

# Relationship between reproductive performance and meteorological variables in French Alpine goats in the northwestern part of Croatia



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**Abstract** The study aimed to determine the relationship between reproductive performance, kidding distribution, and birth weight of French Alpine goats and meteorological variables in the northwestern part of Croatia throughout six consecutive years (from 2013 until 2018). During the study, French Alpine goats (n=948) on the 6 dairy goat farms, birthed 1025 goat kids after 893 successful matings (55 matings were unsuccessful) during six consecutive years. The average birth weight was 3.46±0.48 kg for females (n=478) and 3.71±0.51 kg for male kids (n=547). French Alpine does with single kids accounted for 85.89% (n=767), with twins 13.44% (n=120) and triplets 0.67% (n=6). The average litter size was 1.15, and the average parity was 2.95. The birth weight of goat kids in primiparous and pluriparous goats was not significantly different. Survival rate (until 1 month of age) was 93.66% (n=960). French Alpine does fertility in northwestern Croatia, through six years was 94.18%. Seasonal kidding of French Alpine was distributed mostly on two seasons: winter (73.57%) and spring (24.52%) in the northwestern part of Croatia during six consecutive years 2013-2018. Observed differences in the kidding distribution per month during the years of observation were statistically significant ( $P = 0.018$ ). The highest number of kidding was recorded in February in all years of observation. It can be concluded that there was not any relationship between monthly air temperature and precipitation amounts with tested reproductive performances in French Alpine dairy goats in the NW part of Croatia during the observed period.

**Keywords** air temperature, birth weight, kidding distribution, rainfall precipitation

## 1. Introduction

The largest number of goats belong to the Croatian indigenous breeds (the Croatian colored and the Croatian white goat) located in the coastal area, raised mostly for meat, in the extensive form of farming (Mioč et al 2007). The extensive breeding has been gradually replaced by the (semi-)intensive breeding of dairy goats (French Alpine, Saanen, and German Improved Fawn goats) located in the continental area. The most numerous breed of dairy goats in Croatia is the French Alpine (HPA 2018). The goat kids are the most often weaned at the age of 1 month.

The most European breeds of sheep and goats are seasonal breeders in the moderate climate region (Sušić et al 2005; Djuricic et al 2010, Đuričić et al 2019a,b). The natural breeding season of the dairy goat breeds in the Northern Hemisphere begins in late August and ends in late December to mid-January with the clear anoestrous period from February to the end of May (Shelton 1978; Chemineau et al 1992). Reproductive performance of goats is influenced by age of goats at puberty and first kidding, interkidding interval, litter size, and birth and weaning weight of kid goats (Song et al 2006).

The northwestern part of Croatia belongs to a continental zone, classified as Cfa (based on the Köppen Climate Classification). This region is characterized as a moderate wet region (mean annual precipitation of 870 mm per year) with maximal insolation of 2000 hours per year (Zaninovic et al 2008).

This study aimed to determine the relationship between the air temperature, monthly precipitation amounts, and reproductive performance in French Alpine dairy goats, seasonal distribution of kidding, and birth weight, raised under semi-intensive management throughout six consecutive years (from 2013 until 2018) in the northwestern part of Croatia.

## 2. Materials and Methods

### 2.1. Animals

During six consecutive years (2013 to 2018) at 6 medium-scale dairy goat farms with 25 to 47 does in northwestern Croatia, data of the reproductive performance were collected. Management and feedings, on all 6 farms, were very similar. On each farm, goats were kept at pasture

and browse outlets, with access to stables during the night. Bucks were kept with does throughout the year (ratio buck to does was approximately 1 to 20). The type of breeding in all flocks of goats was natural. All animals were yearly, serologically tested and were negative on *B. melitensis*. According to standard farming practices, the animals had free access to good quality meadow hay (about 1.5-1.8 kg per doe daily), concentrate for dairy goats, and drinking water *ad libitum*. Concentrate (40% corn, 17% soybean, 16% oats, 16% barley, 8% wheat flour, and 3% mineral and vitamin supplement for dairy goats) was provided, every day at the same time, twice a day during lactation 0.9 kg/day and 0.5 kg/day during the dry period. Following kidding, the does were together with their kids until weaning at 1 month of age. Kids were weighted after parturition (when dry off) with spring balance (precision ± 0.05 kg). Milk control, respecting the recommendations of ICAR, was conducted according to AT method by the employees of the Croatian Agricultural Agency, where every 30 (28-34) days is controlled by alternating morning or evening milking.

