Reproductive performance and fertility index of Etawah-crossbred goats based on several parities at goat breeding station-Singosari, Malang, Indonesia

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Abstract. This research aimed to analyze the reproductive efficiency of Etawah-crossbred (PE) goats. Data were collected through a survey method. The research materials were 228 first-parity (P1), 226 second-parity (P2), 147 third-parity (P3), and 73 fourth-parity (P4) heads acquired in 2011–2017. We then observed the service per conception (S/C), days open (DO), conception rate (CR), kidding interval (KI), litter size, birth weight, and fertility index (FI). The obtained data were analyzed with compare means procedure (one-way ANOVA) by using SPSS version 20 and then Least Significant Difference to determine any significant differences. The CR was computed by chi-square test. Results showed that the PE parities significantly affect (P<0.05) the S/C, DO, CR, litter size, birth weight, and fertility index (FI). The obtained data were analyzed with compare means procedure (one-way ANOVA) by using SPSS version 20 and then Least Significant Difference to determine any significant differences. The CR was computed by chi-square test. Results showed that the PE parities significantly affect (P<0.05) the S/C, DO, CR, litter size, birth weight, and fertility index (FI). The FI was significant on P3 (63.75). Therefore, the reproductive performance of PE goats on several parities based on S/C, DO, CR, litter size, and birth weight was favorable, and P3 had the best reproductive traits according to the FI value.

1. Introduction
Etawah-crossbred (PE) goat is one of the most important types of dual-purpose goats in tropical areas, especially Indonesia. It is a crossbreed between an Etawah goat and an Indonesian local goat [1]. PE Goat is known as dairy production. PE goats are often crossbred with other local goats of Indonesia through reproductive technology, such as artificial insemination (AI) or natural mating. The crossbreeding aims to obtain goats capable of producing milk and meat (dual purpose).

The success of crossbreeding is determined by its high productivity. Reproductive success will increase livestock productivity in addition to feeding factors and goat farming management. Good reproduction and management lead to high reproductive efficiency [2,3]. Reproductive efficiency is determined by the fertility index (FI), which indicates reproductive performance by combining the reproductive variables such as the conception rate (CR), days open (DO), and service per conception (S/C) [4]. Evaluation of reproductive performance is necessary to assess the potential of PE goats.

The doe reproductive appearance increases from the first to fourth parity and then subsequently decreases. This increase is caused by the maturation of reproductive organs in adults. Then, the fifth parity and subsequent reproductive performance of the doe declines. This decrease is caused by goats entering the old age, which decreases the function of the reproductive organs and hormonal mechanisms in the body [5].
In tropical areas, especially Indonesia, environmental temperature is also an important focus on the reproductive system. Environmental factors such as radiation, high temperatures, and humidity contribute to the heat stress in livestock. Goats adapt to heat-stressed weather conditions through behavior, morphology, physiology, and genetics [6]. Stress consequently disrupts reproduction, thereby lowering the reproductive performance [7]. An assessment study of doe reproduction was conducted at various parities that provided information on reproduction rates. This study aimed to implement an efficient reproductive system in PE goats.

2. Materials and methods

2.1. Animals
The research was conducted in UPT-PT and HMT Singosari, Malang, in February 2017. The UPT-PT and HMT is a center for breeding and cultivation of PE goats. The materials used were data recordings of does and birth of PE goats obtained from 2011 to 2017. In this research, 228, 226, 147, and 73 does were used for the first, second, third, and fourth parities (P1, P2, P3, and P4), respectively.

2.2. Management of doe farming
The animals were kept intensively using a stage stable. A pregnant doe was placed in a special group. Old pregnant does were placed in individual stables; if an offspring was born, it was placed in a special stable with the lactating doe. Feed was in the form of concentrate at 0.5 kg/head/day and forage at 3.88 kg/head/day, while the drinking water was served ad libitum.

