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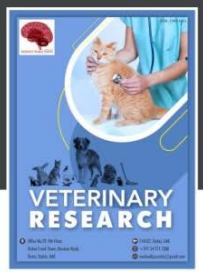

Analysis of the Development of Bali Cattle Population in Pasture Agroecosystem of Timor Island

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Key words: Systemdynamics, Bali cattle population, pasture agroecosystem, lirestock, cattle

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Abstract: This research aims to project the development of Bali cattle population in the Timor Island pasture agroecosystem with a dynamic model for 75 years. The material used is Bali cattle (50 head of Bali cattle) with 12 months of research time from January-December 2018. Farmers and research locations were selected purposively based on criteria such as physical (land area), biology (agroecosystem) and social which generatessampling locations representing pasture located in the district of Belu, Malaka and Timor Tengah Utara. Respondents determination 5-10% of the number of farmers in theagroecosystem with the number of Bali cattle >10 cows (127 respondents). Respondents were interviewed using prepared questionnaire. In addition to interviews, field observations were also carried out. This research data uses primary data documentation. Data analysis uses a system dynamics approach with the help of powersim 2.5 software for windows. The results showed an increase in the population of Bali cattle will not reach it's maximum point until the next 75 years if managed according to the existing conditions as applied, so far. Therefore, a strategy is needed to increase the population of Bali cattle by increasing livestock reproduction status and limiting the export/sale of Bali cattle in and out of the agroecosystem.

INTRODUCTION

Most national beef needs (60%) are concentrated in the provinces of DKI Jakarta, Jawa Barat and Banten which are referred to as the main consumers of national beef needs. The need for cattle to be slaughtered in these three regions reaches 750 cattle per day which is supplied by imports from Australia and brought in from the

provinces of Jawa Timur, Jawa Tengah, Bali, Nusa Tenggara Barat and Nusa Tenggara Timur (NTT). Bali cattle contribute ±26.9% to the supply of slaughtered cattle and one of the highest Bali cattle supplier areas for slaughter is Bali cattle from the province of NTT[1-3].

The central of Bali cattle production in NTT is the island of Timor with a population distribution reaching 65.97% of the total cattle population in NTT under limited feed conditions due to long drought season[4-6].

The existing exporting of Bali cattle from Timor Island to consumer areas, if it does not take into account the capability of the region will certainly speed up the degradation of cattle population for several reasons, namely; high calf mortality (35-40%) per year; high female parent mortality (>20%) per year; high number of productive females slaughtered at slaughterhouses (>60%) of the total number of cattle per day; long dry season (±8-10 months) causes feed quality and quantity limitations; traditional livestock farming systems with low production inputs Timor Island is endemic to brucellosis and anthrax with a high prevalence (<40.76%) in the last 10 years (2010-2020); weak supervision of cattle exports which causes the realization of exports higher than April 30, 2020 the stipulated quota; a decrease in the body weight of export/sale cattle out of NTT where in the 1970-1980s the body weight of cattle reached 450-275 kg/head starting in 2010[1-3, 7-10]. Meanwhile, the NTT Provincial Government continues to send cattle out of NTT between 55.000-63.000 cattle per year by implementing a quota system based on NTT Governor Decree No. 207/Kep/HK/2012 concerning Export Quota of Beef Cattle.

The population of Bali cattle is very affected by the population structure starting from born, growing into the phase of young and mature until culling, whilst mortality, calf crop and sales are also happening during every phase of growth and development. Jay W Forester in the 1950s introduced one analytical tool that connects various kinds of variables that influence each other (causal loop) which is named system dynamics analysis tool, namely information sources and information flow networks that are interconnected to form structures information system. Yani[11] explains that systems dynamics are methods that can describe as the process of behavior and complexity arising from the cause and effect of various variables in the system, thus, this research was designed using a system dynamics analysis to project the growth and development of Bali cattle population for the next 75 years using a system dynamics modeling of Bali cattle population.

