USE OF INFRARED THERMOGRAPHY IMAGES TO PREDICT LIVE WEIGHT OF GROWING RABBITS

Silva S.R., Guedes C.M., Almeida, M., Pinheiro V.*

Veterinary and Animal Research Centre (CECAV), Universidade de Trás-os-Montes e Alto Douro (UTAD), Quinta de Prados, 5000-801, Vila Real, Portugal
*Corresponding author: vpinheir@utad.pt

ABSTRACT

The objective of this study was to evaluate the possibility of using infrared thermography (IRT) images to predict the live weight (LW) of growing rabbits. A total of 144 growing rabbits with 1.739 ± 0.448 kg were used to capture images with infrared thermography technique. Rabbits were weighed in the morning (8 to 9 hours). The IRT images were taken using an infrared Flir F4 camera. Images were analyzed and the body measures (area, perimeter, major and minor from the primary and secondary axis of the best fitting ellipse, Feret's diameter and minimum caliper diameter) and shape descriptors (aspect ratio, roundness, solidity, circularity) were recorded. The data were analyzed following multiple linear regression to predict live weight (dependent variable) with body measurements and shape descriptors (independent variables). Results showed that the body measurements obtained after IRT image analysis presented more variation than shape descriptors (CV between 12 and 20% vs 1.4 and 10%, respectively). The best prediction model used four independent variables (area, major and minor axis of ellipses and Ferret´s) calculated from IRT (k-fold-R^2=0.945; RMSE=106.9 g). We concluded that the IRT imaging technique was able to accurately predict the LW of rabbits. Future work will be focused on the increase of accuracy and precision in order to make the process of image acquisition and analysis faster, so that it can be applied as a practical tool for determining rabbit LW.

Key words: Prediction, image analysis, weight monitoring, animal welfare

INTRODUCTION

Monitoring live weight regularly is an important task to assess the health and growth of the rabbits. Also, LW is a crucial trait to determine whether growing rabbits reach the market weight target. Additionally, LW is directly related to the productive and reproductive response of adult breeding rabbits. For both growing rabbits and breeding rabbits, the determination of LW represents a monotonous and labor-intensive task which is stressful for rabbits and stockmen. Over the years, various approaches have been developed to overcome these drawbacks caused by manual weighing (Tscharke and Banhazi, 2013; Rosell-Polo *et al.*, 2015). One of the most promising is based on image analysis. The image-based approaches have shown positive results on different farm species (Kongsro, 2014; Menesatti *et al*., 2014; Jun *et al*., 2018; Nir *et al*., 2018; Fernandes *et al*., 2019). Typically, the procedure involves animal contour segmentation, and its extraction from the background and the subsequent image analysis allows measurements of the animal to predict the LW (Jun et al., 2018; Qiao *et al*., 2019). Despite all the promising results presented for the different farm species, , there are few results with the application of imaging to predict LW in rabbits (Negretti *et al*., 2007). In addition, the use of IRT images was examined to overcome the drawbacks of images obtained by photography in environments with very variable ambient lighting, which is the case for rabbits housing. In this sense, it is the objective of this work to apply the analysis of images obtained by the IRT technique to estimate the live weight of growing rabbits.

MATERIALS AND METHODS

Animals and experimental design

The trial was carried out at the Rabbit Research Unit of the Department of Animal Science of the Universidade de Trás-os-Montes and Alto Douro, at Vila Real, Portugal. The animals were handled according to animal welfare principles, according to Portuguese legislation (Portaria nº 1005/92, 214/08, 635/09). A hundred and forty-four New Zealand x Californian growing rabbits ranged between 930 to 3039 g were used.

Weighing, IRT images acquisition and analysis

All rabbits were weighed in the morning between 8 and 9 hours following the same routine. A digital scale (Precise 32000D, 32000 ± 0.01 g) was used for weighing rabbits. After weighing, the rabbits were returned to the cage (0.5.0.6.0.35 m; Figure 1A) and IRT image acquisition was carried out using a FLIR F4 camera (FLIR Systems, Portland, USA). The IRT camera was set on a tripod at a 60 cm from the cages. The distance to the rabbit cage was kept constant. This procedure was always followed for IRT image acquisition. Among the IRT captured images, the ones that presented the rabbit in a posture considered as standard were selected (Figure 1B). The IRT images were segmented, first with a fitted polygon of the rabbit body contour (Figure 1C) and then through a body contour in a binary image (Figure 1D). After image analysis, the following body measurements were recorded: area, perimeter, major and minor from the primary and secondary axis of the best fitting ellipse, Feret's diameter and minimum caliper diameter. Also, the following shape descriptors were recorded: aspect ratio, roundness, solidity, and circularity. The IRT images were analyzed using the Fiji ImageJ 1.49u image analysis software (ImageJ, National Institutes of Health, USA).

