



DETERMINING THE RELATIONS OF DAILY LIVE WEIGHT GAIN OF SAANEN KIDS USING CONCORDANCE CORRELATION

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Abstract: In this study, the Concordance Correlation Coefficient (CCC) method was used to evaluate the consistency between the daily live weight gain (DLWG) data obtained in the six-month period from birth. CCC is a powerful analysis tool in terms of determining both the strength of the relationship between repeated measurements and how close the measurements are to each other. As a result of the analysis, it was seen that the CCC values were low especially between the first month and the following months, but these values increased significantly from the third month onwards. The findings obtained revealed that the CCC method was effective in evaluating the consistency of the weight gains that changed over time. Therefore, CCC can be used as a reliable statistical tool in the analysis of growth dynamics in animal science studies.

Keywords: Concordance correlation, Weight, Saanen, Relation, Autocorrelation

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1. Introduction

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Various correlation analyses are used to evaluate the relationships between variables on data obtained in the field of animal science (Kurdal and Önder, 2020). Correlation is a statistical method that measures how and in which direction two variables are related to each other. This analysis helps to understand how an increase or decrease in one variable causes a change in the other variable. However, the method to be used in correlation analysis depends on the structure of the data and the provision of certain statistical assumptions. For example; while the Pearson correlation coefficient is preferred in the presence of continuous and normally distributed variables and independent observations; the Spearman correlation coefficient can be applied to ordinal or continuous/discrete data where at least one of the variables is not normally distributed (Kurdal and Önder, 2020).

The concordance correlation coefficient can potentially be an excellent tool in many types of goodness-of-fit evaluations, by simply examining how well the observed outcomes concord with the hypothesized values (Lawrance and Lin, 1992). In general, these measures do not address both precision and accuracy as does the concordance correlation coefficient; however, the equivalency and similarities of the intraclass correlation coefficient to the concordance correlation coefficient under certain scenarios has been discussed. The CCC measures how far the fitted linear relationship of two

variables deviates from the concordance line (accuracy) and how far each observation deviates from the fitted line (precision) (Crawford et al., 2007).

Concordance Correlation Coefficient (CCC) allows the evaluation of the level of relationship and equivalence together, especially in repeated measurements, by taking into account not only the directional relationship between variables but also the degree to which the measurements are close to each other and of similar magnitude. The dataset used in this study was analyzed with the Concordance Correlation Coefficient (CCC) method using the R software *epiR* package in order to evaluate the level of agreement between repeated measurements obtained from the same individuals over a period of six months.

2. Materials and Methods

The continuous data in this study was the data set consisting of daily live weight gain from birth to the 6th month of life of 75 Saanen kids used in the study conducted by Önder and Abacı (2015). Analyses were performed using the R software version 4.4.3 (R Core Team, 2025). The codes used in the analysis was given:

```
install.packages("readxl")
install.packages("epiR")
library(readxl)
library(epiR)
file.choose()
data <-
read_excel("C:/Users/Username/Desktop/data.xlsx")
```



```
ccc1 <- epi.ccc(data$variable1, data$variable2)
print(ccc1)
```

2.1. Concordance Correlation Coefficient

The CCC measures agreement between two methods or time points by measuring the variation of their linear relationship from the 45° line through the origin. Therefore, this coefficient is not only measuring how far each observation deviates from the line fit to the data (precision), but also how far this line deviates from the 45° line through the origin (accuracy).

Lin characterizes the degree of concordance between two variables X and Y by the expected value of the squared difference, and defines the CCC as given in Equation 1:

$$\rho_c = 1 - \frac{E[(X - Y)^2]}{E_{indep}[(X - Y)^2]} \tag{1}$$

$$= \frac{2\sigma_{XY}}{\sigma_{XX} + \sigma_{YY} + (\mu_X - \mu_Y)^2}$$

where $\mu_X = E(X)$, $\mu_Y = E(Y)$, $\sigma_{XX} = \text{var}(X)$, $\sigma_{YY} = \text{var}(Y)$, and $\sigma_{XY} = \text{cov}(X, Y)$. This coefficient is related to the Pearson correlation coefficient ρ in that when $\mu_X = \mu_Y$ and $\sigma_{XX} = \sigma_{YY}$, then $\rho_c = \rho$ (Lawrance and Lin, 1989). Where μ_X and σ_{XX} represent the mean and variance for the first rater, μ_Y and σ_{YY} represent the mean and variance for the second rater, and σ_{XY} is the covariance for the first and second rater (Barnhart et al., 2002).

