Profile and population dynamics of Aceh cattle in livestock breeding and forage centre, Indrapuri

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Abstract. This study aims to determine the profile and population dynamics of Aceh cattle in Livestock Breeding and Forage Center (BPTU-HPT), Indrapuri. On the Aceh cattle profile, qualitative data consisting of the colour and form of the horns and quantitative data consisting of the weight and body size were used. The data for population dynamics was the livestock recording data, which includes population structure of Aceh cattle, death, births, expenditure and animal input data for five years (2015 to 2019). Population dynamics have been predicted by time series analysis. The results showed Aceh cattle in BPTU-HPT Indrapuri have a predominantly brick red colour, with a lower body weight and size compared to other local Indonesian cattle. Furthermore, it was projected that the population dynamics of Aceh cattle will increase by an average of 65 heads or 6.02 per cent from 2020 to 2024. In conclusion, Aceh cattle have different profile from other local Indonesian cattle, with a smaller phenotype in particular, but a strong resistance to bad environments. Furthermore, based on the estimates of population dynamics analysis, it has the potential to continue evolving as breeding stock source in BPTU-HPT, Indrapuri.

1. Introduction
Aceh cattle are one of Indonesia’s local breed and are a wealth of genetic resources of livestock. They are a small cattle breed present exclusively in the Aceh region [1] and ideal for production in the tropics. This is because of they are resistant to poor environmental conditions such as shortage of feed, water and high fiber feed, parasitic diseases, hot temperatures and traditional extensive rearing systems [2]. The Livestock Breeding and Forage Center (BPTU-HPT) Indrapuri is one of the Technical Implementing Units of the Ministry of Agriculture, has responsibilities to provide breeding stock and feeders. Furthermore, the population of Aceh cattle in BPTU-HPT Indrapuri was 959 heads in 2019.

The population of livestock is always changing or dynamic. It is influenced by slaughtering, output and input animals, initial population, birth and death rate [3]. The population dynamics of an animal is determined from the following parameters: natural population growth or a natural increase (NI), ability to provide replacement livestock or net replacement rate (NRR), and ability to cull the remaining replacement stock, either sold or moved out animals. Population dynamics are calculated based on the...
population data for the last few years, while population output is calculated based on the number of culled cattle per year and the number of remaining replacement stock.

Therefore, this study aims to determine the profile and population dynamics of Aceh cattle in BPTU-HPT Indrapuri. It is expected that the results of this study will be useful in providing input to BPTU-HPT Indrapuri in order to determine the direction and policies for livestock development and efforts to increase productivity and genetic quality of Aceh cattle based on estimated population dynamics.

2. Materials and methods
This study was carried out at BPTU-HPT Indrapuri and the materials used for Aceh cattle profiling was qualitative and quantitative data which includes the body colour, horn shape and body size. For the population dynamics study, data consisted of livestock recording data, which covered the structure of Aceh cattle population, death, birth, input and output data for five years (2015 to 2019) were used.

The variables observed comprised of several components such as 1) qualitative Aceh cattle profile, comprising of body colour and horn shape, as well as quantitative data in the form of body weight and size and 2) population dynamics.

Furthermore, data analysis was carried out by tabulating qualitative data as a percentage and measuring the quantitative data as a mean and standard deviation. In addition, quantitative data were determined using the following formula:

Average number of beef cattle samples a year

\[ P_t = \frac{P_{aw} + P_{ak}}{2} \]  

Where:

- \( P_t \) = average number of cattle samples per year
- \( P_{aw} \) = number of cattle at the beginning of year or one year prior to study
- \( P_{ak} \) = number of cattle at the end of the year of study period

Population dynamics were estimated from Aceh cattle population data in BPTU-HPT Indrapuri over the last five years and further analyzed by time series using least squares method [5] with linear line equations:

\[ Y = aX + b \]  

Where:

- \( Y \) = data futures (time series data)
- \( X \) = the difference between the current year and the reference year
- \( a \) = regression coefficient
- \( b \) = intercept

Based on the linear equation, the population for the next five years was estimated.

