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Wrocław, 15 Sept. 2022

A review of doctoral dissertation by Antoine Grissot "Coordination of male and female parental performance in the Little Auk, *Alle alle*"

The doctoral thesis submitted by Antoine Grissot (MSc) consists of three research papers: one which has already been published in the *Frontiers in Ecology and Evolution* (doi.org/10.3389/fevo.2019.00349) and two others ready for submission to scientific journals. The thesis also includes an extensive introduction providing scientific background for the presented research and a chapter summarizing the most important conclusions from the project and proposing further research. The entire dissertation is 130 pages long, including tables, figures and technical parts (list of contents, Polish and English long summaries, acknowledgments, lists of references [which are at the end of each chapter], appendixes and co-authors statements specifying their participation in the project).

The thesis is the result of a research project, the field part of which was carried out within 7 breeding seasons (2009 – 2010, 2016 – 2018 and 2019 – 2020) at Spitsbergen. As far as I understood, data analysis was done in 2019 and 2020. Altogether the three articles making up the main body of the thesis were co-authored by 13 (!) researchers. This naturally rises the question what actually was the contribution of the senior author and whether it was enough to apply for a doctoral degree. To be honest, I wish that co-authors statements were more informative. I suppose that the "conceptualization", refers to the project design. I am not quite sure what does the "formal analysis" mean (is there also "informal" one?) and I assume that it refers to the statistical analysis of data. The word "investigation" is quite vague. Only a few co-authors (including AG) "investigated", and I guess that it means that they collected field data at Spitsbergen. To sum up: Antoine Grissot, together with his supervisor and two other co-authors, designed the study, he also wrote the draft of the first article and co-edited its final version, and his role in writing and editing of the rest of the manuscripts was at least major. I guess that, as he "formally analyzed", he actually participated in the statistical analysis of data. Finally, the hard fact is that he was the first and corresponding author of the manuscript which was already published in the *Frontiers*, and also he is going to be the first author of the remaining two articles. Co-authorship of scientific papers involves both cooperation and conflict. The role and contribution of each co-author are carefully scrutinized by others. You cannot be the first author in a team of several people, if you do not deserve it. I am therefore fully convinced that the contribution of Antoine Grissot to his doctoral dissertation was significant and decisive.

The thesis dealt with important scientific questions and provided interesting results. However, it is the duty of the reviewer to comment on the entire study and point out its weaker points. In the remainder of the review, I will address four main chapters of the work, starting with its theoretical background, and following with three chapters containing the project results. I will use the same numbering of research papers as used in the dissertation.

General introduction (pages 19 – 33)

Birds are a unique group in the animal world, because of their mating and parental systems. The vast majority of species are monogamous and bi-parental care for the offspring prevails. It is quite obvious that bi-parental care requires extensive cooperation between both members of the pair. On the other hand, considering that each individual is genetically programmed to maximize its own fitness, there is some propensity to cheat, that is to provide less than a fair share of parental care at the fitness costs paid by the partner. Cooperation and conflict coexists, but research of bi-parental care usually focuses on one only aspect. In the dissertation, Antoine Grissot focused on cooperation, which makes sense because the study species, the Little Auk, inhabits a harsh environment and also is long-lived with enduring pair-bonds. Sexual conflict between pair members is most likely reduced since cheating would negatively influence the physical condition and survival prospects of the partner (therefore, in a longer perspective, reducing also the residual reproduction of a potential cheater). Thus, and this was the rationale behind the doctoral project, the study of bi-parental cooperation in the Little Auk should reveal pressures of natural selection which modify the degree of cooperation between pair members.

The "General Introduction" is well written and it is easy to follow the (correct) logic of the author. However, I was disappointed that the information about the study species was quite limited. First, I would like to learn what exactly the "long-lived" means and what is the average duration of pair bonds in the studied species. Second, the author wrote that bi-parental care is "crucial for successfully raising an offspring", but provided no details. I understand that individual removal experiments are ethically questionable and such studies might not be available for this particular species. However, given the long period of research on Spitsbergen, I suppose that there are at least some anecdotal data on breeding success of single parents (due to naturally occurring mortality of adult birds). Third, it would be a good idea to add a mini-review of studies on divorce in monogamous species (and the Little Auk, in particular: is there a "secondary market" of potential mates in this species?) and the effects of the duration of pair-bonds on breeding success.