2.3. Reproductive management
Reproductive management was applied in natural mating. The mature does were gathered with a buck in one stable. The doe:buck ratio was 10:1, with good supervision from the farmer. If estrus was no longer evident after 40 days, the doe underwent abdominal palpation.

2.4. Data collections
The research method applied was observation. The data obtained in each goat included the following: S/C (the number of conceptions to pregnancy), DO (an empty time between the goats giving birth to pregnancy), kidding interval (KI) (the distance between before birth and then), CR (the percentage value of the number of pregnant does in the first conception), litter size (the number of offspring produced at one birth by viviparous animal), FI (the value of doe reproductive traits and the birth weight), and birth weight (measured on the first day after birth).

2.5. Data analysis
The animals were grouped by the same parity. The S/C, DO, KI, litter size, and birth weight data were analyzed using the SPSS version 20 with compare means procedure (one-way ANOVA). To determine significant differences, we analyzed the results by employing the Least Significant Difference (LSD). Birth weight based on the type of birth and sex of offspring was analyzed by independent samples t-test. The CR data were analyzed by chi-square. Furthermore, FI was calculated with the following formula:

\[ FI = \frac{CR}{S/C} - (DO - 90) \]

Description:
- FI = Fertility Index
- CR = Conception Rate
- DO = Days Open
- S/C = Service per Conception
3. Result and discussion

3.1. Service per conception (S/C)
Table 1 showed that the S/C value of Etawah-crossbred goat from 1st to 4th parity were significantly different (P<0.05). The average S/C of Etawah-crossbred goat tended to lower with an increase in parity up to third parity and slightly decrease at fourth parity. The average of S/C in the 1st, 2nd, 3rd, 4th parity were (1.15±0.36 times), (1.11±0.31 times), (1.03±0.18 times) and (1.11±0.31 times), respectively. The lowest S/C value was in 3rd parity.

This S/C value was lower than the research of (2015) stated that the S/C of Saanen goats in the 1st, 2nd, 3rd and 4th parity were (1.53±0.14 times), (1.68±0.13 times), (1.59±0.14 times) and (1.61±0.15 times) [8]. The lower S/C value, the more efficient the mating system. Ciptadi et al (2014) stated that a good S/C value for pregnancy is one service (S/C= 1.0) [9]. The efficient pregnancy system can be achieved with the intensive management system that is managing the time of proper mating management. The value of the S/C Black Bengal goats on the intensive management system which was 1.0±0.28 times, lower than the semi-intensive system which was 1.2±0.23 times [10].

Table 1. Average reproduction performance Etawah-crossbred goat in the 1st to 4th parity.

| Parity | n  | S/C       | DO        | CR          | KI          | Litter size | FI  |
|--------|----|-----------|-----------|-------------|-------------|-------------|-----|
| 1st    | 228| 1.15±0.36a| 84.65     | -           | 1.14±0.49a  | 33.98       |     |
| 2nd    | 226| 1.11±0.31a| 136.54±40.11a| 89.38 | 277.57±52.48 | 1.65±0.47b  |     |
| 3rd    | 147| 1.03±0.18b| 120.03±27.31b| 96.59 | 265.83±52.73 | 1.66±0.47b  |     |
| 4th    | 73 | 1.11±0.31ab| 126.56±27.96b| 89.04 | 273.26±107.40 | 1.53±0.50ab |     |

Different superscript shows significant differences (P<0.05). S/C: service of conception; DO: days open; CR: conception rate; KI: kidding interval; FI: fertility index.

3.2. Days open (DO)
The parity gave significant effect (P<0.05) on the days open of Etawah-crossbred goat (table 1). The average DO ranged from 120.03±27.31 to 136.54±40.11 days. The lowest DO was found at the 3rd parity, then the 4th parity, last the 2nd parity. The average days open of Etawah-crossbred goat in this research was lower than the research of Gautam et al (2018) which was 144.00±4.09 days [11].