The research protocol and animal management were following Directive 2010/63/EU (European Union 2010) on the protection of animals used for scientific purposes.

### 2.2. Meteorological data

The air temperature and rainfall records were obtained by the Croatian Meteorological and Hydrological Service (CMHS) from the nearest meteorological recording station, located within 5-25 km from selected farms. Seasonal variations of air temperature and rainfall precipitation from 2013 to 2018 were compared with the long-term average data obtained for the past 30 years (1961–1990) by the CMHS.

Research started from December 21, 2012, until December 20, 2018. Season refers to a calendar specific period: winter includes days from December 21 of the previous year, and January, February, and March (until March 20), spring (March 21-June 20), summer (June 21-September 22), and autumn (September 23-December 20).

### 2.3. Statistical analysis

All data were analyzed by Stara 13.1 (Stara Corp. USA) using the chi-square test for kidding distribution and the gender frequency of goat kids per season compared between different years of observation. We analyzed the birth weight of goat kids by analyzing the variance (ANOVA). The regression analysis was to check the linear connection between the birth weight of goat kids with the year and the kidding season and the goat kid gender.

### 2.4. Ethical approval

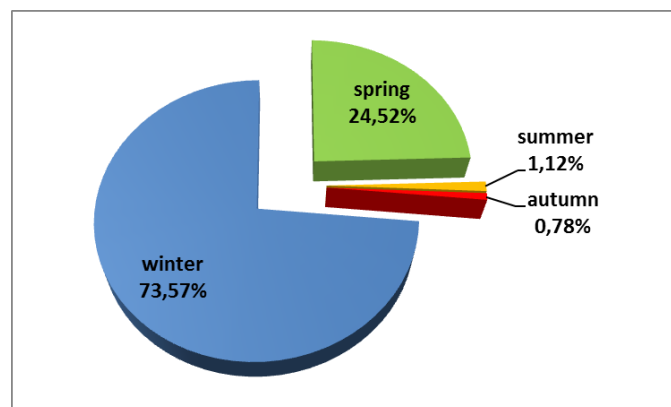
All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All animals were handled in strict accordance with good animal practices as defined by the relevant national and/or local animal welfare bodies. All procedures performed in studies involving animals were following the ethical standards of the institution or practice at which the studies were conducted.

## 3. Results

Seasonal kidding in the French Alpine goat was distributed mostly on two seasons: winter and spring (Figure 1) during six consecutive years 2013-2018 in the northwestern part of Croatia. Observed differences in the kidding distribution per month during the years of observation were statistically significant ( $P = 0.018$ ). The highest number of kidding was recorded in February in all years of observation (Table 1).

In northwestern Croatia, the breeding season of French Alpine goats began in August and ends in late October with an anoestrous period from February to the end of May (Figure 2).

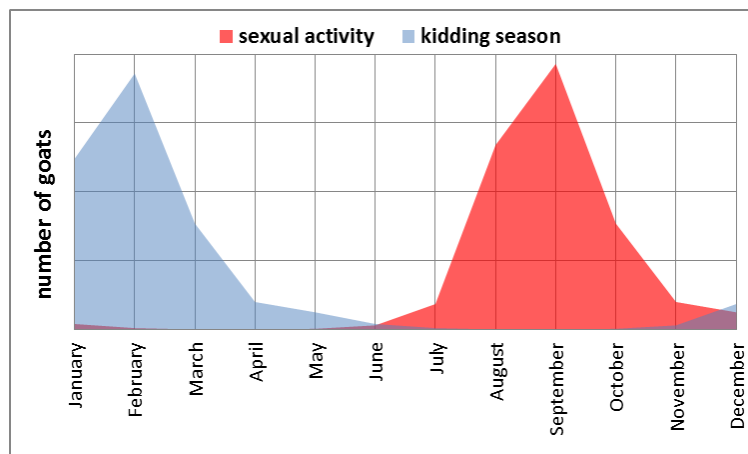
The observed differences in the birth weight of French Alpine kid goats differ between individual years of observation in both sexes ( $P < 0.001$ ). The average birth weight of male kid goats was greater than the average birth weight of female kid goats in all observed years, and statistically significantly higher in all observed years except the years 2014. and in 2015. When comparing the average birth weight of the same sex in the different months of the same year, the observed differences in the average birth weight were not statistically significant ( $P > 0.05$ ).



