



# Peer Community In Ecology

## Sexual segregation in a sexually dimorphic seabird: a matter of spatial scale

**Denis Réale** based on peer reviews by **Dries Bonte**  and 1 anonymous reviewer

Christophe Barbraud, Karine Delord, Akiko Kato, Paco Bustamante, Yves Cherel (2019) Sexual segregation in a highly pagophilic and sexually dimorphic marine predator. Missing preprint\_server, ver. Missing article\_version, peer-reviewed and recommended by Peer Community in Ecology. <https://doi.org/10.1101/472431>

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Sexual segregation appears in many taxa and can have important ecological, evolutionary and conservation implications. Sexual segregation can take two forms: either the two sexes specialise in different habitats but share the same area (habitat segregation), or they occupy the same habitat but form separate, unisex groups (social segregation) [1,2]. Segregation would have evolved as a way to avoid, or at least, reduce intersexual competition. Testing whether social or habitat segregation is at play necessitates the use of combined approaches to determine the spatial scale at which segregation occurs. This enterprise is even more challenging when studying marine species, which travel over long distances to reach their foraging areas. This is what Barbraud et al. [3] have endeavoured on the snow petrel (*Pagodroma nivea*), a sexually dimorphic, polar seabird. Studying sexual segregation at sea requires tools for indirect measures of habitat use and foraging tactics. During the incubation period, in a colony based at Pointe Geologie, Adelie land, East Antarctica, the team has equipped birds with GPS loggers to analyse habitat use and foraging behaviour. It has also compared short-, mid-, and long-term stable isotopic profiles, from plasma, blood cells, and feather samples, respectively. Barbraud et al. [3] could not detect any evidence for sexual segregation in space use. Furthermore, the two sexes showed similar  $\delta^{13}\text{C}$  profiles, illustrating similar foraging latitudes, and indicating no sexual segregation at large spatial scales. Snow petrels all forage exclusively in the sea ice environment formed over the deep Antarctic continental shelf. The authors, however, found other forms of segregation: males consistently foraged at higher sea ice concentrations than females. Males also fed on higher trophic levels than females. Therefore, male and female snow petrels segregate at a smaller spatial scale, and use different foraging tactics and diet specialisations. Females also took shorter foraging trips than males, with higher mass gain that strongly benefit from higher sea ice concentration. Mass gain in males increased with the length of their foraging trip at sea ice areas. The authors conclude that high sea ice concentration offers the most favourable foraging habitat

for snow petrels, and thus that intersexual competition may drive females away from high sea ice areas. This study shows that combining information from different tools provides an elegant way of isolating the potential factors driving sexual segregation and the spatial scales at which it occurs.

### **References:**

[1] Conradt, L. (2005). Definitions, hypotheses, models and measures in the study of animal segregation. In Sexual segregation in vertebrates: ecology of the two sexes (Ruckstuhl K.E. and Neuhaus, P. eds). Cambridge University Press, Cambridge, United Kingdom. Pp:11–34.

[2] Ruckstuhl, K. E. (2007). Sexual segregation in vertebrates: proximate and ultimate causes. *Integrative and Comparative Biology*, 47(2), 245-257. doi:

[10.1093/icb/icm030](<https://dx.doi.org/10.1093/icb/icm030>)

[3] Barbraud, C., Delord, K., Kato, A., Bustamante, P., & ChereI, Y. (2018). Sexual segregation in a highly pagophilic and sexually dimorphic marine predator. *bioRxiv*, 472431, ver. 3 peer-reviewed and recommended by PCI Ecology. doi: [10.1101/472431](<https://dx.doi.org/10.1101/472431>)

## **Reviews**

### **Evaluation round #2**

#### **Reviewed by anonymous reviewer 1, 20 May 2019**

Globally I'm pleased with the improvements the authors made to the manuscript. The work was already interesting, very well designed and written in a way it was easy and clear to follow the string of the story.

Thus, in my humble opinion the work is ready for acceptance by PCI Ecology.

### **Evaluation round #1**

DOI or URL of the preprint: [10.1101/472431](https://doi.org/10.1101/472431)

Version of the preprint: 1

#### **Authors' reply, 09 April 2019**

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#### **Decision by Denis Réale, posted 05 March 2019**

##### **Revision round#1**

Dear Authors,

Thank you for submitting your preprint to PCI Ecology. Following the comments from two reviewers on your preprint, and after having read it myself I am not yet ready to recommend it for PCI ecology. The two reviewers, however, are positive, and agree to say that the study provides new insights on sexual segregation. In addition to the reviewers, I have two points that I would like to suggest you consider.

