Journal of Animal Science and Veterinary Medicine
Volume 10(1), pages 35-40, February 2025
Article Number: 7AA82DDB7
ISSN: 2536-7099
https://doi.org/10.31248/JASVM2024.526
https://integrityresjournals.org/journal/JASVM
Full Length Research

Growth rate and body size mapping of male Bali cattle during fattening phase

I Putu Sampurna[1]*, Tjokorda Sari Nindhia[1] and Ni Luh Putu Sriyani[2]

[1]Laboratory of Biostatistics Faculty of Veterinary Medicine, Udayana University, Bali, Indonesia.
[2]Faculty of Animal Science, Udayana University, Bali, Indonesia.

*Corresponding author. Email: putu_sampurna@unud.ac.id

Received 21st December 2024; Accepted 27th January 2025

ABSTRACT: The objective of this research was to evaluate the growth dynamics in body size of high-potential male Bali cattle during the fattening period. Growth differences in body size can be attributed to the composition of body parts, with those predominantly composed of bone maturing earlier than those consisting mainly of muscle or fat. Throughout the fattening process, variations in the growth rates of male Bali cattle's body sizes were observed, reflecting disparities in their potential body sizes. Specifically, male Bali cattle exhibiting higher growth rates possess greater growth potential, whereas those with lower rates may have limited growth potential or have reached their maximal body size. The mapping of the body sizes of male Bali cattle during fattening allows farmers to identify the optimal body size benchmarks for determining appropriate slaughter weights and ages, thereby maximizing economic profitability. Data were collected from all male Bali cattle based on health and physical condition criteria within the fattening pen of the Abdi Pertiwi Banjar Livestock Farmers Group, located in Patas village, Gerogak sub-district, Buleleng district, Bali. Body size measurements were conducted three times in a month. These data were analyzed using power model regression analysis to ascertain the growth rates of the cattle's body sizes. Furthermore, Promax rotational biplot analysis was utilized for growth rate mapping, with the estimated body sizes derived from the power regression equation serving as variables and the ages of the male Bali cattle as objects. The findings of this research revealed that neck circumference exhibited the highest growth rate or greatest potential, followed by chest circumference, body length, hip circumference, and hip height, with shoulder height showing the slowest or least potential. Growth rate measurements of male Bali cattle aged thirteen to twenty-two months shown on the biplot graphs indicated a still significant growth potential. Body sizes closest to the overall body size, particularly chest circumference and body length located in quadrant I, are the most accurate predictors for estimating the body weight of male Bali cattle during the 13-22 month fattening period.

Keywords: Biplot analysis, growth rate, male Bali cattle, power regression.

INTRODUCTION

The growth rate of livestock varies with each stage of development. Post-birth growth in livestock can be categorized into three distinct phases: an initial phase of accelerated growth leading up to weaning, followed by a phase of exponential growth until puberty, and finally, a phase where growth decelerates until it halts completely upon reaching adult body size (Swatland, 1987; Sampurna *et al*., 2014). Although an animal's body size continues to increase over time, the growth rates of different body parts vary. Summing up the measurements of all body parts yields the total body size (X), and the overall growth rate represents the average of these individual growth rates.

For any given body part, the growth rate might match, exceed, or lag behind the overall body size growth rate. Power regression analysis, represented by the equation $Y=aX^b$, is employed to assess this. If the exponent b is greater than one (b>1), the growth rate of a specific body part exceeds the average, indicating high growth potential. Conversely, if b is less than one (b<1), the growth potential of that body part is considered low or nearing its limit.

Variations in growth rates can be attributed to physiological differences, diverse functional demands, and the nature of the constituent components (Sampurna and Nindhia, 2017). The growth of meat and fat deposits within specific body parts is indicative of the growth rate of those areas.

The variability in growth rates, as determined by the Power function, can be effectively visualized using a Biplot graph with Promax kappa 90 rotation. This method allows for the categorization of different growth rates into three distinct quadrants, facilitating the analysis of growth rates across various organs, tissues, or body parts of animals (Sampurna and Nindhia, 2017). Within this framework, body parts exhibiting medium growth potential are positioned in quadrant II, parts with high growth potential are found in quadrant I, and those with low growth potential are allocated to quadrant III.

