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Growth Allometry among the Rabbit of Amoron i Mania

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Abstract The rabbits have a special feature for adaptation to the different types of food and climate. In addition, the composition of food and the mode of farming have a consequence to the mode of growth and body composition of the rabbit. In Madagascar, the research focused on rabbits is very rare. In this case, we found an absence of documents of reference concerning the growth of existing rabbits in the region of Amoron i Mania. A thorough research for the biological characteristics of these existing breeds is desired in order to improve this field. Then the objective of this study is to understand the type of rabbit growth in this region of study within a mathematical equation. During the conduct of this study, 1052 rabbits from the 100 family farms are measured. For the population of the rabbit measured in this region, the global allometric coefficient is 2.32 which is significantly equal to the theoretical allometry (b = 3), equivalent to an isometric growth. Therefore, the increase in weight is evolving in parallel with the increase in the length. The result by race has always shown the same type of growth except the blue of Vienna variety which presented a negative allometric growth. The distribution of samples by sex and by district has also figured this type of isometric growth. This type of growth belongs to rabbits which reach slowly its weight. This state of slow growth could be a result of the practice of an extensive and traditional breeding system which generally stands on a poor diet to the rabbit. Then this study allows establishing a tool to estimate the weight of the rabbit from the total length. The equation $LW = 0{,}3558LT^{2{,}3224}$ was chosen as a model of allometric equation applicable to livestock.

Keywords Growth, Allometry, Rabbit, Amoron i Mania, Madagascar

1. Introduction

Particularly, the feeding of rabbits concerns their breeder, but it only represents a factor of the economic success [8]. The digestion of rabbits is very special by the practice of caecotrophy. In addition, the rabbits can adapt themselves into various food environments, from desert to the temperate climate and where even cold [5]. While the mode of livestock is likely to change the quality of the rabbits on the body shape and the live weight at the sale [7], it seems to us to retain that amendments to the performance of rabbits can actually be obtained by modifying the composition of the Food [9].Therefore, the mode of rearing and feeding directly affects the growth of rabbits. Then the growth of an animal corresponds to the increase in size and its weight as well as to the changes in shape and body composition that are to be correlating [14]. The allometric growth of the species can be designed by estimating the live weight of the individual from the length [16].The allometric growth is an essential element for the management of animal resources but also a tool to guide the work to the selection of animals for rapid growth.

The rabbit is a species less studied in Madagascar. In the region of Amoron i Mania, the workable data for the population of farmed rabbits is missing. The description of the growth of rabbits encountered is still unknown up to now. The development of this sector requires a higher knowledge concerning of the biological characteristics to the currently existing variety. The objective of this study is to understand the type of growth of rabbits in this region studied from a mathematical model. This method allows analyzing the evolution of the rabbit weight growth in function of its total length. The methodology adopted during this study includes the measurements of the rabbit within 100 family farms in the region of Amoron i Mania. Facing the lack of knowledge in biological characteristics, the general work assumption assumes that the existing rabbits in Amoron i Mania region present a type of slow growth.