3. Result and discussion
3.1. Aceh cattle profile
Aceh cattle are one of Indonesia’s local cattle, which are the genetic resources of Indonesian livestock according to the Decree of the Minister of Agriculture Number 2907/Kpts/OT.140/6/2011. The cattle have been distributed in the province of Aceh and they derived from Indian cattle (Bos indicus), where the nucleotide base composition of Aceh and Bos indicus is equivalent to 94.36% and 88.52% for Bos taurus. Therefore, they are similar to Bos indicus, which implies that Aceh's cattle are from maternal zebu [1]. Furthermore, the relationship between both cattle based on regional analysis of the D-loop mtDNA showed that the dominant hybridization occurred between female zebu cattle and male bulls.

Qualitatively, the colour pattern of the female Aceh cattle in BPTU-HPT Indrapuri was dominated by brick red as shown in Figure 1. Meanwhile, the male cattle were dominated by brick red, which appeared darker at the front as shown in Figure 2 and Table 1. This was consistent with the qualitative characteristics of Aceh cattle documented in the Indonesian National Standard for Aceh Cattle Number 7651.3 of 2013. However, in 2019, 4.59% or 44 male cattle and 1.04% or 10 female cattle had a colour
other than brick red and were later sold as feeders. The colour pattern of female Aceh cattle appeared more uniform compared to the male, with only 1.69% having a colour other than brick red. This result was lower compared to the study that was carried out by [6] which showed that 10% of the female Aceh cattle population in BPTU-HPT Indrapuri had a colour other than brick red. This further shows that the efforts of BPTU-HPT Indrapuri to preserve phenotypic uniformity have been well underway, namely by eliminating and selling the animal that does not comply with Indonesia National Standard (SNI) criteria and selling them as feeder livestock.

Table 1. Aceh cattle colour patterns in BPTU-HPT Indrapuri in 2019.

| Body colour                  | Male | % to male | % to population | Female | % to female | % to population | Total | % to population |
|------------------------------|------|-----------|-----------------|--------|-------------|-----------------|-------|-----------------|
| 1. Brick red                 | 323  | 88.01     | 33.68           | 582    | 98.31       | 60.69           | 905   | 94.37           |
| 2. Colour does not match SNI |      |           |                 |        |             |                 |       |                 |
| White stripes                | 21   | 5.72      | 2.19            | 4      | 0.68        | 0.42            | 25    | 2.61            |
| Albino                       | 3    | 0.82      | 0.31            | 2      | 0.34        | 0.21            | 5     | 0.52            |
| Grey                         | 0    | 0.00      | 0.00            | 2      | 0.34        | 0.21            | 2     | 0.21            |
| Black                        | 8    | 2.18      | 0.83            | 1      | 0.17        | 0.10            | 9     | 0.94            |
| White                        | 3    | 0.82      | 0.31            | 1      | 0.17        | 0.10            | 4     | 0.42            |
| Black stripes                | 2    | 0.54      | 0.21            | -      | -           | -               | 2     | 0.21            |
| Black and white stripes      | 4    | 1.09      | 0.42            | -      | -           | -               | 4     | 0.42            |
| Brownish black               | 3    | 0.82      | 0.31            | -      | -           | -               | 3     | 0.31            |
| Total                        | 44   | 11.99     | 4.59            | 10     | 1.69        | 1.04            | 54    | 5.63            |

Figure 1. Female Aceh cattle at BPTU-HPT Indrapuri.

Figure 2. Male Aceh cattle at BPTU-HPT Indrapuri.

The shape of Aceh's cattle horns in BPTU-HPT Indrapuri varies, ranging from those that are pointed sideways and curved upwards according to SNI criteria, straight to the side, curved downward, shaped like the letter V, have short horns, and have no horns. According to the study carried out by [6] it was stated that 52.68% of female Aceh cattle horns in BPTU-HPT Indrapuri are shaped like the letter V.

In addition, BPTU-HPT Indrapuri is committed to ensuring the quality of the breeding stock in circulation, one of which is through the certification of Aceh cattle products. In 2019, 20 male and 37 female cattle have been registered as SNI certified by the Product Certification Institute (LSPro) of the Ministry of Agriculture. This implies that the cattle had passed the conformity test of the SNI Aceh criteria.
Quantitatively, the body weight and size of Aceh cattle in BPTU-HPT Indrapuri was lower compared to that of Bali, Madura and PO cattle, as presented in Table 2 and 3. This was in accordance with the results from previous studies, which showed that the body weight and size of Aceh cattle at all age levels is lower compared to that of Bali, Madura and PO cattle at the same age, but higher compared to the body weight and size of Pesisir cattle in West Sumatra [2].

