

CRISTIANE H. MILLAN

**Causas e consequências da variação interindividual
na escolha de parceiros pelas fêmeas**

**Causes and consequences of interindividual variation in
female mate choice**

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Resumo

A escolha de parceiros pelas fêmeas é um processo fundamental que contribui para a seleção de uma ampla variedade de traços sexualmente selecionados nos machos. Durante muito tempo, foi amplamente assumido, tanto teoricamente quanto empiricamente, que fêmeas de uma população possuem preferências consistentes por determinados traços masculinos. No entanto, evidências crescentes sugerem uma considerável variação interindividual em vários componentes relacionados à escolha de parceiros, incluindo, por exemplo, a preferência por ornamentos masculinos. Nesta tese, buscamos entender (1) a influência de fatores ecológicos, sociais e fisiológicos na evolução e manutenção da variação interindividual na escolha de parceiros pelas fêmeas e (2) as potenciais implicações dessa variação para a força e direção da seleção sexual sobre os traços sexualmente selecionados nos machos. Para abordar essas questões, utilizamos modelos computacionais para simular interações entre machos e fêmeas durante uma estação reprodutiva e ao longo de várias gerações. Os resultados mostram que a quantidade de variação nos ornamentos masculinos é o fator mais relevante e que impulsiona positivamente a evolução da variação interindividual na seletividade das fêmeas; provavelmente devido aos benefícios indiretos associados ao acasalamento com machos de maior qualidade. Além disso, fatores como a quantidade de recursos disponíveis para as fêmeas e o custo da busca por parceiros também influenciam a evolução da variação interindividual na seletividade, embora em menor grau. As consequências da variação interindividual na escolha de parceiros pelas fêmeas sobre a evolução dos ornamentos masculinos dependem do componente específico da escolha de parceiros que está sendo considerado (i.e., preferência ou seletividade), o tipo de função de preferência (fechada ou aberta) e a magnitude de variação interindividual na preferência feminina em comparação com a variação nos traços masculinos. Em resumo, esta tese destaca a necessidade de considerar diversos fatores que influenciam a evolução e manutenção da variação interindividual na preferência das fêmeas. Adicionalmente, ressalta a importância de investigar tanto a preferência quanto a seletividade ao avaliar o efeito da escolha de parceiros pelas fêmeas na evolução de traços sexualmente selecionados nos machos. Futuros estudos devem explorar empiricamente as predições apresentadas aqui em diversas espécies e contextos ecológicos para obter uma compreensão abrangente sobre a dinâmica da escolha de parceiros.

Abstract

Mate choice is a critical process contributing to the selection of a diverse range of sexually selected male traits. For a long time, it was widely assumed, both theoretically and empirically, that females in a population exhibit consistent preferences for male traits. However, growing evidence now suggests substantial interindividual variation in various components related to mate choice, including for instance the preference for male ornaments. Nonetheless, there is still much to understand about the causes and consequences of this variation. This thesis aims to investigate two key aspects: (1) the influence of ecological, social, and physiological factors on the evolution and maintenance of interindividual variation in female mate choice, and (2) the potential implications of such variation for the strength and direction of sexual selection acting on sexually selected male traits. To address these questions, we employed computational models to simulate the interactions between males and females during a mating season and over multiple generations. The findings reveal that the amount of variation in male ornaments is the most influential factor positively driving the evolution of interindividual variation in female choosiness, likely due to the associated fitness benefits of mating with the highest-quality males in the mating pool. Additionally, factors such as the quantity of resources available to females and the cost of mate searching also affect the evolution of interindividual variation in choosiness, but to a lesser extent. Furthermore, the study demonstrates that the consequences of interindividual variation in female mate choice on the evolution of male ornaments depend on several factors, including the specific component of mate choice being considered (i.e., preference or preference strength), the type of preference function (closed or open-ended), and the magnitude of interindividual variation in female preference compared to male trait variation. In summary, this thesis highlights the importance of considering the several factors that influence the evolution and maintenance of interindividual variation in female preference. Additionally, our findings emphasize the importance of investigating both preference and preference strength when assessing the effect of female mate choice on the evolution of sexually selected male traits. Future studies should empirically explore the predictions presented here in various species and ecological contexts to gain a comprehensive understanding of the mate choice dynamics.