The long DO will reduce the efficiency of animal reproduction. The doe after partum can be remated after 90 days or after weaning because the reproductive tissue has recovered normally. Days open abnormally caused the differences in the waiting period of mating or insemination. The DO value of Etawah-crossbred goat in this research above 90 days may be due to the doe has abnormality oestrus post-partum. Oestrus post-partum is an important factor that affects reproductive efficiency. The shorter the first oestrus distance after partum, the shorter the kidding interval and vice versa.

3.3. Conception rate (CR)
The parity gave significant effect (P<0.05) on the conception rate of Etawah-crossbred goat (table 1). The average CR ranged from 84.65% to 96.04%. The lowest average CR was found at the 1st parity and the highest was found at the 3rd parity. The average CR of Etawah-crossbred tended to increase at the 1st to 3rd parity, then decreased at the 4th parity.

Similarly, Abdalla et al (2015) in Saanen goat showed that CR ranged from 90.09%–96.87% [8]. Reproductive management of Etawah-crossbred goat in this research was used in natural mating. The CR of a goat was varied on the different mating system, with natural mating and artificial insemination were 93% and 70%, respectively [12]. CR of goats that are naturally mating is higher than artificial insemination. The normal CR value of the goat is at 50–80% [13]. The value of CR is higher then the reproductive rate is better.
3.4. Kidding interval (KI)

The parity gave no significant effect (P>0.05) on the kidding interval of Etawah-crossbred goat (table 1). The average KI in the 2nd, 3rd and 4th parity were 277.57±52.48 days, 265.83±32.73 days and 273.26±107.40 days, respectively. The lowest average kidding interval was found at the 3rd parity and the highest was found at the 2nd parity. The obtained result was different from El-Moghazy et al (2018) who stated that the kidding interval of 3rd parity which was 350.29 days for Zaraibi dairy goat [14]. Miah et al (2016) at the 2nd and 4th parity, the kidding intervals reached 185.97 and 187.49 days for the Black Bengal goats, while 199.88 and 200.40 days for the Jamnapari goat [15]. This might be due to differences in the breed, management breeding, nutrition, and genetics. The kidding interval is also affected by the management system. The value of the KI on the semi-intensive management system which was 233.8±13.12 days, lower than the extensive system which 242.8±32.66 days [16]. The average kidding interval of Etawah-crossbred goat in this study was following Jainudeen et al (2008) who stated that kidding interval of goats in the tropics on the condition of feed and good management range from 240 to 290 days [17].

The highest KI value is the longer kidding interval. The value of KI is lower then the reproductive rate is better. The period of mating is the defining factor of kidding intervals. The interval between parturition and oestrus post-partum is an important trait of reproductive efficiency [18]. Moreover, the involution of the post-partum uterine is an important factor in achieving of kidding interval efficiency [19,20]. The more declining period of oestrus post-partum indicates that goat is more rapidly occurring after parturition. The average KI of Etawah-crossbred tended to decrease at the 2nd to 3rd parity, then increased at the 4th parity. The kidding interval is affected by environmental, parity, genetics, maintenance and season factors [17,21].

3.5. Litter size

Table 1 showed that the parity gave significant effect (P<0.05) on the litter size of Etawah-crossbred goat. The average litter size was found at the 1st parity and the highest was found at the 3rd parity. Similarly, the average of litter size reported in the 1st, 2nd, 3rd, 4th parity were 1.43, 1.48, 1.52 dan 1.65, respectively [16]. This was supported by the statement of El-Moghazy et al (2018) that the parity gave a significant effect on the litter size of Zaraibi dairy goat [14]. The parity correlated with litter size (r=0.49) [22]. The litter size value increases to 4th parity due to increased reproductive efficiency as well as mature [23].

Parity as a main factor affects to the birth type of Etawah-crossbred goat. The litter size value indicates an increase in each parity because of the selection of doe. The intensive management system also increases litter size. The results of this research showed that litter size Etawah-crossbred goat was very varied. Miah et al (2016) stated that the goat ≥2nd parity is more dominant in the parturition of twins and triplets [15]. The litter size is affected by age of doe, body weight, type of parturition, genetic and environmental.