Table 2. Comparison of the weight of Aceh cattle in BPTU-HPT Indrapuri with other local cattle breeds.

| Breed        | Birth weight (n) | Weaning weight (n) | Yearling weight (n) | Reference          |
|--------------|------------------|--------------------|---------------------|--------------------|
| Aceh cattle  | 14.71 ± 1.32 (494) | 78.43 ± 17.52 (319) | 100.62 ± 26.18 (317) | Research result    |
| Bali cattle  | 17.8 ±1.08 (150)  | 88.59 ± 16.15 (150) | 131.12 ± 25.50 (150) | [7]                |
| Madura cattle| 19 ± 1.75 (116)   | 97 ± 13.77 (116)    | 120 ± 10.86 (116)    | [8]                |
| PO cattle    | 30.83 ± 3.00 (1133)| 87.23 ± 5.45 (244)  | -                   | [9]                |

Table 3. Comparison of the body size of Aceh cattle in BPTU-HPT Indrapuri with other local cattle breeds.

| Breed        | n     | Shoulder height | Body length | Chest size | Reference          |
|--------------|-------|-----------------|-------------|------------|--------------------|
| Aceh cattle  |       | 56.69 ± 2.84    | 49.89 ± 4.21| 56.59 ± 2.29| Research result    |
| Birth        | 494   | 89.51 ± 5.98    | 86.05 ± 7.04| 100.47 ± 9.37| Research result    |
| Weaning      | 319   | 92.56 ± 6.55    | 91.90 ± 10.25| 108.47 ± 10.49| Research result    |
| Yearling     | 317   | 114 ± 3.00      | 106 ± 4.71  | 120 ± 5.91  |                    |
| Madura cattle|       | 65 ± 3.00       | 53 ± 5.62   | 60 ± 4.28   | [8]                |
| Birth        | 116   | 103 ± 6.67      | 96 ± 7.17   | 113 ± 7.33  | [8]                |
| Weaning      | 116   | 114 ± 2.46      | 106 ± 4.71  | 120 ± 5.91  | [8]                |

3.2. Structure and population dynamics of Aceh cattle
The percentage of female cattle in BPTU-HPT Indrapuri was greater compared to the male as presented in Table 4. This is because of the objective of breeding Aceh cattle in BPTU-HPT Indrapuri is for the production of breeding stock and feeder livestock.

Table 4. Composition and population structure of Aceh cattle in BPTU-HPT Indrapuri 2015-2019.

| Composition | 2015 | 2016 | 2017 | 2018 | 2019 | Heads | %    |
|-------------|------|------|------|------|------|-------|------|
| Sire        | 126  | 150  | 195  | 208  | 188  | 173   | 20.86|
| Dam         | 339  | 340  | 354  | 377  | 428  | 368   | 44.23|
| Young male  | 44   | 70   | 94   | 82   | 92   | 76    | 9.19 |
| Young female| 41   | 64.5 | 84   | 72   | 81   | 68    | 8.23 |
| Calf male   | 69   | 86.5 | 57   | 79   | 87   | 76    | 9.10 |
| Calf female | 67   | 76   | 50   | 72   | 84   | 70    | 8.39 |
| Total population | 687 | 787 | 834 | 890 | 959 | 831 | 100.00 |

The average increase in the population of Aceh cattle in BPTU-HPT Indrapuri from 2015 to 2019 was 8.77 per cent or 68 cattle, as shown in Table 5 and Figure 3. The growth in population is measurable by a net increase, which is referred to as the growth observed by population dynamics and measured from a five-year time series analysis. Therefore, the average change of the population over the last five years is called the net increase [10].
The estimation of the population dynamics of Aceh cattle at BPTU-HPT Indrapuri from 2015 to 2019 using time series analysis was based on equation Y=64.75X+831.1, which showed an increase in the average population by 68 heads or 8.77% per year. Furthermore, this calculation was used to estimate the population dynamics of Aceh cattle between 2020 and 2024, as shown in Table 6. The estimate shows that the Aceh cattle population increased by 65 heads on average or 6.02 percent between 2020 and 2024, with the remain steady of technical coefficient. These technical coefficients include natural increase, percentage of adult cattle, age of first mating, age of culling, length of breeding and mortality rate [11]. In addition, population dynamics are influenced by slaughter, expenditure and income of livestock, initial population, birth and death of livestock [3].