The primary goal of this research is to assess the growth rate of body size in male Bali cattle during the fattening period, identifying the body sizes with the highest growth potential during this phase. By mapping the body sizes of male Bali cattle throughout fattening, the research aims to provide farmers with valuable insights for optimizing body weight benchmarks and determining the most profitable ages for slaughter in meat production.

Given the premise outlined above, we hypothesize that individual body parts of male Bali cattle exhibit varying growth rates during the fattening process.

MATERIALS AND METHODS

Research objects

The objects of this research were male Bali cattle from the Abdi Pertiwi Livestock Farmers Group located in Banjar Didas Mertasari, Patas Village, Gerokgak Sub-district, Buleleng District, Bali.

Data collection

Data collection on the body size of male Bali cattle was conducted using a comprehensive sampling method, specifically, a saturated sampling technique. This approach involved the inclusion of all male Bali cattle managed by the Abdi Pertiwi Livestock Farmers Group, located in Banjar Mertasari, Patas village, Gerokgak sub-district, Buleleng district, Bali. The selection criteria were based on the animals' age, health status, and physical condition to ensure they met the research requirements.

The physical measurements of the fattened male Bali cattle were conducted directly within the confines of the pens belonging to the Abdi Pertiwi Livestock Farmers Group in Banjar Didas Mertasari, Patas village (Figure 1). A total of 15 male cattle were selected for this research to monitor the progression of their body size. Measurements were systematically taken three times a month, resulting in a total of 45 data points for each body dimension considered.

In this study, the parameters measured for adult male Bali cattle included traditional metrics such as shoulder height, body length, chest circumference, chest depth, and hip height, as reported by Diah et al. (2018). Additionally, two more measurements were introduced: the circumference of the steer and the rear neck circumference, to provide a more comprehensive assessment of the cattle's body size and potential growth during the fattening period. Measurements were conducted through the following procedures:

a) **Shoulder height:** Measure from a flat floor surface to the highest point of the shoulder, ensuring the measuring tape passes perpendicular to the scapula.
b) **Body length:** Measure from the point on the humerus (tuberositas humeri) to the tip of the sitting bone (tuber ischii).
c) **Chest circumference:** Wrap a measuring tape around the chest, just behind the shoulders (Os scapula), to measure the circumference.
d) **Inside chest width:** Measure the width from the lower to the upper chest.
e) **Hip height:** Measure from a flat floor surface to the highest point of the hip.
f) **Hip circumference:** Wrap a measuring tape around the abdomen, in front of the pelvic bones (tuber coxae), ensuring it is perpendicular to the median plane of the body.
g) **Neck circumference:** Measure around the neck, positioning the tape behind the angle of the lower jaw (*Angulus Mandibulae*), and ensure it is vertically perpendicular to the median plane of the body.

Data analysis

The data collected were subjected to power model regression analysis to assess the growth rate of Bali cattle body size. The outcomes from the power regression analysis for body size estimation were graphically represented through Biplot analysis, employing a Promax kappa rotation of 270 degrees. In this analysis, the variable under consideration was the body size of male Bali cattle, while the age of these cattle in the Abdi Pertiwi Livestock Farming Group, located in the Mertasari service hamlet, Patas village, Gerokgak sub-district, Buleleng district, Bali, served as the object of study. The analysis was conducted using the IBM SPSS (Statistical Product and Service Solutions) software package, version 28.

RESULTS AND DISCUSSION

The results of the growth rate measurement of male Bali

Table 1. The growth rate of body size of male Bali cattle aged between 13-22 months during fattening.

No.	Body size (cm)	Correlation coefficient (R)	Constant (a)	Growth rate (b)	Equality regression
1	Shoulder Height	0.605	5.597	0.442	$Y = 5.597X^{0.442}$
2	Body Length	0.806	0.502	0.804	$Y = 0.502X^{0.804}$
3	Chest Circumference	0.876	0.287	0.934	$Y = 0.287X^{0.934}$
4	Inside Chest Width	0.879	0.0002	1.889	$Y = 0.0002X^{1.889}$
5	Hip Height	0.612	1.917	0.609	$Y = 1.917X^{0.606}$
6	Hip Circumference	0.760	0.004	1.600	$Y = 0.004X^{1,609}$
7	Neck Circumference	0.760	1.900	0.945	$Y = 1.900X^{0.945}$