MATERIALS AND METHODS

The research was conducted on Timor Island of NTT with a 1 year pasture agroecosystem for the object of research, conducted from January to December, 2018. The location/area of research determination was selected purposively based on criteria namely physical (land area), biology (availability and population of Bali cattle) and socio-cultural such as the condition of farmers in the target location and policies that support the Bali cattle program on Timor Island which generates sampling locations representing pastures are located in the District of Belu, Malaka and Timor Tengah Utara.

The research material used was 50 head of Bali cattle, involving respondents of 5-10% of the total number of Bali cattle farmers (127 respondents) who had >10 head of Bali cattle and domiciled at the research location. Respondents were interviewed using a prepared questionnaire. In addition, to interviews, field observations were also carried out. This research data uses primary data.

Data processing and analysis using the Powersim 2.5 program for windows. The model is developed through a system approach method. The phase of making analysis and simulation models are: Identification of problems, objectives and limatation conceptualization of the model model specifications; model evaluation use of the model.

RESULTS

Identification of problems, objectives, and limitation: Structure model of Bali cattle population in thepasture agroecosystem of Timor Island consists of elements such ascattle population (calf, young, adult, culling) that are influenced by internal factors such as cattle (mortality, calf crop, pregnancy, breast feeding and age of production) and external factors (farmer, cattle sale and environment).

Model conceptualization: Conceptualization of the model connects the identified components and their interrelation using a causal loop presented through Fig. 1. Figure 1 explains that in the main model of Bali cattle population onthe pasture agroecosystem of Timor Island the main focus is the population of Bali cattle and productivity which has a causal loop with various factors.

Model specifications: The relationship marked with arrows is then converted into numerical equations with clear units in the time variable as presented in Fig. 2. This stage is carried out by the quantification

