BIOLOGY LETTERS

rsbl.royalsocietypublishing.org

Invited reply

Cite this article: Møller AP, Erritzøe J. 2017 Brain size, hunting and the risk of getting shot: a reply to Zink & Stuber (2017). *Biol. Lett.* **13**: 20170113.
http://dx.doi.org/10.1098/rsbl.2017.0113

Received: 20 February 2017
Accepted: 27 April 2017

Subject Areas:
behaviour, ecology, evolution

Author for correspondence:
Anders Pape Møller
e-mail: anders.moller@u-psud.fr

The accompanying comment can be viewed at http://dx.doi.org/10.1098/rsbl.2016.0946.

Electronic supplementary material is available online at https://dx.doi.org/10.6084/m9.figshare.c.3783626.

THE ROYAL SOCIETY PUBLISHING

Conservation biology

Brain size, hunting and the risk of getting shot: a reply to Zink & Stuber (2017)

Anders Pape Møller[1] and Johannes Erritzøe[2]

[1]Ecologie Systématique Evolution, Université Paris-Sud, CNRS, AgroParisTech, Université Paris-Saclay, 91405 Orsay Cedex, France
[2]House of Bird Research, Taps, Christiansfeld 6070, Denmark

APM, 0000-0003-3739-4675

Møller & Erritzøe [1] investigated whether shot birds that were delivered to a taxidermist differed in brain mass from birds that were not shot, but brought to the same taxidermist, once the potentially confounding effects of species, sex, age, body mass and body condition had been controlled statistically. Zink & Stuber [2] claimed that these analyses did not support their conclusions. Surprisingly, their re-analyses did not control for potentially confounding variables.

Two issues are potentially at stake in the Zink & Stuber analyses of the relationship between the risk of getting shot and relative brain size. Collinearity between brain and body size is high, and this could potentially affect the conclusions. However, Freckleton [3] pointed out that collinearity is not necessarily a major issue in analyses like theirs. Least-squares regression is an adequate method for dealing with even high levels of collinearity [4]. Specifically, Freckleton noted that if there are differences in measurement error among variables [3], this could affect the results [5]. There is no reason to assume that there are differences in measurement error for the different variables. An analysis restricted to species that were hunted reached a similar conclusion [1]. The same applies to an analysis that included body condition as a predictor [1].

In a second series of analysis, we calculated residual brain mass from a regression of log-transformed brain mass on log-transformed body mass. Subsequently, we used these residuals in combination with species (fixed effect), sex and age (fixed effects) as predictors in a logistic regression with whether the individual was shot or not as the response variable (based on data in the supplementary material). This model revealed a significant effect of residual brain mass ($\chi^2 = 29.39$, d.f. $= 1$, $p < 0.0001$, estimate (s.e.) $= 14.982$ (2.764)). If we restricted this analysis to species that could be hunted legally, we reached a similar conclusion (partial effect of residual brain mass: $\chi^2 = 22.75$, d.f. $= 1$, $p < 0.0001$, estimate (s.e.) $= 13.368$ (2.803)). Even if we restricted this analysis to species that could not be hunted legally, we still reached the conclusion that whether an individual was shot (illegally) or not was best predicted by residual brain mass (partial effect of residual brain mass: $\chi^2 = 3.64$, d.f. $= 1$, $p = 0.03$, estimate (s.e.) $= 58.152$ (128.460)).

Finally, the mass of the liver and the heart can be considered controls hypothesized not to be related to the risk of getting shot. We found no significant relationships between the risk of getting shot and the relative size of these organs, sex and age as fixed factors and residuals from a regression of log-transformed organ mass on log-transformed body mass as a covariate (heart mass: $\chi^2 = 0.005$, d.f. $= 1$, $p = 0.943$; liver mass: $\chi^2 = 0.50$, d.f. $= 1$, $p = 0.48$). Hence, the conclusion for risk of getting shot is specific to an analysis based on relative brain size and not to analyses of the relative size of two other organs that were hypothesized not to affect the risk of getting shot.

If we use Akaike's Information Criterion for small sample sizes (AICc) values [6] to list models with respect to their performance, we can draw the following conclusions. The null model including sex, age and species had an

AICc = 937.32, d.f. = 246, while the model that also included residual brain mass had an AICc = 903.419, d.f. = 247, which gives an improvement in fit by AICc = 33.90, d.f. = 1. This change in AICc provides strong evidence for one model being better than the other [7].

Finally, Zink & Stuber [2] make a number of erroneous claims about their study relating to hunting methods and species subject to hunting. For example, they claim that hunting mainly is associated with decoys in their study area, while we have not during the last 50 years seen one single case of hunting with decoys. Likewise, their list of species that have been hunted legally during this period of 50 years lacks a large number of species that have been hunted. Their claims about hunting methods and species subject to hunting are not based on published information, nor are they based on actual hunting practices in the area from which their specimens were derived.

In conclusion, we can, based on previously published, but also new analyses, state that birds with small brains for their body mass have a disproportionately large risk of getting shot, while that is not the case for heart or liver size.

Data accessibility. The data accompanying the paper are available as electronic supplementary material.

Competing interests. We declare we have no competing interest.

Funding. We received no funding for this study.

References

1. Møller AP, Erritzøe J. 2016 Brain size and the risk of getting shot. *Biol. Lett.* **12**, 20160647. (doi:10.1098/rsbl.2016.0647)
2. Zink RM, Stuber EF. 2017 No relationship between brain size and risk of being shot in hunted birds: a comment on Møller & Erritzøe (2016). *Biol. Lett.* **13**, 20160946. (doi:10.1098/rsbl.2016.0946)
3. Freckleton RP. 2011 Dealing with collinearity in behavioural and ecological data: model averaging and the problems of measurement error. *Behav. Ecol. Sociobiol.* **65**, 91–101. (doi:10.1007/s00265-010-1045-6)
4. Draper NR, Smith H. 1998 *Applied regression analysis*. Oxford, UK: Blackwell Scientific Publications.
5. Carroll RJ, Ruppert D, Stefanski LA, Crainiceanu C. 2006 *Measurement error in nonlinear models: a modern perspective*. London, UK: Chapman & Hall.
6. Burnham KP, Anderson DR. 2002 *Model selection and inference*, 2nd edn. New York, NY: Springer.
7. Richards SA. 2008 Dealing with overdispersed count data in applied ecology. *J. Appl. Ecol.* **45**, 218–227. (doi:10.1111/j.1365-2664.2007.01377.x)