Table 5. Population dynamics of Aceh cattle in BPTU-HPT Indrapuri from 2015-2019.

| Year | Population | Growth |
|------|------------|--------|
|      | Heads      | %      |
| 2015 | 687        | -      |
| 2016 | 787        | 101    | 14.64 |
| 2017 | 834        | 47     | 5.91  |
| 2018 | 890        | 56     | 6.72  |
| 2019 | 959        | 70     | 7.81  |
| Average | 831 | 68     | 8.77  |

Figure 3. Aceh cattle population in BPTU-HPT Indrapuri from 2015-2019.

Table 6. Estimation of Aceh cattle population dynamics in BPTU-HPT Indrapuri based on time series analysis.

| Year | Total | Growth |
|------|-------|--------|
|      | Heads | %      |
| 2020 | 1,025 | 66     | 6.92  |
| 2021 | 1,090 | 65     | 6.31  |
| 2022 | 1,155 | 65     | 5.94  |
| 2023 | 1,220 | 65     | 5.61  |
| 2024 | 1,284 | 65     | 5.31  |
| Average | 1,155 | 65     | 6.02  |
Population dynamics of Aceh cattle in BPTU-HPT Indrapuri increased from 2015 to 2019, despite there was an average cattle mutation of 7.70% or 64 heads and an average mortality of 7.42% or 60 heads. Furthermore, the Aceh cattle mortality rate at BPTU-HPT Indrapuri for 5 years is still relatively high, exceeding the key performance indicators set by the Directorate of Breeding and Animal Production, Ministry of Agriculture for UPT Nursery number 25006/TU.020/F2.2/07/2019, where the cattle mortality rate is ≤ 3% of the population per year. High mortality and low productivity of livestock can slow down the growth of populations [12]. Therefore, the increase in population in BPTU-HPT Indrapuri probably occurred due to the high birth rate, which was an average of 24.85% or 205 individuals annually [13].

The difference between the birth and death rate over a period of one year is called a natural increase [14]. The natural increase of Aceh cattle at BPTU-HPT Indrapuri in 2019 was in the medium category, (19.08%) [15]. This demonstrates that the population dynamics of Aceh cattle in BPTU-HPT Indrapuri could increase. The efforts to increase population development can be made by increasing the natural increase, i.e. increasing the birth rate and reducing the livestock mortality rate. This is because when the natural increase is low, there would be no population increase. In addition, natural increase is also achievable by keeping the productive females in the population and culling the unproductive females, particularly older female [10]. It is therefore important to control replacement breedstock to maintain the balance of the population.

Replacement cattle can be calculated by the net replacement rate (NRR). The NRR is used to describe the births that can be able to cover the need for replacement breedstock to remain the population constant [4]. The NRR of Aceh cattle at BPTU-HPT Indrapuri in 2019 have fulfilled the needs of replacement cattle since the NRR value for males and females were 240.08% and 173.33%, respectively [15]. This implies that the replacement stock of male and female over the needs by 140.08% and 73.33% respectively. This result was supported by statement of [10] when NRR is < 100%, the need for replacement stock is not fulfilled and vice versa. Thus, the remaining stock used for replacement stock and culling (output) may therefore be issued as output without disrupting the balance of the population [14].

In 2019, the output value of Aceh cattle at BPTU-HPT Indrapuri was the same as the NI value (19.08%) which consisting of 5.49% males and 4.09% females of the remaining replacement stock and, 3.92% male and 5.58% female of the culling cattle [15, 16] so that the population can be balance. Based on the output value and the estimated population dynamics of Aceh cattle in BPTU-HPT Indrapuri as presented in Table 6, it was estimated that from 2020 to 2024 there will be an increase in the average output amount of 220 ± 19.53 heads along with the increase in population. Furthermore, the most optimal output value of the livestock population was the same as the NI value, which implies that when the livestock output value is lower than the NI value, there will be an increase in population and vice versa [4]. Therefore, to improve the development/population dynamics of Aceh cattle in BPTU-HPT Indrapuri, the output value should be considered.

4. Conclusion
The results of this study are expected to increase the knowledge on how to detect and predict population dynamics in a limited population. This is because population dynamics are generally predicted over a wide and varied coverage area. In addition, population dynamics estimation may also be used as a basis for determining the number of livestock that should be removed without affecting the Aceh cattle population balance in BPTU-HPT Indrapuri.

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