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General Conclusion

Understanding the causes and consequences of interindividual variation in female mate choice, including both preference and choosiness, has posed a persistent challenge in the field of evolutionary biology. While correlational studies conducted under natural field conditions have evaluated the influence of various variables on female mate choice, they lack the experimental rigor necessary to establish causal relationships. Conversely, laboratory studies employ experimental designs but often focus on only one or two variables affecting female mate choice. Furthermore, both field and laboratory studies are typically limited to a single generation, offering limited insights into the long-term consequences of interindividual variation in mate choice for the evolution of sexually selected male traits.

In this thesis, my coauthors and I used individual-based models (IBMs) to address the causes and consequences of interindividual variation in mate choice from a theoretical perspective. IBMs offer a flexible and accessible approach to modeling intricate scenarios with a heightened level of realism, which would be challenging or even infeasible using analytical methods such as differential equations. By utilizing IBMs, we were able to explore complex dynamics and incorporate a multitude of factors to provide a comprehensive understanding of the phenomena under investigation. This approach allowed us to capture the intricacies of the system and simulate realistic individual-level interactions, enabling us to derive valuable insights into the causes and consequences of interindividual variation in mate choice.

In the first chapter of the thesis, my coauthors and I delve into the *causes* behind the interindividual variation in female choosiness (a component of the preference function). Moreover, we quantified the relative significance of the underlying mechanisms that drive interindividual variation in female mate choice. More specifically we investigated the potential role of four variables as drivers of the evolution and maintenance of interindividual variation in choosiness: (i) availability of food resources, (ii) condition dependence of choosiness, (iii) trade-offs between mate searching and offspring production, and (iv) quantity and quality of males in the mating pool. The integration of these factors in a single computational model yielded some unexpected findings.

Firstly, we discovered that variation in sexually selected male traits within a population exerted a significant, albeit previously underappreciated, influence on the evolution and maintenance of interindividual variation in choosiness. This effect likely arises from the fitness benefits associated with mating with high-quality males. Secondly, although the costs of mate searching imposed constraints on interindividual variation in choosiness, the influence of food

resource availability—and consequently, the energetic reserves necessary for mate searching—proved to be relatively minor compared to other factors. Lastly, we demonstrated that the emergence of condition dependence is not a prerequisite for the occurrence of interindividual variation in choosiness, which contradicts findings from numerous empirical studies.

In the second chapter of the thesis, my coauthors and I investigated the potential *consequences* of interindividual variation in female mate choice for the strength and direction of sexual selection acting on sexually selected male traits. More specifically we explored how interindividual variation in female preference (i.e., which male trait value is preferred) and preference strength (i.e., how strong the preference is) affects the opportunity for sexual selection and the evolution of a sexually selected male trait. Again, our findings are not in full agreement with verbal models proposed in the literature of sexual selection. Basically, we demonstrated that variation in the two components, as well as in the shape of the preference function (closed or open-ended), can yield distinct effects on the opportunity for sexual selection and the evolution of male traits.

The highest values of opportunity for sexual selection occurred when females had high variation in preference and an open-ended preference function. The lowest values of opportunity for sexual selection occurred when the magnitude of variation in female preference and male trait value were the same and preference function was closed. Male trait exaggeration was higher when there was high interindividual variation in preference and females had an open-ended preference function. Also, higher male trait variation was maintained by high variation in preference, but only for a closed preference function. Thus, we found that only interindividual variation in female preference, not in preference strength, influences the opportunity for sexual selection and the evolution of sexually selected male traits. Moreover, we found that the shape of the preference function and the magnitude of interindividual variation in female preference compared to male trait variation also influences the opportunity for sexual selection and consequently the evolution of male traits.

In conclusion, although there is growing evidence that females show great interindividual variation in mate choice, we still do not understand the causes and consequences this variation. This thesis highlights the need to consider several factors that influence the evolution and maintenance of interindividual variation in female preference. Additionally, our findings emphasize the importance of investigating both preference and preference strength when assessing the effect of female mate choice on the evolution of sexually selected male traits. Future studies should empirically explore the predictions

presented here in various species and ecological contexts to gain a comprehensive understanding of the mate choice dynamics.