1) In its current form the abstract seems to be a bit contradictory: first, you summarise results showing an absence of sexual segregation in snow petrels. Second, you describe a few results showing foraging differences between the sexes. Third, you conclude that your study shows habitat segregation in snow petrels. I would

recommend you provide a more balanced interpretation of the elements supporting or rejecting the sexual segregation hypothesis, and clarify in which aspects the sexes differ and in which aspects they don't.

2) You use a lot of comparative tests, and false discovery rate corrections may be necessary. FDR corrections may affect your main results and thus the conclusions of your study.

I would like to invite you to resubmit a new draught of the preprint before a decision can be made about a recommendation.

Sincerely, Denis Réale

### Reviewed by **Dries Bonte** , 21 February 2019

The authors report on the sexual habitat and resource segregation in an Antarctic sea bird (snow petrel). They combined data on individual movements, body condition changes and stable isotopes to show the putative role of intraspecific competition resulting in a very specific habitat segregation in relation to sea ice cover. The study therefore adds new insights on the ecological correlates of sex-dimorphism in a vertebrate species; it especially adds evidence for such processes in polar species.

I found the study very well conducted and interesting, and have no substantial comments; nor did I detect methodological flaws – I have to say that I am not an expert in the used methodological approaches, so I cannot judge to which degree they are state of the art.

I have some recommendations that might improve the paper:

1. General (including abstract): you make a distinction between habitat and spatial segregation. You need to make clear (somewhere, in the intro) how you interpret them as different. Although I see the differences, habitat segregation is to my opinion always spatial process as well. So make clear that spatial segregation is a mechanism to avoid competing for the same habitat by choosing other foraging locations; while the latter is about selecting different resources at the same location – so the distinction is scale-dependent. This is a nice example of putative fitness stabilising and equalising mechanisms (see Jeltsch et al. 2013 – Movement Ecology).
2. Introduction – you introduce all hypotheses that were developed to explain segregation between sexes. Some of them are not relevant (thermal hypothesis is actually also a resource-based hypothesis; the social segregation and the predation-hypothesis). You might consider shortening this paragraph in this respect.
3. Line 75: incomplete sentence
4. Line 367: being structurally larger sounds awkward to me
5. Line 660: this is clear interpretation (cfr. Point 1): Results indicate an absence of sexual segregation at a broad-spatial scale, but suggest that sexual segregation in snow petrels is mediated by habitat segregation at a microhabitat scale.

### Reviewed by anonymous reviewer 1, 01 March 2019

Globally the manuscript is well written which allows a fluid and comprehensive reading. All sections have enough detail to be fully understandable and replicable. Above I highlight some major suggestions of changes and few minor ones, which I hope the authors find useful to improve their work.

Major comments .

L240 - Not sure if I understood well the method used to achieve the h-value. But for being able to compare the UD estimates of each individual like the authors later did, the h-value should be the same in all computed kernel UDs.

One possible way to do this would be if (1) you randomly select a few number of trips; (2) run the kernelUD function with the ad hoc method href; (3) check the h-value of such trips and compute the mean value; (4) use that value as a h-value, to then run the kernel.overlap function. Or was this more or less what you did?

L316 - Statistical analysis

Describe also in this section that you used Student's t-tests and Wilcoxon rank tests to test for differences (1)

between sexes in the body measurements and foraging trip metrics; (2) between tissues on the stable isotopic data; Etc.

L451 - Discussion

I found it strange to see several statistical results along the discussion. Please move them to the results section and then at discussion you interpret those findings at the light of ecological theories and debate if those findings are alike findings from other related species/ from similar environments on other regions of the world.

Minor comments

L65 - Maybe you wanted to say "social segregation"? It's true that under that proposed concept, single-sex groups tend to aggregate... Please confirm.

L67-68 - Rewrite as "social and habitat segregations"

L75-76 - Rewrite and rewrite this phrase to make sense. It seems the beginning of it was deleted by mistake

L118 - Please add a question mark after "use"

L119 - Again, add a question mark after "sexes"

L134 - Remove the extra bracket

L197 - Rewrite as "consistency of their foraging niche over time"

L201-202 - Rewrite as "the average trip duration during incubation"

L243 - Rewrite as "40 min"

L348 - Replace "identify" by "identity"

L396 - Rewrite as "it increased"

L447-448 - Replace "p's" by "P"

L468 - Replace "that present no" by "without an"

L520 - "females" .

L535 - Substitute "with" by "which" .

L565 - Replace by "Procellariiform"

L625 - "González-Solís" .

L1015 - Table 4 legend, please start with "Generalized Mixed Additive Model (GAMM)". Also add to the legend a description of what "edf" means .

L1033 - Table 5 legend, please start with "General Additive Model (GAM)". Also add to the legend a description of what "edf" means .

Add to the legends of Tables 6-8 - "The results of student t-tests are also shown, with significant differences in bold" .

Figure 1 - increase the size of the bathymetry legend .

Figure 4 - increase the overall lettering size .