3. Results and Discussion

According to the results obtained from the analysis, the change in the average live weight values of individuals for six months from birth is shown. A regular and nearly linear increase is observed in the weight values from birth. There is a clear increasing trend between the monthly measurements, and it is seen that there is approximately a similar amount of live weight gain each month. In addition, the error bars (standard error) of the data points show a slight widening over time, which

shows that the variation between individuals increases slightly in the following months. In general, the graph reveals that growth progresses continuously and steadily (Figure 1).

According to Figure 2, the daily live weight gain (DLWG) values calculated at the end of each month from birth are shown. The daily weight gain was at its highest level in the first month, and a gradual decrease was observed in the following months. The slowdown in weight gain became apparent especially from the 3rd month onwards. This decrease coincides with the period when the kids are weaned and reflects the effect of weaning on growth performance. Although the daily gain values follow a more stable course after the 4th month, it is seen that the average gain level is lower compared to the previous months from the 3rd month onwards. The error bars show that this decreasing trend can be evaluated together with the variation arising from the differences between individuals.

According to the results obtained, it provides important clues about how the growth process changes over time and which periods are more similar to each other (Table 1). It is seen that the CCC values especially between M1-B (first month - birth) and the following months are quite low. The coefficient of concordance between M1-B and M6-B is only 0.178, which shows that the weight gain in the first month after birth does not establish a consistent and predictable relationship with the other periods up to the sixth month. Similarly, it was determined that the values between M1-B and M4-B (0.288) and M1-B and M5-B (0.223) are also low. However, the values after M2-B, especially between M3-B and M4-B (0.902), M4-B and M5-B (0.962) and M5-B and M6-B (0.960), were determined to be quite high. This finding shows that following weaning, weight gain values reach a more stable, predictable and close structure.

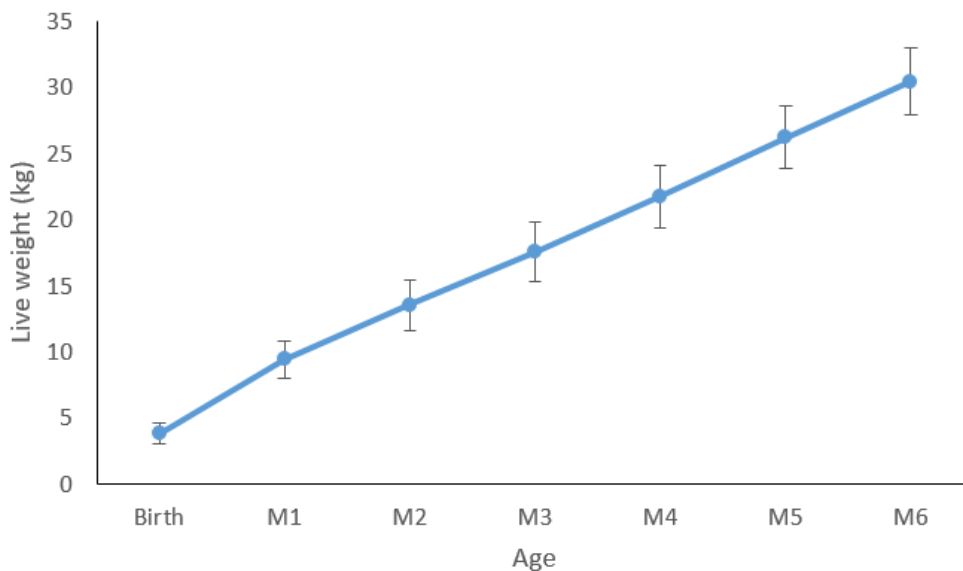


Figure 1. Live weight according to the age. M1= 1st month, M2= 2nd month, M3= 3rd month, M4= 4th month, M5= 5th month, M6= 6th month.