cattle's body size aged 13-22 months during the fattening process in Kalianget village, Seririt sub-district, Buleleng district are shown in Table 1. The results reveal that among male Bali cattle aged 13 to 22 months, the fastest growth rate in body size, indicating the greatest potential, is observed in the "dalem" (a specific body measurement) with a rate of 1.804, followed by neck circumference at 1.706, chest circumference at 1.160, and body length at 0.942. Other measurements show hip circumference at 0.907, hip height at 0.828, with shoulder height having the slowest or least potential growth rate at 0.633. Male Bali cattle reach sexual maturity around 18 months, evidenced by a fur colour change from brick red to dark brown or black, while full body maturity is not achieved until 30 months (Payne and Rollinson, 1973). At sexual maturity, Bali cattle exhibit their fastest body size growth rates, which slow down post-maturity.

Sampurna *et al*. (2014) highlighted that both male and female Bali cattle attain their peak growth rates and adult sizes at different ages, influenced by factors such as milk components and body size, affecting bone, muscle, or fat growth. Measurements like shoulder height, hip height, and body length, which reflect bone growth, show slower growth rates (b<1) since these body sizes reach maturity sooner. Conversely, neck circumference and chest measurements, indicative of muscle growth and fat deposition, display faster growth rates (b>1) as muscle and fat development follow bone growth. Hip circumference's slower rate compared to neck and chest circumferences suggests less muscle growth and fat deposition in the hip area.

The variation in growth rates of male Bali cattle body sizes during the 13 to 22-month fattening period stems from differing functional demands and constituent components. Body sizes comprised of bones, such as shoulder height and hip height, show that long bones grow earlier and cease growing quicker, resulting in lower growth rates at this age. Body length, associated with flat bones, grows more slowly, indicating a higher potential compared to height. In contrast, body parts like chest width and circumference, primarily consisting of muscle and fat, maintain a relatively high growth rate (b>1), reflecting the physiological growth sequence from bones to muscles and finally to fat. The potential for growth in livestock body sizes primarily composed of muscle and fat is higher if there is significant muscle growth or fat accumulation in those areas.

Sampurna and Nindhia (2017) reported that the overall body size (X) can be determined by summing the sizes of all organs, tissues, or body parts. The overall body size growth rate represents the average growth rate across all body components, indicating varying rates of growth for different organs, tissues, or parts compared to the body as a whole. According to Swatland (1984) and Sampurna and Suatha (2010), the differences in growth rates among organs or tissues over time depend on their function, while the growth rate of body parts relative to the overall body size is influenced by the dominant component, be it bone, muscle, or fat.

The variety of body size growth rates of male Bali cattle resulting from the regression power analysis is presented in Figure 2. The figure illustrates the growth rates of body measurements in male Bali cattle during fattening. Measurements with a growth rate of less than one (b<1), such as shoulder height and hip height, exhibit a convex curve. Conversely, measurements with a growth rate greater than one (b>1), like neck and chest circumferences, display a concave curve (downward convex). The growth rates of chest circumference, hip circumference, and body length, which are approximately equal to one (b≡1), result in a linear pattern, indicating a steady growth rate.

Sampurna and Nindhia (2017) observed that the Power Function, defined by the equation $Y=aX^b$, generates different curves based on the growth rate: a concave curve for rates greater than one (b>1), a convex curve for rates less than one (b<1), and a straight line for rates approximately equal to one (b≡1).

Further, the mapping of body size changes through biplot analysis, based on power regression analysis of the body size in Bali cattle during the fattening period, is depicted in Figure 3. The figure illustrates the coordinates of body size for male Bali cattle and their ages from 13 to 22 months (A13 - A22). The body sizes are plotted across Quadrants I, II, and IV, whereas the ages of the male Bali cattle are distributed in quadrants I and III. Specifically, rapid growth rates are represented in Quadrant II, moderate growth rates in Quadrant I, and slow growth