**Figure 1** Seasonal kidding distribution of French Alpine in NW Croatia during six consecutive years (2013-2018).

**Table 1** Monthly kidding distribution of French Alpine during years of observation.

| Year     |   | Month of kidding |       |       |       | Total |
|----------|---|------------------|-------|-------|-------|-------|
|          |   | 1                | 2     | 3     | 4-12  |       |
| 2013     | N | 40               | 78    | 33    | 24    | 175   |
|          | % | 22.86            | 44.57 | 18.86 | 13.71 | 100   |
| 2014     | N | 54               | 82    | 37    | 10    | 183   |
|          | % | 29.51            | 44.81 | 20.22 | 5.46  | 100   |
| 2015     | N | 32               | 63    | 26    | 29    | 150   |
|          | % | 21.33            | 42.00 | 17.33 | 19.33 | 100   |
| 2016     | N | 64               | 77    | 32    | 25    | 198   |
|          | % | 32.32            | 38.89 | 16.16 | 12.63 | 100   |
| 2017     | N | 50               | 64    | 35    | 16    | 165   |
|          | % | 30.30            | 38.79 | 21.21 | 9.70  | 100   |
| 2018     | N | 56               | 57    | 23    | 18    | 154   |
|          | % | 36.36            | 37.01 | 14.94 | 11.69 | 100   |
| total    | N | 296              | 421   | 186   | 122   | 1,025 |
|          | % | 28.88            | 41.07 | 18.15 | 11.90 | 100   |
| <i>P</i> |   | 0.018            |       |       |       |       |



**Figure 2** Sexual activity (breeding season) and kidding season of French Alpine goats in northwestern Croatia.

**Table 2** Average birth weight and linear regression of the birth weight of newborn French Alpine goat kids in relation to year of kidding, gender, and the month or season of kidding.

| Year   | Kid goat weight (mean±SD) |                          |        |                          | <i>P</i>                |
|--------|---------------------------|--------------------------|--------|--------------------------|-------------------------|
|        | N                         | Female                   | N      | Male                     |                         |
| 2013   | 80                        | 3.12 ± 0.62 <sup>a</sup> | 95     | 3.43 ± 0.70 <sup>b</sup> | 0.0027                  |
| 2014   | 86                        | 3.67 ± 0.55 <sup>a</sup> | 97     | 3.85 ± 0.65 <sup>a</sup> | 0.0521                  |
| 2015   | 71                        | 3.50 ± 0.60 <sup>a</sup> | 79     | 3.65 ± 0.62 <sup>a</sup> | 0.1441                  |
| 2016   | 92                        | 3.41 ± 0.58 <sup>a</sup> | 106    | 3.78 ± 0.64 <sup>b</sup> | <0.0001                 |
| 2017   | 76                        | 3.58 ± 0.56 <sup>a</sup> | 89     | 3.87 ± 0.59 <sup>b</sup> | 0.0016                  |
| 2018   | 73                        | 3.43 ± 0.55 <sup>a</sup> | 81     | 3.69 ± 0.53 <sup>b</sup> | 0.0036                  |
| Factor | Coefficient               | SEcoefficient            | t      | <i>P</i>                 | Confidence Interval 95% |
| Year   | 0.040                     | 0.012                    | 3.443  | 0.001                    | 0.017 - 0.062           |
| Month  | -0.005                    | 0.020                    | -0.222 | 0.824                    | -0.044 - 0.035          |
| Gender | -0.262                    | 0.039                    | -6.694 | 0.000                    | -0.338 - -0.185         |

Values with different superscripts in the same row differ significantly (*P* < 0.05).