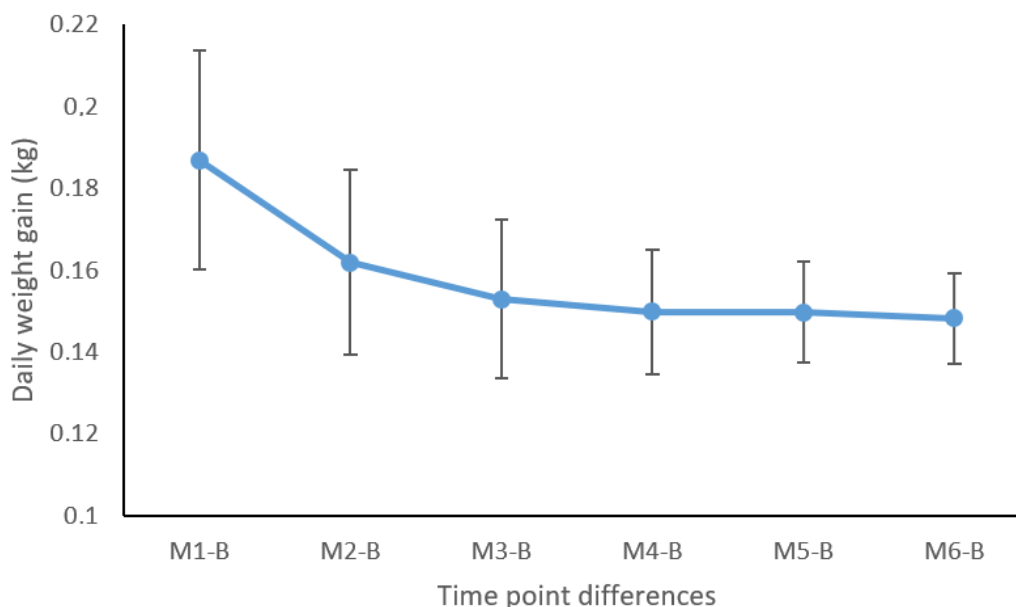


Figure 2. Absolute daily weight gain. M1-B= from birth to the 1st month, M2-B= from birth to the 2nd month, M3-B= from birth to the 3rd month, M4-B= from birth to the 4th month, M5-B= from birth to the 5th month, M6-B= from birth to the 6th month.

Table 1. Concordance Correlation Coefficients between time points for absolute daily weight gain

	M2-B	M3-B	M4-B	M5-B	M6-B
M1-B	0.610	0.420	0.287	0.223	0.178
M2-B		0.883	0.717	0.600	0.493
M3-B			0.902	0.792	0.676
M4-B				0.962	0.892
M5-B					0.960

According to the obtained table, the early period (first 1-2 months) shows a process in which individual differences are more dominant; however, after the 3rd month, environmental conditions stabilize and growth begins to follow a more standard course.

4. Conclusion

In this study, the Concordance Correlation Coefficient (CCC) method was used to evaluate the agreement between 6-month daily live weight gain data obtained from the same individuals. CCC is a powerful method in that it shows not only the relationship between measurements but also how close they are to each other. The analysis results showed that the compliance was low, especially between the first month and the following months; however, this compliance increased significantly from the third month onwards. This situation shows that the compliance between the monthly live weight gain values was low in the first months of the growth process, but over time these values became closer to each other and the development began to follow a more stable course.

CCC is therefore quite useful for assessing the consistency of growth data over time in animal science studies. It provides the opportunity to evaluate both the accuracy and precision of the live weight gains recorded

by individuals over certain time periods, especially in cases where repeated measurements are taken. In addition, the fact that CCC evaluates both the directional relationship (correlation) and the closeness of values to each other (concordance) makes it a more comprehensive method than traditional correlation analyses. In future studies, more comprehensive analyses can be performed by separating the data set by gender, working with larger sample groups, and integrating the effects of different genotypes or environmental conditions into the model. This method is recommended as an effective analysis tool for comparing developmental periods in similar longitudinal studies to be conducted in the future.

Author Contributions

The percentages of the author' contributions are presented below. The authors reviewed and approved the final version of the manuscript.

	B.K.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The author declare that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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