2. Materials and Methods

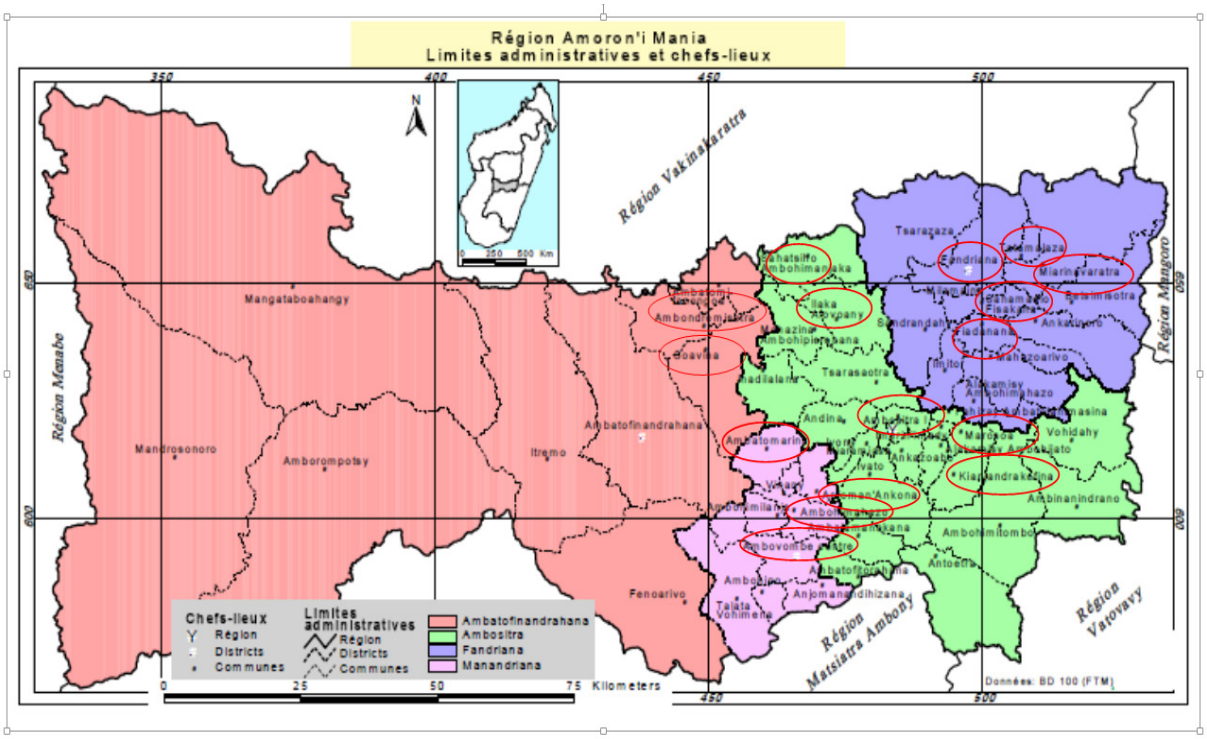

Figure 1. Map of the Amoron i Mania region: administrative limits and heads-places including the investigation sites (Source: pcd, 2003, improved by the author)

2.1. Survey Location

The Region of Amoron i Mania is located in the Southern central part of the Highlands of Madagascar which altitude varies from 1200 to 1500 meters in the eastern part (Ambositra, Fandriana, Manandriana), from 700 to 1000 meters on the plains and up to 2000 meters on the massifs of the Western Area (Ambatofinandrahana). The region is bounded within 45°7'West and East longitude, and 19°8' to 21°0' South latitude. It is a part of the former province of Fianarantsoa. The town of Ambositra is located at 250 km south off Antananarivo, on the Number 7 national road and approximately at 150 km north off Fianarantsoa. The region is composed of four sub-prefectures: Ambatofinandrahana, Ambositra, Fandriana Manandriana and [13].

2.2. Sampling

The values of the biological parameters have been collected by surveying of rabbits with 100 family farms in the region of Amoron i Mania. The measurements are carried out from 05 March to 20 April 2013. The affected measurement concern of 971 individuals belonging to 9 varieties (Alaska, Blue of Vienna, Gray of Vienna, Giant of Bouscat, Fawn of Burgundy, Californian, local race, Chinchilla and Angora) and have established a database with two variables (live weight and total length).

2.3. Measurement of Biological Parameters

As soon as the owners of rabbits in study have accepted the survey, a person held the animal in order to measure the biological parameters. The collection of live weight (LW) has been carried out using an electronic scale (Mark KERNE brand) authorizing a maximum load of 6,000g at a precision of only 1 decimal of 0.5g. The measurement of the total length (TL) has been made with a 150cm ribbon tape measure at precision of 1mm unit. To have the total length, rabbits have been measured from the end of their nose up to the end of their tail.

2.4. Database Worksheet

At first time, the procedure of the data query was performed to delete the missing data and the clearance of data has been realized to eliminate the outlier data. After sorting and clearing data, the database obtained includes 2 columns of variables (live weight and total length) with 971 records that make sense to the studied individuals.