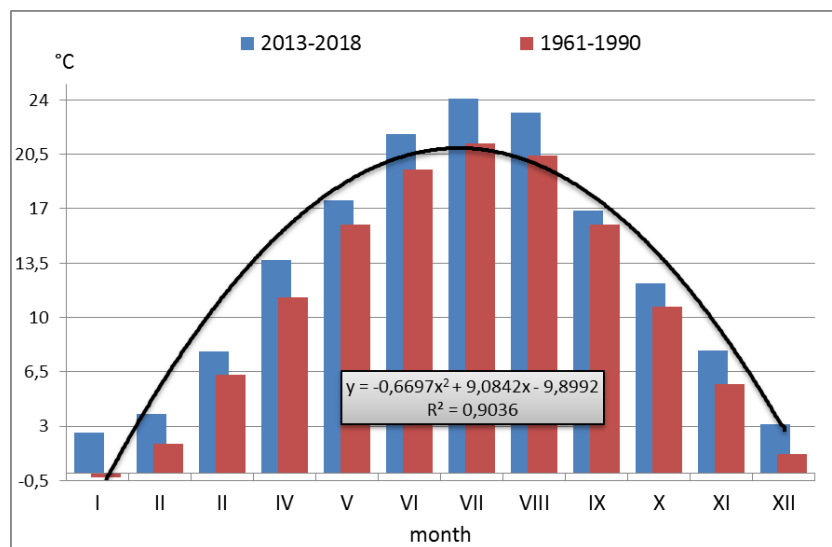
The birth weight of newborn goat kids is linear statistically significantly related to the kidding year and the gender, but not with the month or season of kidding (Table 2).

During the study, French Alpine goats (n=948) on the 6 dairy goat farms, birthed 1025 goat kids after 893 successful matings (55 matings were unsuccessful) during six consecutive years. The average birth weight was 3.46±0.48 kg for females (n=478) and 3.71±0.51 kg for male kids (n=547).

French Alpine does with single kids accounted for 85.89% (n=767), with twins 13.44% (n=120) and triplets 0.67% (n=6). The average litter size was 1.15, and the average parity was 2.95. The birth weight of goat kids in primiparous and pluriparous goats was not significantly different. Survival rate (until 1 month of age) was 93.66 % (n=960). French Alpine does fertility in northwestern Croatia, through six years was 94.18% (Table 3).

**Table 3** French Alpine dairy goats data of reproductive performance during six consecutive years (2013-2018).

| Year  | Total number of does | Pregnant | Non-pregnant | Kid goats | Litter size | Died until 1 month | Parity | Fertility |
|-------|----------------------|----------|--------------|-----------|-------------|--------------------|--------|-----------|
| 2013  | 155                  | 148      | 7            | 175       | 1.19        | 10                 | 2.59   | 95.48     |
| 2014  | 167                  | 157      | 12           | 183       | 1.17        | 16                 | 2.79   | 94.01     |
| 2015  | 151                  | 139      | 10           | 150       | 1.08        | 13                 | 2.99   | 92.05     |
| 2016  | 174                  | 165      | 9            | 198       | 1.2         | 9                  | 3.16   | 94.83     |
| 2017  | 152                  | 144      | 8            | 165       | 1.15        | 8                  | 3.02   | 94.74     |
| 2018  | 149                  | 140      | 9            | 154       | 1.1         | 9                  | 3.12   | 93.96     |
| Total | 948                  | 893      | 55           | 1025      | 1.15        | 65                 | 2.95   | 94.18     |



**Figure 3** Monthly air temperatures during 2013-2018 in comparison to 1961-1990 years in NW part of Croatia, trendline, and coefficient of determination (R<sup>2</sup>) for period 2013-2018.