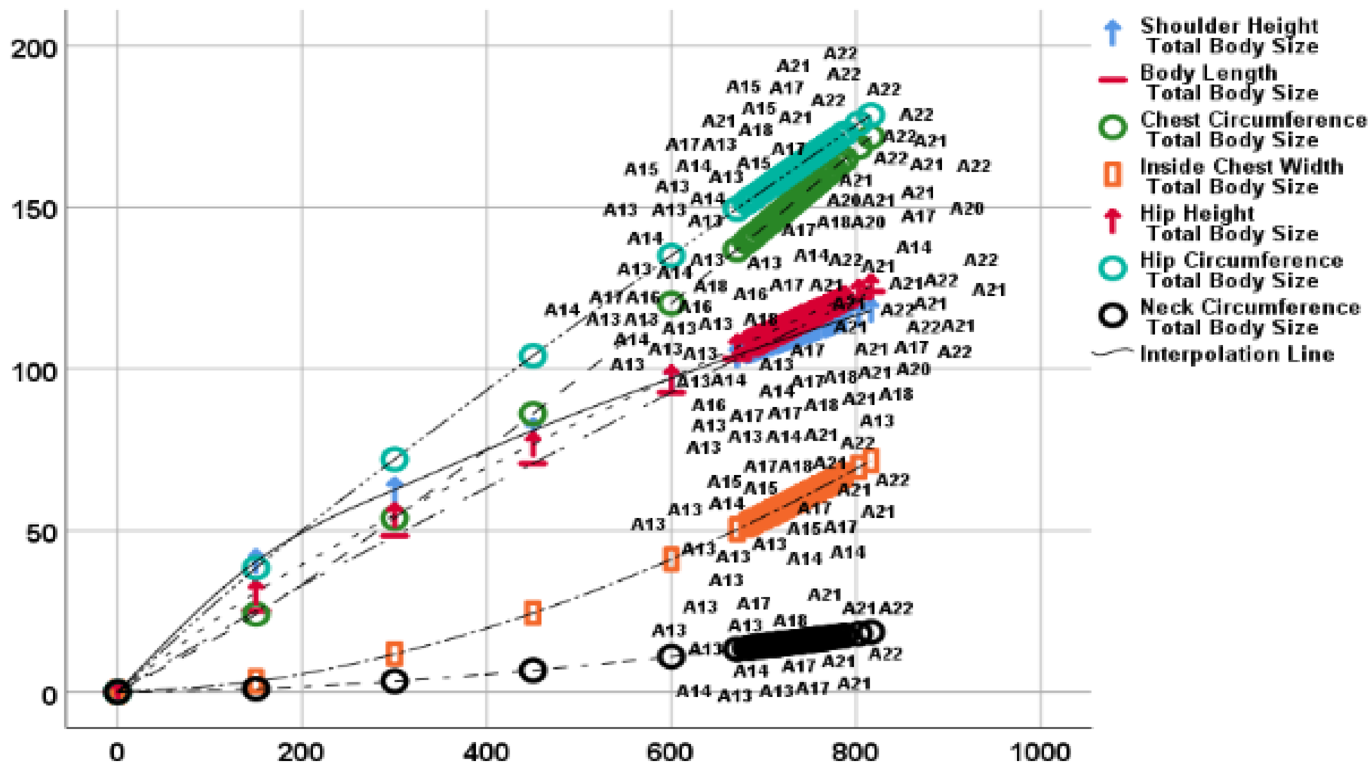

Figure 2. The body size growth rate of male Bali cattle during fattening at the age of 13-22 months (A13 -A22).