2.5. Weight-length Relationship

According to Tomanova S. and al. [16], it is not necessary to determine the weight of the individuals on the ground because we can estimate it from their length, if allometric relations length/weight known for each species. These relationships can be defined for the samples that are greater than or equal to 20 in order to compile the growth of the species [4], in Aliko N'G. et al. [1]. A similar correlation can be encountered during the growth phase of the animals as well as in rabbits. These relations applied on an animal were conformed to the model of allometric growth following the formula described by Bertalanffy L. V. [2]: The weight is

proportional to the volume of the animal which corresponds to the cube (allometric exponent) of the length. The relationship of size-weight is expressed by the following formula (1):

$$LW=aTL^{b} \quad (1)$$

Where
LW: live weight
TL: total length.
a: proportionality coefficient
b: allometric coefficient

Concerning the application of this relationship in rabbit, the value of b explains the type of growth. The growth is called isometric if b=3. In this case, the growth in weight is equal to the growth in the size. And the growth is called then allometric if b≠3. If b< 3, growth is negative allometric, which means that the growth in weight is less than the growth in size; if b> 3 growth is positive allometric or growth in weight is greater than the growth in the size. The t test by Student was applied to check if the values of b differ significantly from the number of 3, [17].

2.6. Statistical Processing

The designed database has enabled to proceed out the analysis of adjustment to Y as a function of X. This function is applicable to the equation of allometric growth for animals in estimating the weight from the total length according to the formulae (1). The analysis has been carried out with considering that the live weight of the animal concerned has therefore been the explained variable and the total length of the rabbit has been the explanatory variable. The description of the adjustment to the values of the two variables is shown by a power curve. The application Microsoft Excel 2013 has been used to compile the analysis of adjustment that allows determining the coefficient of proportionality a and the allometric coefficient b. The value of t is calculated as follows (2):

$$t_{calculated} = \frac{|b-3|}{\text{Standard deviation (b)}} \quad (2)$$

Where
b: allometric coefficient

3. Results

For the total population of rabbits *Oryctolagus cuniculus* measured in the region of Amoron i Mania, the total allometric coefficient is 2.32 (Table 1). This value is less than the theoretical allometry (b=3). According to the t test by Student, the value of t is computed at less than 3. The difference between the **calculated t** and the **theoretical t** (t = 3) is therefore not significant. All these mean that the value of b from the total population is identical to the value of theoretical allometry (b = 3). The type of growth in the total population is therefore isometric. The growth in the size is identical to the growth in weight.

Table 1. Rabbits Size-Weight Relationship by typological Group

			Model	Growth Parameters			Statistical test		
N°	**Variety**	**n**	**$LW=aTL^{b}$**	**a**	**b**	**R^2**	**t**	**Signification**	**Growth type**
1	Alaska	25	$LW= 0,54TL^{2,223}$	0,54	2,222	0,83	2,202	NS	I
2	Angora	9	$LW = 0,0217TL^{3,078}$	0,021	3,078	0,92	0,221	NS	I
3	Bleue de vienne	15	$LW = 9,3518TL^{1,3797}$	9,3518	1,379	0,81	4,587	S	A-
4	Race locale	136	$LW = 0,2022TL^{2,4876}$	0,2022	2,487	0,85	1,452	NS	I
5	Géant de Bouscat	285	$LW = 0,2535TL^{2,4176}$	0,2535	2,417	0,82	1,650	NS	I
6	Chinchilla	250	$LW = 0,2486TL^{2,4212}$	0,2486	2,421	0,86	1,638	NS	I
7	Gris de Vienne	137	$LW = 0,7863TL^{2,0912}$	0,7863	2,091	0,75	2,572	NS	I
8	Fauve de Bourgogne	32	$LW = 0,6848TL^{2,149}$	0,6848	2,148	0,78	2,411	NS	I
9	Californienne	64	$LW = 0,1223TL^{2,6218}$	0,1223	2,621	0,81	1,072	NS	I
10	Mâle	366	$LW = 0,401TL^{2,2789}$	0,401	2,278	0,81	2,043	NS	I
11	Femelle	605	$LW = 0,3597TL^{2,3248}$	0,3597	2,324	0,82	1,913	NS	I
12	Ambositra	209	$LW = 0,3666TL^{2,3302}$	0,3666	2,330	0,84	1,896	NS	I
13	Fandriana	184	$LW = 0,7273TL^{2,1345}$	0,7273	2,134	0,78	2,451	NS	I
14	Manandriana	129	$LW = 0,2527TL^{2,4175}$	0,2527	2,417	0,87	1,650	NS	I
15	Ambatofinandrahana	83	$LW = 0,086TL^{2,6965}$	0,086	2,696	0,82	0,860	NS	I
16	Total Population	971	$LW = 0,3558TL^{2,3224}$	0,3558	2,322	0,82	1,919	NS	I

LW: live weight, TL: total length, n: number of individuals, a: the constant of proportionality, b: allometric coefficient, R^2: coefficient of determination, t: t calculated, S: Significant, NS: not significant, I: isometric growth, A-: negative allometric growth.