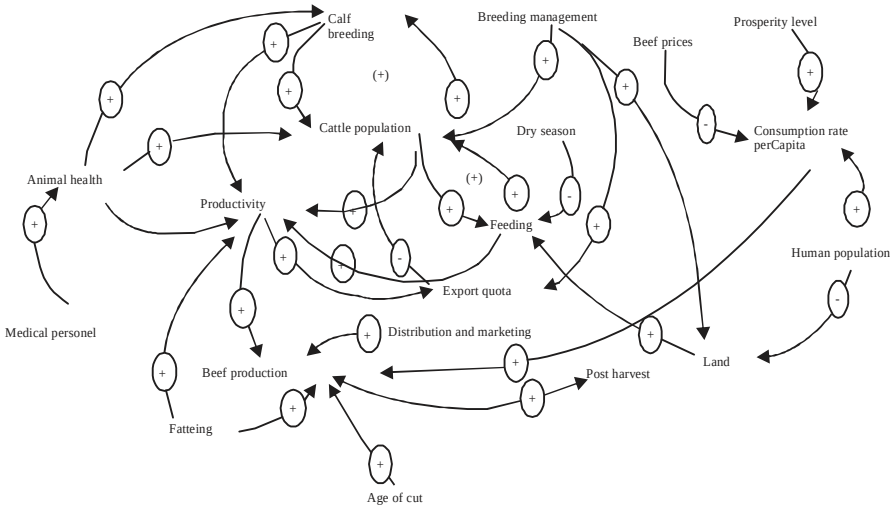

Fig. 1: Bali cattle population model

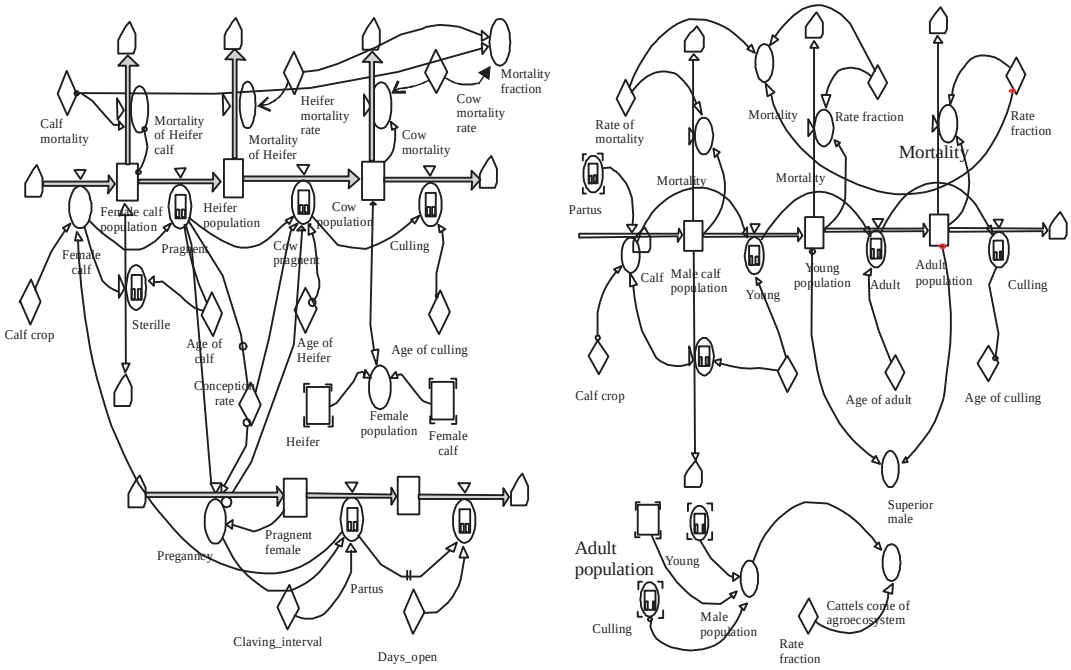

Fig. 2: Model of Bali cattle population: (a) Model of female Bali cattle populatn; (b) Model of male Bali cattle population

of the model by referring to the causal loops which can then be simulated with a software of systems dynamics.

The Bali cattle population model in the pasture agroecosystem of Timor Island is very influenced by calf crop and mortality of livestock, age distribution, cattle that leave the agroecosystem and the reproductive status of female Bali cattle. The better the condition of the reproductive status of female Bali cattle influences the increase in the population of Bali cattle (natural increase). Information and data used in the system dynamics model for existing conditions of the population are presented in Table 1.

Model evaluation: Evaluate the model for the relative usefulness of the model with special objectives[11, 12]. A model is useful specifically for only one purpose and can not be used for other modeling purposes. Evaluation

Table 1: Existing conditions of Bali cattle population in 2018

Data of populatin model	Sex	
	Female	Male
Number of Bali cattle population (tail)		
Calf	119	137
Young	233	352
Adult	425	405
Culled	55	49
Total	832	943
Situation of female reproduction		
Pregnancy	20	-
Partus	40	-
Breastfeeding	85	-
Fraction of influence factors (%)		
Ratio of calf crop	55.2	44.8
Mortality		
Calf	37.2	31.9
Young	18.5	9
Adult	13.6	4,7
Conception rate	50.3	-
Cattle out agroecosystem		
Female of culling	8	-
Male of culling	-	30
Steer	-	24
Adult	-	35
Fraction of times production (month)		
Age of calf	6	6
Age of young	20	18
Age of adult	72	67
Age of culling	86	84
Days open	21	-
Age of pregnancy	9	-
Data processed 2019		

Table 2: Model evaluation

Models	Logic	Comparison of model behavior with expected patterns
All model	Yes	Compatible
Sub model of female Bali cattle population	Yes	Compatible
Sub model of male Bali cattle population	Yes	Compatible

of the model is done by comparing the expected behavior of the model to the behavior of the existing conditions, so as to form a logical parameter like the interaction of relations between elements to form the overall model[13]. The results of the model evaluation are presented in Table 2.