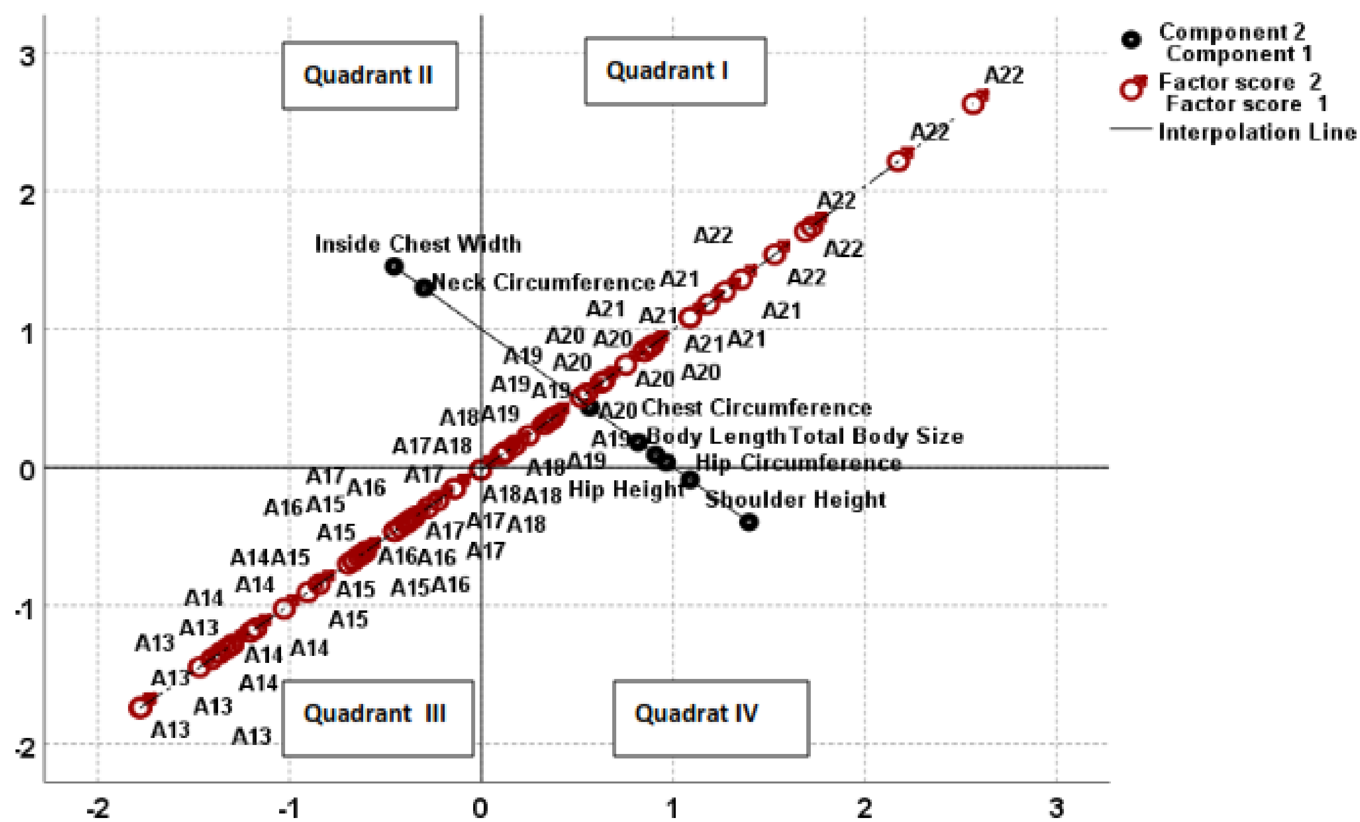

Figure 3. Biplot mapping results of fatted Bali cattle's body size at the age of 13-22 months (A13 – A22).

rates in Quadrant IV. In contrast, the coordinates for younger Bali bulls are found in Quadrant III, with older bulls situated in Quadrant I. Sampurna and Nindhia (2017) have highlighted that biplot simulations with a kappa rotation of 90 degrees are effective in assessing the growth rates of organs, tissues, or specific body parts in animals.

Measurements of chest circumference, body length, and hip circumference are positioned in Quadrant I, indicating these body metrics grow at a rate close to one (b≈1). The overall size, which closely aligns with chest circumference and body length within the same quadrant, reflects the body weight of male Bali cattle during fattening. Consequently, chest circumference and body length are reliable indicators for estimating body weight, as supported by Williamson and Payne (1993). These measurements provide a precise estimate of an animal's body weight.

Sampurna and Batan (2000) proposed that body weight (BW) can be accurately estimated using chest circumference (CC) and body length (BL), through the equation BW = a(CC^2)(BL). This formula is predicated on the observation that the body shape of Bali cattle closely resembles a cylinder, with the volume of a cylinder calculated as: $\pi R^2 T$ (where R is the radius and T is the height).

2πR = CC, thereby: $R = \frac{LD}{2\pi}$, hence BW = $\pi(\frac{LD^2}{4R^2})(BL) = \frac{1}{4\pi}(CC)^2(BL)$.

Zafitra *et al*. (2020) reported that chest circumference showed the highest correlation between body sizes and body weight in Bali cattle and cymbal cattle, both male and female.