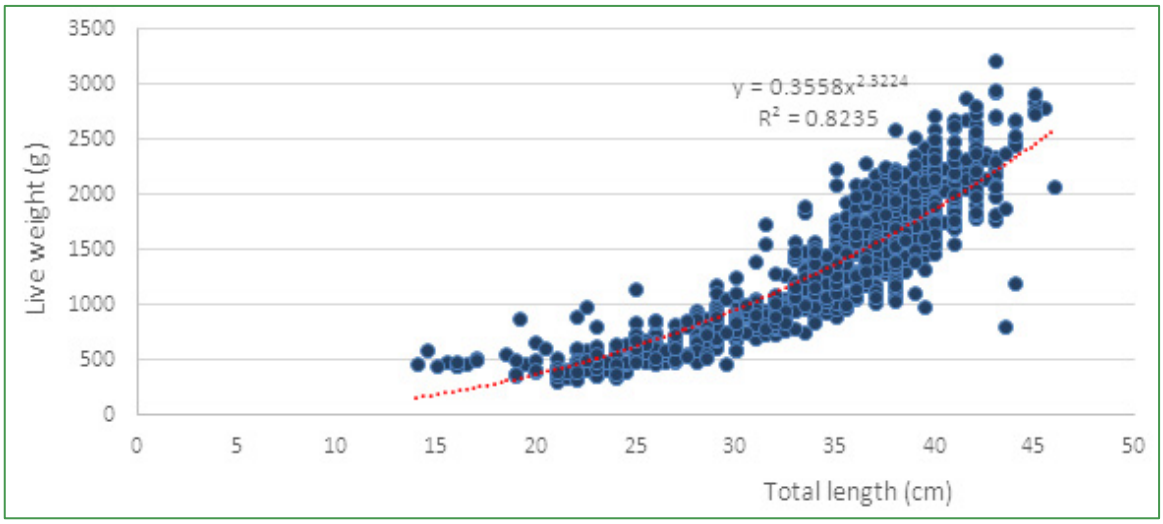

Figure 2. Weight-Length Relationship of the total population of the rabbit in Amoron'i Mania

The separation by variety of the samples has given three types of value. The value of coefficient b is more important for the Angora race (b = 3.07). This value is lower for the blue of Vienna race (b = 1,379). For the other races, the value is around 2. This implies that the value of b is different for the 9 races considered. This difference could be due to a slight inequality of growth speed between the 9 races encountered. According to the result of Student's t test at the materiality level α = 0.05F for breeds Alaska, Gray of Vienna, Angora, local, Giant of Le Bouscat, Chinchilla, Californian and Fawn of Burgundy, the allometric coefficients b have presented values significantly identical to the theoretical allometry (b = 3) (Table 1). This coefficient takes the value of 2.22 for Alaska's, 3.07 for Angora's, 2.09 for Gray's and 2.62 for Californian's, 2.48 for locals, 2.14 for Burgundy's. The type of growth recorded for these breeds is isometric. Therefore, the growth in weight of these eight races is identical to the growth in the size. By contrast, the result of Student's t test of the Blue of Vienna race has exposed that the values of b is significantly lower than the theoretical allometry (b<3). This allometric coefficient takes the value of 1.37. The type of growth of the Blue race of Vienna is then negative allometric (Table 1). This result explains that the growth in weight of this race is less than the growth in the size.