The development of the female cattle population is influenced by the rate of female calf crop that will grow and develop into young and adult females. Physiological changes and body functions of young and adult females causes the reproductive ability (pregnancy and partus) of female cattle to increase the population of cattle. However, the reproductive status of female cattle is influenced by reproductive performance such as conception rate, calving interval and age of production. In addition, the existence of a mortality factor in each structure of the female cattle population is very significant in decreasing the population of Bali cattle. These data and information are then simulated into the model to obtain the results of the same female Bali cattle population between the real world and the expected behavior. The conclusion of this female cattle population model can be said that this model is very logical.

The development of the male cattle population is influenced by the structure of the male population that will grow and develop until it becomes a culling cattle. Meanwhile, the availability of males as main beef cattle is influenced by the rate of calf crop, mortality and productive age of males. The calf crop of males is influenced by the population of females giving calf crop and the calf crop of these males influences the increasing rate of the population of Bali cattle on Timor Island. These data and information are then simulated into a model so that the results of the male Bali cattle population are the same between the real world and the expected behavior. The conclusion of this population model is very logical. Zainuddin *et al*.[14] and Maier *et al*.[15] explain that the model is not intended to prove whether a projection will be appropriate but the model is intended to find a way that is reasonable, credible and relevant.

The purpose of designing a model in this research is to determine changes in the population of Bali cattle in the pasture agroecosystem of Timor Island using a system dynamics. In general, the model can be used and useful for resource management that focuses on the population of Bali cattle.

DISCUSSION

Model usage: The policies in the model are at least able to answer the goal-setting of the issues studied and support the study's objectives so that the modeling of the system dynamics applies the projected results. The results of modeling will produce dynamic changes in the system.

Model usage to female population: This simulation applies if the population of female Bali cattle in the pasture agroecosystem is managed according to data and information that has been available or previously processed (business as usual). The results of simulations carried out on existing conditions periodically (75 years) are presented in Fig. 3.

The system dynamics simulation results show that if the farmers and stakeholders continue to conduct Bali cattle farming according to the existing conditions in the period of the next 20 years there will be a significant decrease in the female Bali cattle population, the next gradually increase starting from the 25th period. Bali cattle farming activities like this show that farming activities are not effective and efficient.

Increasing number of female calves that are born can lead to the overall increase to the female population of young and adult but the affect on supporting the increase