**4. Discussion**

The breeding season of most breeds of sheep and goats in the moderate climate region is restricted to the late summer and autumn. Consequently, the seasonal distribution of parturitions was not uniform throughout the year, and the most of sheep and goats delivered in the late winter and early spring (Đuričić et al 2019a,b). The winter solstice marks the shortest day and longest night of the year (Chemineau and Delgadillo 1994). The kidding season occurred mostly in the winter and spring when daylight became longer. The goats produced more milk during longer

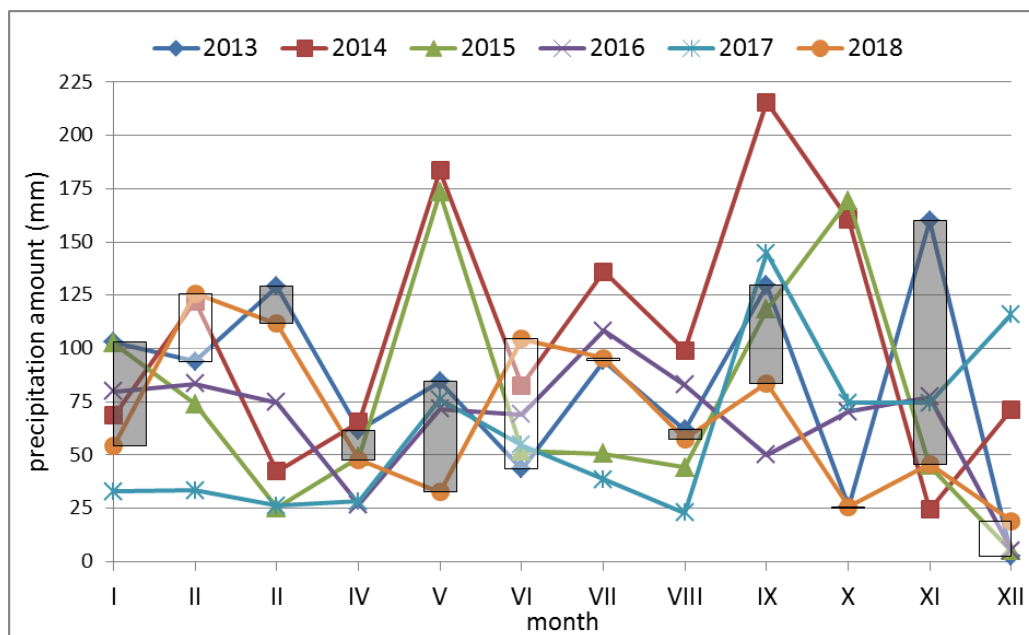
days (Chemineau et al 2007; Russo et al 2013; Arnal et al 2018).

The interkidding period of German Improved Fawn goats in Serbia was 337 days (Ćinkulov et al 2009). The average value of the interkidding period of Boer goats in Croatia was 265.35 ± 4.42 days (Đuričić et al 2009) while in our study average interkidding period of French Alpine was about one year.

All domestic goats delivered litters with a significantly higher proportion of males in the ratio of male to female kids 57:43 representing all kids born over a period of 12 years (Polak et al 2015). In our study ratio of male to female goat

kids was 53.4:46.6, which is very close to the report by Tolu et al. (2007), but the opposite to the results of Gorecki and Koscinski (2003). Male kids of dairy goats are less valued by farmers because after early weaning and fattening, kids sold for meat and slaughtered. Only few the best-quality male kids are left and kept for breeding. Females with productive and reproductive potentials are much preferred by farmers (Polak et al 2015). The single and male goat kids were always heavier than the twins and the females (Mabrouk et al 2010), as in our study. Al-Shorepy et al (2002) indicated that the season of birth was not significant for birth weight. In our study was similar to the previous statement, because there were only

two seasons of kidding, winter, and spring to compare. In high prolific breeds of goats (for ex. Boer goats) incidence of multiple-births was high, that more than half does had twins (Skinner1972; Seabo et al 1994, Đuričić et al 2012), while in low prolific breeds incidence of multiple-births was very low. A similar result was in our study (less than 14% of does had multiple-births). Relationship between litter birthweight and litter size of Saanen, Toggenburg, and French Alpine goat under intensive conditions, were compared birthweight for kids born as twins, triplets and quadruplets were, on average, 92%, 87%, and 83%, respectively, of that of singleton kids weight (Mellado et al 2011).