Chapter 1: Effect of environment on Parental Coordination of Chick Provisioning (pages 34 – 68)

The chapter, which is a copy of the paper published in the *Frontiers*, addresses the problem of relationship between parental coordination and environmental stress. The Little Auk has two potential food sources: with the low and with the high energetic density. The study produced results which, in my opinion, falsified the hypothesis that parental coordination in nestling feeding period is of evolutionary importance. First, adult birds cooperated more strictly in favorable foraging conditions (i.e. when high-energy food was available)

comparing to poor conditions. Second, parental coordination did not correlate with the growth rate of nestlings. A researcher's competence can be judged by whether she or he can publish "negative" (that is contradicting the proposed hypothesis) results, thus Antoine Grissot passed this exam positively. I agree with the authors that a complete model of relationships between coordination of parental feeding effort and foraging conditions, should also include proxies of fitness of all three parties involved: both adult partners and the offspring. Most likely, adults can react flexibly to variation in foraging conditions by shifting their investment more to self-maintenance or more to helping the partner to cope with unfavorable conditions, or investing more heavily in the offspring. Each scenario may produce different patterns of long and short foraging trips and different degrees of parental coordination. Perhaps experiments depending on a rapid "worsening" of foraging conditions (for example by increasing the costs of foraging by attaching a weight to the adult) could help unravel these relationships.

Chapter 2: Coordination of Parental performance Through the Whole Breeding Season (pages 69 – 94)

The second article was an extension of the project described in the publication by Wojczulanis-Jakubas et al. (2018; Seabird parents provision their chick in a coordinated manner. PLoS ONE, doi.org/10.1371/journal.pone.0189969), who analyzed the coordination of parent Little Auks nestling feeding effort. Antoine Grissot and co-authors, using the same method, analyzed parental coordination within the entire breeding cycle. Parental coordination was the highest in the incubation period and then gradually decreased until nestlings had fledged. This pattern might suggest that the coordination of incubation bouts and feeding trips may indeed be an important component of parental reproductive strategy, otherwise we should not expect its variation within the breeding cycle. Thus this result contradicts conclusions of the previous chapter and make the phenomenon of parental coordination yet more complex, suggesting that its potential complete model should also include the dynamics in time.

Chapter 3: Development Of A New Method To Look At Parental Investment And Coordination Using Miniaturised Light-Based Geolocators (gls) (pages 95 – 124)

The authors used small devices in the form of "knapsacks" attached to adult birds, which measure changes in light intensity over time. This allows to track the frequency and timing of nest visits and foraging trips. The method was validated using recordings of the same individuals with video cameras located in the breeding colony. I appreciate that the authors provided the ROC curve. The chapter is as a methodological article should be: deadly boring and saturated with details, but potentially very useful. If the proposed new method of data collection provides good results, and it seems so, it might be a game changer in research of breeding biology of hole-nesting birds, because it allows to collect long series of good-quality data. Also, unlike video-recordings which are now routinely used in such research, it requires less expensive equipment and less effort in data retrieval.

Final conclusions

I think that the most important merit of the project is that it focuses on an essential ingredient of cooperation between parents – coordination of parental care – which is treated and analyzed as a continuous trait depending on environmental conditions. This approach creates prospects for further research into the evolution of parental care systems.

My opinion on the doctoral thesis is positive. The author's contribution to its creation was crucial and the results of this project can be considered, in accordance with applicable law (The Higher Education and Science Act from the 20th of July 2018; Polish Journal of Laws of 2018, item 1668, as amended), as "an original solution to a scientific problem". Therefore, I kindly recommend the Scientific Council of Biological Sciences, University of Gdańsk, to admit Antoine Grissot (MSc) to the next stages of the doctoral dissertation.



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