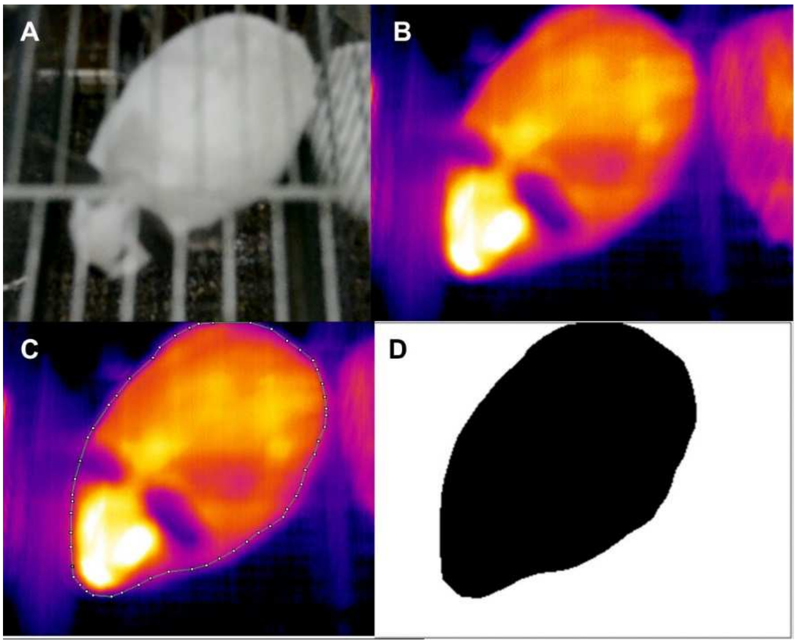

Figure 1 A top view image showing rabbit in the cage (Figure 1A); IRT image of a rabbit in a standard posture (Figure 1B); IRT image with a fitted polygon of the rabbit body (Figure 1C); segmentation of body contour in a binary image (Figure 1D).

Statistical Analysis

A simple descriptive statistical analysis was done for LW, body measurements and shape descriptors obtained from IRT images. The data were analyzed following multiple linear regression to predict LW (dependent variable) with body measurements and shape descriptors (independent variables). The best model was obtained using a k-fold cross-validation approach using k=10. The accuracy of the model was based on the k-fold coefficient of determination (k-fold-R^2), while the root mean square error of the cross-validation (RMSE) was used to determine the precision of the prediction model. All statistical procedures were carried out using the JMP software version 14 (SAS Institute, Cary, NC, USA).

RESULTS AND DISCUSSION

Live weight is the variable that shows the greatest variation (CV = 26%). The body measurements obtained after IRT image analysis show more variation than shape descriptors (CV between 12.4 and 19.9% vs 1.4 and 10,2%, respectively) (Table 1).

Table 1. Mean, standard deviation (Std Dev), minimum, maximum and coefficient of variation (CV) for live weight, body measurements and shape descriptors obtained by IRT images (n = 144).

Trait		**Mean**	**Std Dev**	**Minimum**	**Maximum**	**CV (%)**
Live weight (g)		1739.3	447.8	930.0	3039.0	25.7
Body measurements	Area (cm2)	391.5	78.0	234.4	580.2	19.9
	Perimeter (cm)	76.1	9.527	54.0	98.6	12.5
	Major axis (cm)	29.3	3.949	21.5	40.2	13.5
	Minor axis (cm)	17.3	2.222	13.0	24.1	12.8
	Feret's diameter (cm)	29.8	3.813	19.9	38.8	12.8
	Minimum caliper diameter (cm)	17.5	2.179	13.3	22.2	12.4
Shape descriptors	Aspect ratio	1.683	0.170	1.316	2.101	10.1
	Roundness	0.600	0.061	0.476	0.760	10.2
	Solidity	0.968	0.014	0.919	0.989	1.4
	Circularity	0.821	0.044	0.698	0.927	5.4

The prediction model performed by multiple linear regression using k-fold cross-validation and the relationship between measured and predicted LW is shown in the scatterplot (Figure 2). In this model four independent variables were used (LW=-1530.2+1.16 area + 20.47 major + 59.08 minor + 40.12 ferret; k-fold-R^2=0.945; RMSE=106.9 g).