**Figure 4** Monthly precipitation amounts (mm) during observed period in NW Croatia.

The average number of kids per doe depended on the goat breed (Amoah et al., 1996). Average litter size in Boer goats was 1.80 (Đuričić et al 2012), while litter size in Saanen goats in Croatia was 1.22 (HPA 2018), in German Improved Fawn goats was 1.96 (Činkulov et al 2009), and in Bengal goats 1.65±0.67 (Halder et al 2014). In our study litter size was very low as in indigenous breeds (HPA 2018): the Croatian colored (1.13) and the Croatian white goat (1.14). Litter size reduces the birth weight and survival rate of indigenous goat kids (Lehloenya et al 2005). Goat kids born in Mexico, from October to January always showed a higher survival rate than those born in April–July partly due to heat stress (Perez-Razo et al 1998). Weather conditions are the main factors affecting the survival rate of newborn lambs in Patagonia (Coronato 1999). Survival rates for Alpine goats in February was 89.6 ± 1.4, March 91.0 ± 1.3 and April–July 81.9 ± 1.6 and October–January 90.4 ± 1.5% (Perez-Razo et al 1998), while in our study was 93.66% during the observed period because only a few does of French Alpine delivered in June, July and none in August and September (very and extremely warm summer with exception of the year 2014). Weather conditions did not affect survival rates of goat kids

in this study, because does from all flocks mostly delivered into the stables, and food for the kids after early weaning was the top quality.

Đuričić et al (2019a,b) assumed that air temperature and rainfall during different seasons could affect the reproductive efficiency in Romanov breed of sheep in the continental part of Croatia and a positive or negative correlation between the air temperature and rainfall precipitation variations with tested reproductive performances of Jezersko-Solčava breed sheep. Opposite to previous statements, Djuricic et al (2010) observed that number of mating does, kidding rate, and the number of goat kids were significantly different, depending of the season, although there was not any correlation between air temperature, rainfall precipitation, and reproductive efficiency of Boer goats in the northwestern part of Croatia.

## 5. Conclusions

We can conclude that there was not any relationship between monthly air temperature and precipitation amounts with tested reproductive performances in French Alpine dairy goats in the NW part of Croatia during the observed period.

## Conflict of Interest

The authors declare that they have no conflict of interest.