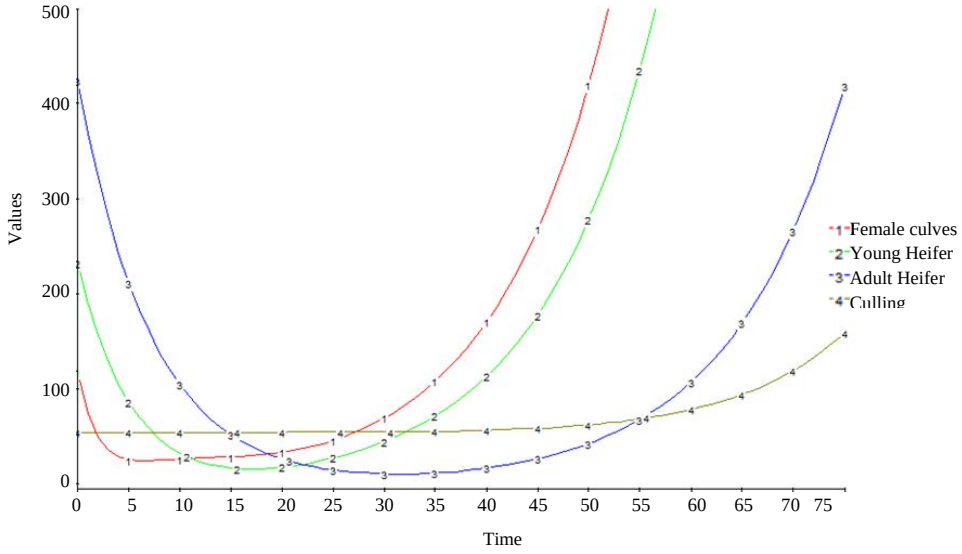

Fig. 3: Simulation diagram of female Bali cattle population for 75 years

of population structure is relatively small for several reasons namely: calf mortality is very high (37.2% per year); high female parent mortality (16.05% per year) long calving interval of female parent cattle (2.5 years) despite having a high conception rate (50.3%) and the age of productive females giving calf crop to a fairly old calf (1.9 years). The simulation results are in accordance with the opinion by Tanari *et al*.[16] which states that the low value of natural increase can affect the need for the seedling as a potential replacement stock and increase the number of livestock (supply) owned by an area. Kusuma *et al*.[17] states that the magnitude of the natural increase is greatly influenced by the large number of livestock mortality in the population where the higher the mortality rate, the more the natural value decreases and vice versa if the mortality rate is lower the natural increase will increase. Budiawan etc. and Crowe *et al*.[18] states that long calving interval are mostly caused by unweaned calves which prolonge the first postpartum, the farmers mating their livestock for a long time, high chances of mating failure causes high service per conception and the first age of females in slow conception.

Scenarios to improve the condition of existing Bali cattle farms in the pasture agroecosystem of Timor Island can be done by reducing the mortality of a parent and females calves and shortening the calving interval value. Priyanto *et al*.[19] and Priyanto[10] explained that improving the productivity quality and quantity of Bali cattle can be done by shortening calving intervals, saving productive females, delaying the slaughtering time of Bali cattle and implementing artificial Insemination (IB) controlled conception to increase conception rate value.

Model usage to male population: This simulation applies if the population of male Bali cattle in the pasture agroecosystem is managed according to data and information that has been available or previously processed (business as usual). The results of simulations carried out on existing conditions periodically (75 years) are presented in Fig. 4.

The simulation results in Fig. 4 show that during the next 19 years there will be a decrease in the population of male calves, followed by a decrease in the population of young cattle, the population of adult cattle, thus affecting the decrease in the number cattle of culling. The main factor of the decline in male cattle population is the high mortality rate of male calves is, reaching 31.9% per year and the high rate of export/sale in and out from agroecosystems (an average of 29.5% per year). Some researchers report that the value of natural increase in the population of Bali cattle on the island of Timor NTT is still low due to the high calf mortality (35-40%) and high female parent mortality (>20%) in the population[7, 8].

Thus, the population size is closely related to the number of populations (male and female), calf crop and mortality in an area that affects the value of natural increase where if the high natural increase value indicates the area has a number of productive female livestock and its handling and management is good and vice versa if the high mortality rate will reduce the value of natural increase and become more degradation of the population if the female reproductive status is low[10, 17, 20, 21]. Meanwhile, livestock export/sale from an area that does not take into account the region's ability will accelerate the rate of population disappearance[22, 23].