4. Discussion

The relationship between the length of the body and the weight of the rabbits total population presents a strong and positive correlation (r = 0,884). That result means that the increase in weight also entails a substantial evolution of the length in the rabbit. The value of R^2 indicates that the variation in live weight of rabbit is explained at 82%. The best coefficient of determination is observed in the Angora race ($r^2 = 0.92$), while the lowest is encountered in the gray of Vienna race ($R^2 = 0.75$). This indicates that the variation in live weight of rabbit is explained at 92% for the Angora race. But the equation n°3 corresponding to this value represents only 9 individuals. Therefore, we cannot take this equation as the best model.

For the different categories of individuals studied, the value of the allometric coefficient varies from 1.37 to 3.07. The allometric coefficient of the total population is equal to 2.32. The growth of the total population of the rabbit studied is an isometric type of which the increased weight is proportional to the increase in the total length.

This result of the recorded allometric coefficient in this study (b=2.32) is significantly lower than those of Ouhayon J. [11] relating to body composition with a value of allometric coefficient of adipose tissue equal to 3.21 (b > 3) and to those of Bourehail N. [3] on the study of the age, growth, and reproduction of the Baracuda sphysaena viridensis from the Algerian coastline with a value of b=3.13. This result is consistent with those of Aliko N'G. [1] (b=3.07) on the characteristics of the Distichodus rostratus population from the Taabo Lake. By contrast, this b value found in this study is superior to that of Sallami's and al. [15] who have found values lower than 3 on their study for allometric relationship between the length of the fish and the size of the otolith among three anguillifores the northern Tunisia coast.

Some authors argue, by their previous research, the existence of a consequence from the feeding mode to the body composition of the rabbit. According to Robelin J. [14], the levels of feeds or the mode of different livestock have been able to influence more or less the evolution of the body composition of the animals. And also, the diet has been carried according to the objective to change the body composition [10]. The rabbits quickly reaching a given weight (rapid growth) have characteristics assets that are different from those which earn slowly this weight (slow growth) [12]. By deduction, the body composition of the rabbits recorded in this study is corresponding to an isometric growth that is appropriate to the rabbits slowly reaching its weight. This confirms the research hypothesis stating that "the existing rabbits to Amoron i Mania are experiencing a slow growth". This slow growth recorded may be due to the results of the practice of extensive and

traditional breeding, and the adaptation to the non-balanced feeding in this region studied.

In the four districts (Fandriana, Ambositra, Manandriana and Ambatofinandrahana), the growth recorded is an isometric. This similarity could be due to the similarity of the composition of the breeds. They are dominated by the local breeds, the Giant of Le Bouscat's and the Chinchilla's (more than 65%). These are preliminary breeds identified in this isometric growth study.

In general, a little part of research has been conducted on the morphometry of the rabbits. The advantage provided by the present study is to establish a tool for the estimation of weight from the total length. The allometric models provided here can find applications in livestock. The equation n°1 "$LW=0{,}3558TL^{2{,}3224}$ " has been chosen as the model of allometry equation for rabbits in Amoron i Mania region. Two reasons allow this choice. At first, this equation has used a maximum number of individuals (n=971). And secondly, this equation has a high coefficient of determination ($r^2 = 0.82$), which means that 82% of the variability in the live weight has been well explained by the total length. In addition, the reliability of this equation is justified by a strong correlation between body weight and total length (r = 0,884). Finally, to complete the biological knowledge of existing breeds, it would be interesting to complement this parametric study of growth by a study of genotypic evolution since the first race import up to present.

5. Conclusions

The development of this field requires a comprehensive study on the biological characteristics of currently existing breeds. The study mentioned that the growth of rabbits recorded in the region of Amoron i Mania was an isometric type of which is appropriate to the rabbits that are slowly reaching their weight. This situation confirms the research hypothesis stating that the existing rabbits in the area show a slow growth because of the farming practice that stands on extensive and traditional method. This study has permitted to establish a relationship between the biological parameters such as body weight and the total length by the compilation from a mathematical model. The determination of this relationship can help the breeders on the control of weight of the animals in the case of absence of the weighing equipment. This relationship of live weight and total length is an exponent function $LW=0{,}3558TL^{2{,}3224}$ meaning the total length of the rabbit increases with the increase of the live weight. The parameters a and b provide information on variations of live weight with the total length. It seems to be relevant to supplement this parametric study of growth by an applied research directed to the genetic characteristics of existing rabbits in Amoron i Mania.

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