbelly; KN=Katahdin; SC=Saint Croix; WA=West African.

**Table 7**. Lambing interval in different hair breeds.

| Breed | Place | LI (d) | Reference |
|---|---|---|---|
| PY | Chiapas, México | 268 .0±66.2 | González-Garduño *et al.* (2010) |
| PY | Habana, Cuba | 294 | Herrera *et al.* (2010) |
| SI | Piauí, Brasil | 281.1±64.7 | Neto Rego *et al.* (2012) |
| MN | Distrito Federal, Brasil | 284.8±70.6 | Quesada *et al.* (2002) |
| SB | Piauí, Brasil | 281.3±9.8 | Braga Magalhães *et al.* (2010) |
| DR | Piauí, Brasil | 244 | Rosanova *et al.* (2005) |
| BY | Tabasco, México | 256.2±79.1 | Hinojosa-Cuellar *et al.* (2011) |
| BY | Islas del Caribe | 257 | de Almeida (2018) |
| BY | Trinidad y Tobago | 262.3±3.1 | Knights *et al.* (2012) |
| SC | Utah, USA | 262 | Evans (1987) |
| WA | Lara, Venezuela | 268.8±72.5 | Dickson *et al.* (2004) |

PY=Pelibuey; SI=Santa Inés; MN=Morada Nova; SB=Brazilian Somali; DR=Dorper; BY=Blackbelly; SC=Saint Croix; WA=West African.

and Santa Inés, Somali, and Morada Nova from Brazil. The LI will mainly depend on the feeding that the ewe receives (Herrera *et al.*, 2010).

## CONCLUSIONS

The onset of puberty in 15-43 kg hair ewe lambs ranges from 175 to 335 d. Ewe lambs born in September-October began puberty earlier than those born in April-June.

According to the type of lambing, single-birth ewe lambs in Brazil began puberty earlier than multiple-birth ewes. Meanwhile, single-birth ewe lambs born in Mexico began puberty earlier than multiple-birth ewe lambs. In average, the estrus cycle in Mexico lasts for 17 d and 21 d for the autumn-winter and spring-summer periods, respectively. In the case of Brazil, in spring-summer, the estrus cycle length is 17 d and 18 d in autumn-winter. In the United States of America and Venezuela, the estrus cycle length was similar in both seasons of the year. The occurrence of the estrus in Mexican ewes was, on average, 97.1% in autumn-winter and 76.5% in spring-summer. The estrus lasts from 16 to 52 h. Seasonal anestrus occurs from May to July and is closely related to rainfall and forage availability. The ovulation rate ranges from 1 to 3 oocytes. Fertility is higher in the temperate months (80-100%) than in the warm ones (37%). Gestation lasts from 144 to 152 d. The prolificacy ranges from 1.0 to 2.2 offspring per ewe. The lambing interval ranges from 244 to 294 d.

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