3.6. Fertility index (FI)

The average fertility index ranged from 33.98% to 63.75%. The lowest FI was found at the 2nd parity (33.98%), then the 4th parity (42.95%), last 3rd parity (63.75%). In Bedouin goat, Kouri et al (2018) found that the fertility index was 55.9% [24]. FI reflects the value of doe reproductive. The fertility index was determined by S/C, CR, and DO. DO related to poor reproductive management or reproductive disease, thus estrus retreats after parturition.

The FI value of 2nd and 4th parity were lower than 3rd parity. This may be due to the long days open intervals. The long days open were may be due to the lack of nutrition intake for reproductive needs. Jainudeen et al (2008) revealed that the ovulation can be enhanced with flushing during early of mating season and end of mating season [17]. Moreover, Suyadi et al (2019) suggested that for evaluating the reproduction efficiency of goat dam could be using the reproduction index, since this indicator expresses litter size, pre-weaning mortality and kidding intervals [30]. These variables
represent not only the potential of dam to produce kids per time interval, but more far also evaluate the success management to maintain the kids until weaning age.

3.7. Birth weight

Table 2. showed that the parity gave significant effect (P<0.05) on the birth weight. The average birth weight ranged from 2.69±0.57 kg to 3.07±0.62 kg. The average birth weight of Etawah-crossbred tended to decrease at the 1st to 3rd parity, then increased at the 4th parity. This was caused when doe was mated by different buck, so the birth weight trait was different for a kid. The average birth weight in this study was higher than the study of Hassan et al (2010) which was 1.6 kg [25], but similarly with Belay et al (2014) on Abergelle goat in the 1st, 2nd, and 3rd parity were weighted 2.89 kg, 2.73 kg, and 3.21 kg, respectively [26].

| Variable            | n   | Birth weight (kg) | Mean ± sd |
|---------------------|-----|-------------------|-----------|
| Parity              |     |                   |           |
| 1st                 | 245 | 2.94±0.62         | a         |
| 2nd                 | 265 | 2.75±0.60         | b         |
| 3rd                 | 201 | 2.69±0.57         | b         |
| 4th                 | 86  | 3.07±0.62         | a         |
| Type of birth       |     |                   |           |
| Single              | 207 | 3.39±0.53         | a         |
| Twins               | 590 | 2.61±0.50         | b         |
| Sex of offspring    |     |                   |           |
| Male                | 397 | 2.83±0.62         |           |
| Female              | 400 | 2.79±0.61         |           |

Different superscript shows significant differences (P<0.05).

The sex of offspring gave no significant effect (P>0.05) on the birth weight. The birth weight of a male kid (2.83±0.62 kg) was higher than the birth weight of a female kid (2.79±0.61 kg). The male kid was almost always heavier than a female kid in the same breed and birth type. The influence of hormones in males to the development of fetus so that the birth weight of males higher than females. Sodiq et al (2015) reported that the average birth weight of male kid and female was 2.18 kg and 2.02 kg [27]. Talukder et al (2016) also confirmed that the birth weight of male kid and female is influenced by parity [28].

The type of birth gave significant effect (P<0.05) on the birth weight. Single born kids had a higher birth weight (3.39±0.53 kg) than twins born kids (2.61±0.50 kg). Similarly, single kids was reported heavier than twins and triplets kids [29]. Moreover, Sodiq et al (2015) stated that the birth weight of single and twin kids was 2.10 and 1.99 kg, respectively [27]. A single born kid has a faster growth rate than a twins born kid [26].

4. Conclusion

The reproductive performance of PE goats in UPTPT-HMT Singosari on several parities based on S/C, DO, CR, birth weight, and litter size is relatively good. Based on the doe FI, P3 has the best reproductive traits.
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