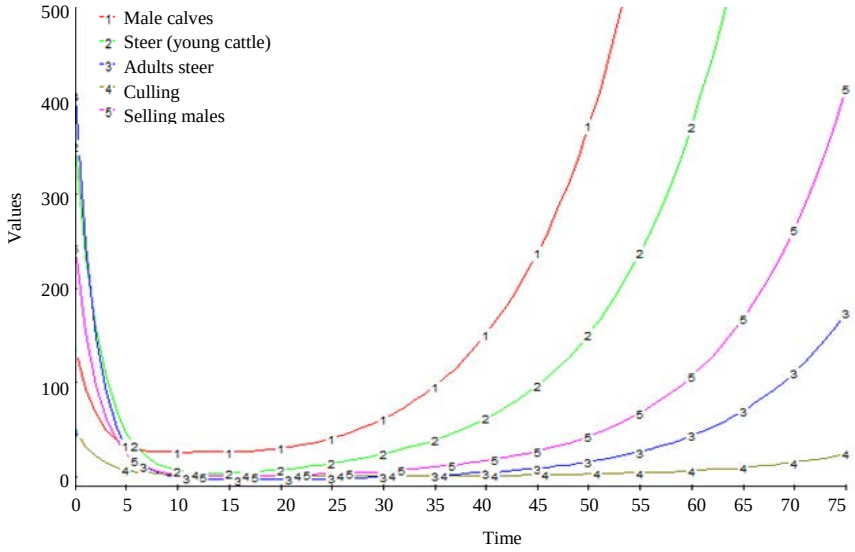

Fig. 4: Simulation diagram of male Bali cattle population for 75 years

Management implications: Based on the simulation results that have been built based on existing condition data in the pasture agroecosystem of Timor Island, there is a decrease in cattle population over the next 19-20 years. Repairing the existing condition of Bali cattle population can be done by regulating the breeding pattern through calf crop inventory, natural increase population every year, population structure based on age group and the fertility status of Bali cattle in agroecosystem areas as a prospective seed supply, limiting export/sale of cattle from agroecosystems according to their output value, improving feed quantity and quality. Some researchers claim that improvements in productivity of Bali cattle in terms of population can be done by reducing calf mortality and increasing calf crop value, increasing the use of superior male or artificial insemination and limiting livestock export/sale from agroecosystems[10, 19, 25-27]. Some of the policy recommendations that can be given from the results of this simulation are:

Farmers and regional governments in trying to increase the population of Bali cattle in pasture agroecosystems can be done with a technical approach including: preventing livestock mortality, increasing the value of natural increase and calf crop, shortening the calving interval value and the value of days open and restrictions on spending cattle from agroecosystems.

Socialization and enforcement of the rule of law from Indonesian Law No. 18 of 2009 which has been revised to Indonesian Law No. 41 of 2014 concerning Animal Husbandry and Animal Health, mainly related to the stability and continuity of livestock populations in one region. This stage is followed by periodic monitoring to ensure that violations do not occur.

The government and stakeholders need to review strategies for overcoming and eradicating endemic diseases in a region-based manner. In addition, the limited availability of productive females in agroecosystems is also accompanied by the fertility of females which is still low so it is necessary to carry out strict supervision of the actions of slaughtering productive females, so as not to add significance to the decrease in the value of natural increase.

Entry of female cattle stock in pasture agroecosystems of Timor Island needs to be managed in good breeding practice. This treatment will help reduce the risk of loss of mortality and of existing females. The results can be obtained with good quality which henceforth can be developed as brood stock or even cattle ready for slaughter at the age of culling cattle.

Development of an information system for recording and planning population stock through integrated animal pregnancy between stakeholders that makes it easy to identify livestock. The local government also needs to work to improve the status of livestock reproduction, so as to accelerate and improve the quality of Bali cattle breeds in the pasture agroecosystem of Timor Island.

CONCLUSION

Based on the results of the analysis, simulation of current data and projections over the next 75 years can be concluded that the population of Bali cattle in pasture agroecosystems will decrease significantly over the next 19-25 years. Some factors are the high mortality of male and female livestock, low reproductive status of females, and the amount of livestock export/sale that does not take

into account the ability of agroecosystems. The repaired policy recommendations are: The Local Government encourages the development of a cattle farming industry (on-farm) that has not been intensively worked on to increase the population of male cattle and optimize the capacity of females; The quality of pasture agroecosystems of Timor Island needs to be improved, the technical approach taken in the agroecosystem is in line with regional development targets through continuous repair activities and Improved performance of farmers (individuals and groups) in pasture agroecosystems to support increased productivity and population of Bali cattle; further research needs to be done using more complex system dynamics methods that connect sub-models such as the population sub-model toward cultivation sub-model, the feed sub-model and the epidemic sub-model.

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