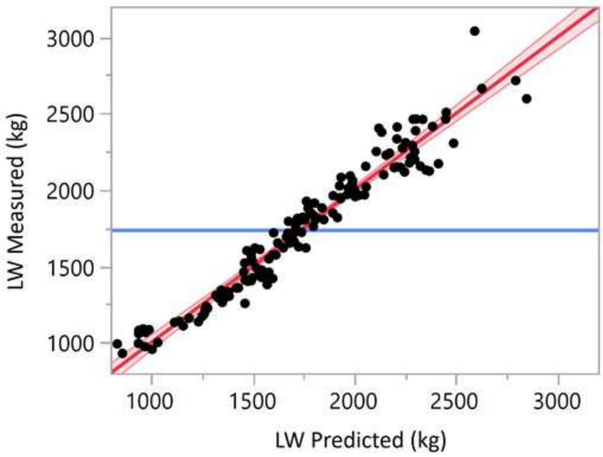

Figure 2 Predicted v. measured values of live weight (LW) after k-fold cross-validation.

The precision and accuracy of the present model compares with other reports obtained with different species, image techniques and different data analysis approaches. For example, Nir *et al*. (2018) working with cattle show that it is possible to explain 94.6% of the body mass variation using a single low-cost 3D computer vision system. Also, Jun *et al*. (2018) using 2D image features found an R2 of 0.79 in the prediction of LW in growing pigs. The ambient lighting conditions, the posture of the animal and dynamic background (e.g. dirty ground or other crossing animals) can affect the quality of rabbit image segmentation. The use of IRT image can overcome these challenging situations as it highlights by others (Jun *et al*., 2018). The IRT camera is a useful tool for extracting the warmer rabbit body shape from its background. The same was observed using IRT to predict LW of cattle (Stajnko *et* *al*., 2008) and also by Halachmi *et al*. (2013) which state that extracting a correct cow contour from its background is simpler using IRT when compared to visible light photography.

CONCLUSIONS

The results show that IRT imaging technique was found accurate to predict the LW of rabbits. New work must be done to increase accuracy and precision and make the process of image acquisition and analysis faster so that it can be applied as a practical tool for determining rabbit LW.

ACKNOWLEDGEMENTS

The authors acknowledge financial support through project CECAV unit, financed by the National Funds from FCT, the Portuguese Foundation for Science and Technology, project number UID/CVT/0772/2019.

REFERENCES

Fernandes A. F., Dórea J. R., Fitzgeral, R., Herring W., Rosa, G. J. 2019. A novel automated system to acquire biometric and morphological measurements and predict body weight of pigs via 3D computer vision. *Journal of Animal Science, 97: 496-508.*

Halachmi I., Klopčič M., Polak P., Roberts D. J., Bewley, J. M. 2013. Automatic assessment of dairy cattle body condition score using thermal imaging. *Computers and Electronics in Agriculture, 99: 35-40.*

Jun K., Kim S. J., Ji, H. W. 2018. Estimating pig weights from images without constraint on posture and illumination. *Computers and Electronics in Agriculture, 153: 169-176.*

Kongsro J., 2014. Estimation of pig weight using a Microsoft Kinect prototype imaging system. *Computers and Electronics in Agriculture*, *109: 32–35.*

Menesatti P., Costa C., Antonucci F., Steri R., Pallottino, F. 2014. A low-cost stereovision system to estimate size and weight of live sheep. *Computers and Electronics in Agriculture*, *103:33–38.*

Negretti P., Bianconi G., Finzi, A. 2007. Visual image analysis to estimate morphological and weight measurements in rabbits. *World Rabbit Science*, *15:37–41.*

Nir O., Parmet Y., Werner D., Adin G., Halachmi, I. 2018. 3D Computer-vision system for automatically estimating heifer height and body mass. *Biosystems Engineering*, *173, 4-10.*

Qiao Y., Truman M., Sukkarieh, S. 2019. Cattle segmentation and contour extraction based on Mask R-CNN for precision livestock farming. *Computers and Electronics in Agriculture, 165, 104958*.

Rosell-Polo J. R., Cheein F. A., Gregorio E., Andujar D., Puigdomenech L., Masip, J., Escolà, A. 2015. Advances in structured light sensors applications in precision agriculture and livestock farming. *Advances in Agronomy, 133: 71-112.*

Stajnko D., Brus M., Ho M. 2008. Estimation of bull live weight through thermographically measured body dimensions. *Computers and Electronics in Agriculture, 61:233–240.*

Tscharke M., Banhazi, T. M. 2013. Review of methods to determine weight and size of livestock from images. *Australian Journal of Multi-disciplinary Engineering, 10: 1-17.*