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## References

- Al-Shorepy SA, Alhadrami GA, Abdulwaha K (2002) Genetic and phenotypic parameters for early growth traits in Emirati goat. *Small Rumin Res* 45:217-223.
- Amoah EA, Gelaye S, Guthrie P, Rexroad CE (1996) Breeding season and aspects of reproduction of female goats. *J Anim Sci* 74:723-728.
- Arnal M, Robert-Granié C, Larroque H (2018) Diversity of dairy goat lactation curves in France. *J Dairy Sci* 101:11040-11051.
- Chemineau P, Delgadillo JA (1994) Neuroendocrinologie de la reproduction chez les caprins. *INRA Prod Anim* 7:315-326.
- Chemineau P, Daveau A, Maurice F, Delgadillo JA (1992) Seasonality of oestrus and ovulation is not modified by subjecting female Alpine goats to a tropical photoperiod. *Small Rumin Res* 8:299-312.
- Chemineau P, Malpaux B, Brillard JP, Fostier A (2007) Seasonality of reproduction and production in farm fishes, birds and mammals. *Animal* 1:419-432.
- Ćinkulov M, Nebesni A, Krajinović M, Pihler I, Žujović M (2009) Reproductive traits of German Fawn Goats in Vojvodina. *Biotechnology in Animal Husbandry* 25:119-124.
- Coronato F (1999) Environmental impacts on offspring survival during the lambing period in central Patagonia. *Int J Biometeorol* 43:113-118.
- Đuričić D, Dobranić T, Samardžija M, Vince S, Grizelj J (2009) Fruchtbarkeitsmerkmale der Burenziegen im nordwestlichen Teil Kroatiens. *Tierarzt Umschau* 64:384-388.
- Djuricic D, Dobranic T, Harapin I, Lipar M, Prvanovic N, Grizelj J, Karadjole M, Gračner D, Folnožić I, Samardžija M (2010) The effects of air temperature and rainfall seasonal variations on reproductive efficiency in Boer goats. *XIth Middle European Buiatrics Congress*, 17-19 June, Brno Czech Republic, 191-194.
- Đuričić D, Grizelj J, Dobranić T, Harapin I, Vince S, Kočila P, Folnožić I, Lipar M, Gregurić Gračner G, Samardžija M (2012) Reproductive performance of Boer goats in a moderate climate zone. *Vet Arhiv* 82: 351-358.
- Đuričić D, BeniĆ M, Žura Žaja I, Valpotić H, Samardžija M (2019a) The effects of monthly air temperature and rainfall variations on the reproductive performance and lambing distribution of the Jezersko-Solčava sheep. *Int J Biometeorol* 63:153-158. doi.org/10.1007/s00484-018-1646-8
- Đuričić D, BeniĆ M, Žura Žaja I, Valpotić H, Samardžija M (2019b) Influence of season, rainfall and air temperature on the reproductive efficiency in Romanov sheep in Croatia. *Int J Biometeorol*, 63:817-824. doi.org/10.1007/s00484-019-01696-z
- Gorecki MT, Kosciński K (2003) Offspring sex ratio in domestic goat (*Capra hircus*). *Archives of Animal Breeding* 46:277-284.
- Haldar A, Pal P, Datta M, Paul R, Pal SK, Majumdar D, Biswas CK, Pan S (2014) Prolificacy and its relationship with age, body weight, parity, previous litter size and body linear type traits in meat-type goats. *Asian-Australas J Anim Sci* 27:628-634.
- HPA (2018) Annual report for sheep, goats and small animals breeding 2017. (Eds. Sinković T, Čačić M), Zebra, Vinkovci [in Croatian]
- Lehloeny KC, Greyling JPC, Schwalbach LMJ (2005) Reproductive performance of south African indigenous goats following oestrus synchronisation and AI. *Small Rumin Res* 57:115-120.
- Mabrouk O, Sghaier N, Costa RG, Amor G, Amel BA E, Delgado J V (2010) The effect of non-genetic factors on the early body weights of Tunisian local goats. *R Bras Zootec* 39:1112-1117.
- Mellado M, Meza-Herrera CA, Arévalo JR, De Santiago-Miramontes MA, Rodríguez A, Luna-Orozco JR, Veliz-Deras FG (2011) Relationship between litter birthweight and litter size in five goat genotypes. *Anim Prod Sci* 51(2):144-149.
- Mioč B, Pavić V, Barać Z, Prpić Z, Vnučec I (2007) Milk yield of some goat breeds in Croatia. *Mljekarstvo* 57:67-77.
- Perez-Razo MA, Sánchez FGF, Meza CH (1998) Factors affecting kid survival in five goat breeds. *Can J Anim Sci* 78:407-411.
- Polák J, Mareš V, Konrád R, Frynta D (2015) Offspring sex ratio in domestic goats: Trivers-Willard out of natural selection. *Czech J Anim Sci* 60: 208-215.
- Russo VM, Cameron AWN, Dunshea FR, Tilbrook AJ, Leury BJ (2013): Artificially extending photoperiod improves milk yield in dairy goats and is most effective in late lactation. *Small Rumin Res* 113:179-186.
- Skinner JD (1972) Utilisation of the Boer goat for intensive animal production. *Trop Anim Health Prod* 4:120-128.
- Seabo D, Aganga AA, Mosienyane M (1994) Reproductive performance of Tswana ewes and Boer does in south-eastern Botswana. *3th Biennial Conference of the African Small Ruminant Research Network*, Kampala, Uganda, 5-9 December 1994.
- Song HB, Jo IH, Sol HS (2006) Reproductive performance of Korean native goats under natural and intensive conditions. *Small Rumin Res* 65:284-287.
- Sušić V, Pavić V, Mioč B, Štoković I, Ekert Kabalin A (2005) Seasonal variations in lamb birth weight and mortality. *Vet arhiv* 75:375-381.
- Tolu C, Savas S, Pala A, Thomsen H (2007) Effects of goat social rank on kid gender. *Czech J Anim Sci* 52:77-82.
- Zaninovic K, Gajic-Capka M, Percec Tadic M (2008) Climate atlas of Croatia 1961-1990, 1971-2000. Zagreb, Državni hidrometeorološki zavod [in Croatian].