The distribution of body size growth rates for male Bali cattle during fattening (aged 13 – 22 months) reveals distinct patterns in their development. Chest and neck circumferences, located in Quadrant II, exhibit a growth rate greater than one (b>1), indicating these areas still possess high growth potential and are actively expanding. Conversely, hip height and shoulder height, positioned in Quadrant IV, have a growth rate of less than one (b<1), suggesting a lower growth potential and nearing cessation of growth.

This differential growth rate indicates that body parts associated with long bone growth, such as shoulder and hip heights, reach maturity more quickly compared to those areas indicative of muscle and fat development. According to Sampurna *et al*. (2014), male Bali cattle achieve adult shoulder height by 18 months and adult hip height by 20 months, whereas chest and neck circumferences reach their adult sizes at 27 and 28 months, respectively.

Regarding the age distribution of fattened male Bali cattle, ages 13 - 22 months (A13 - A22) are plotted in Quadrants I and III. Younger cattle, aged 13 - 17 months, are found in Quadrant III, while those older, aged 18 - 22 months, are located in Quadrant I. The positioning of age coordinates along a line at varying distances from the origin (0,0) reflects their proximity to the average size, with closer distances indicating sizes near the average. Bodies in Quadrant III, being further from the origin, are smaller, whereas those in Quadrant I, further from the origin, are larger.

The spatial separation between the ages of fattened male Bali cattle highlights the rate of change in growth. A smaller distance to the origin suggests a cessation or low potential for growth, indicating the cattle may be ready for market. However, the coordinates for ages 20, 21, and 22 months remain relatively far apart, suggesting that cattle in this age range still hold high growth potential. This aligns with findings by Sampurna and Nindhia (2023), who noted in their promax rotation biplot analysis that greater distances between objects correlate with higher growth potential. Conversely, a short distance or proximity to the origin signals reduced growth potential until growth ceases entirely.

Conclusions and recommendations

The findings of the research indicate that among the measured body size parameters of male Bali cattle, neck circumference exhibits the highest growth rate or greatest potential. This is closely followed by chest circumference, with subsequent rankings being body length, hip circumference, hip height, and finally, shoulder height, which shows the slowest growth rate or lowest potential. The analysis of the growth rates for body sizes of male Bali cattle, aged between 13 to 22 months, utilizing biplot graphs, reveals that their growth potential remains considerably high. This suggests that there is significant room for growth within this age range. Among different body measurements carried out in this research, chest circumference and body length are most closely correlated with the overall body size of the cattle. Therefore, these two parameters—chest circumference and body length—can serve as reliable indicators for estimating the body weight of the cattle.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

REFERENCES

Payne, W. J. A., & Rollinson, D. H. L. (1973). Bali cattle. *World Animal Review*, *7*, 13-21.

Sampurna, I. P., & Batan, I. W. (2000). The estimation of live weight of Bali bulls above 500 kilograms. *Jurnal Veteriner*, 1(1), 18-23.

Sampurna, I. P., & Nindhia, T. S. (2017). Biplot simulation of power function to determine growth rate of animal. *Indian Journal of Applied Research*, *7*(6), 623-626.

Sampurna, I. P., & Nindhia, T. S. (2023). *Penyajian Grafik Hasil Analisis Data Penelitian*. Buku Refrensi. Penerbit Baswara Press. Pp. 1- 66.

Sampurna, I. P., & Suatha, I. K. (2010). The allometric growth of long and circular body dimension of Bali cattle. *Jurnal Veteriner*, *1*(11), 46-51

Sampurna, I. P., Saka, I. K., Oka, G. L., & Sentana, P. (2014). Patterns of growth of Bali cattle body dimensions. *ARPN Journal of Science and Technology*, *4*(1), 20-30.

Swatland, H. J. (1984). *Structure and development of meat animals*. Prentice-HallInc., Englewood Cliff, New Jersey Stephen.

Williamson, G., & Payne, W. J. A. (1993). *Pengantar Peternakan Daerah Tropis*. Terjemahan Oleh S.G.N. Dwija,D.Gajah Mada University Press. Yogyakarta.

Zafitra, A., Gushairiyanto, G., Ediyanto, H., & Depison, D. (2020). Karakterisasi Morfometrik dan Bobot Badan pada Sapi Bali dan Simbal di Kecamatan Bangko Kabupaten Merangin. *Majalah Ilmiah Peternakan*, *23*(2), 66-71.