Are red-crested cardinals *Paroaria coronata* (Aves: Thraupidae) truly monomorphic?: evidence discloses sexual dichromatism and size differences since the nestling stage

| Original Article | Published: 04 January 2024

| Volume 165, pages 649–658, (2024)

Cite this article

Journal of Ornithology

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Luciano N. Segura, Melina Atencio, Facundo X. Palacio, Adrián Jauregui & Bettina Mahler

Abstract

The red-crested cardinal (*Paroaria coronata*) is an emblematic bird of the southern cone of South America that has been traditionally

classified as sexually monomorphic and monochromatic from a human visual perspective. Using reflectance spectrometry, we analyzed sexual differences in the coloration of the red head plumage patch of adult wild red-crested cardinals in central-eastern Argentina. We also described sexual differences in body size and determined the onset of morphometric differences by comparing morphological measurements and growth rate between male and female nestlings. Adult males had on average longer wings and brighter red plumage relative to females. Similar to adults, nestlings were sexually dimorphic at fledging and presented sex-specific growth curves. Male nestlings grew faster and reached a larger size at the fledging time. Both for adults and nestlings, wing length was the trait that expressed sexual

differences in body size. Our results are consistent with recent studies in passerines indicating that many birds considered sexually monochromatic are likely dichromatic when considering avian visual capacities. This study allows the red-crested cardinal to be re-categorized as sexually dimorphic and dichromatic.

Zusammenfassung

El cardenal de cresta roja (Paroaria coronata) es un ave emblemática del sur de Sudamérica que ha sido clasificada tradicionalmente como monomórfica y monocromática desde una perspectiva humana. Usamos espectrofotometría de reflectancia para analizar las diferencias sexuales en la coloración del plumaje rojo de la cabeza en individuos adultos

silvestres de cardenal de cresta roja en el centro-este de Argentina. También describimos diferencias sexuales en el tamaño corporal de los adultos y determinamos si estas diferencias se expresaban desde la etapa de pichones. Los machos adultos tuvieron en promedio alas más largas y plumaje rojo más brillante que las hembras. Similar a los adultos, los pichones fueron sexualmente dimórficos antes de abandonar el nido y presentaron curvas de crecimiento específicas en relación al sexo. Los pichones machos crecieron más rápido y alcanzaron un mayor tamaño al momento de abandonar el nido. Tanto para adultos como para pichones, el largo del ala fue el rasgo que expresó las diferencias sexuales en el tamaño corporal. Nuestros resultados son consistentes con estudios recientes en aves paseriformes en

donde se indica que muchas aves consideradas sexualmente monocromáticas, son en realidad dicromáticas si consideramos las capacidades visuales de las aves. Este estudio permite recategorizar al cardenal de cresta roja como sexualmente dimórfico y dicromático.

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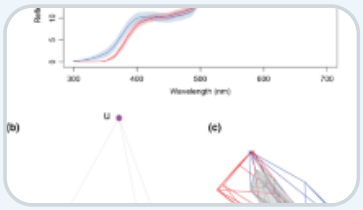

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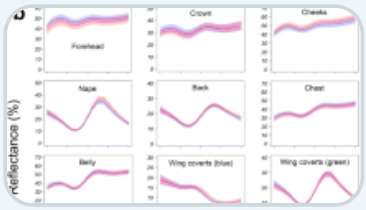

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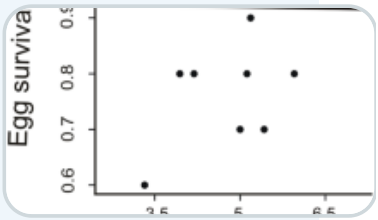

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Acknowledgements

We are grateful to M. L. Del Sotto for allowing us to conduct this study in Estancia ‘La Matilde’. We thank E. Gonzalez and F. G. Di Sallo for help in data collection and nest monitoring. We especially thank C. Facchinetti, A. De la Colina and A. Machado for the technical assistance in molecular sexing. We appreciate the improvements in English writing made by K. Depot. Fieldwork was supported by Agencia Nacional de Promoción Científica y Tecnológica, Grant (PICT-2014-3347). This paper is Scientific Contribution #1245 of the Institute “Dr. Raúl A. Ringuelet” (ILPLA, CCT-La Plata CONICET, UNLP). L. N. Segura, F. X. Palacio and B. Mahler are research Fellow of Consejo

Nacional de Investigaciones Científicas y Técnicas (CONICET).

Funding

Field work was supported by Agencia Nacional de Promoción Científica y Tecnológica (ANPCyT; grant PICT 2014-3347).

Author information

Authors and Affiliations

Laboratorio de Ecología de Aves, Instituto de Limnología Dr. Raul A. Ringuelet (CONICET-Universidad Nacional de La Plata), 122 y 60 (B1900FWA), La Plata, Buenos Aires, Argentina

Luciano N. Segura & Adrián Jauregui

IEGEBA, CONICET-UBA, Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Pabellón II Ciudad Universitaria (C1428EGA), Buenos Aires, Argentina
Luciano N. Segura, Melina Atencio & Bettina Mahler

División Zoología Vertebrados, Facultad de Ciencias Naturales y Museo, Universidad Nacional de La Plata, Paseo del Bosque S/N (B1900FWA), La Plata, Buenos Aires, Argentina
Facundo X. Palacio

Contributions

All authors contributed to the study conception and design. Data collection was performed by

LNS and AJ. Feather preparation for spectrophotometry and molecular sex determination was performed by LNS, MA and BM. Statistical analysis was performed by AJ and FP. The first draft of the manuscript was written by LNS, FP and BM and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Corresponding author

Correspondence to Luciano N. Segura.

Ethics declarations

Conflict of interest

The authors declare that they have no competing interest.

Ethical approval

This study was conducted with research permits from the regional nature conservation authority (Organismo Provincial para el Desarrollo Sostenible, OPDS #003/16, Dirección de Áreas Naturales Protegidas, Buenos Aires province, Argentina).

Additional information

Communicated by A. Fernandes.

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Cite this article

Segura, L.N., Atencio, M., Palacio, F.X. *et al.* Are red-crested cardinals *Paroaria coronata* (Aves: Thraupidae) truly monomorphic?: evidence discloses sexual dichromatism and size differences since the nestling stage. *J Ornithol* **165**, 649–658 (2024). https://doi.org/10.1007/s10336-023-02139-8

Received	Revised	Accepted
12 September 2023	03 November 2023	06 December 2023

Published	Issue Date
04 January 2024	July 2024

DOI

https://doi.org/10.1007/s10336-023-02139-8

Keywords

Body size
Neotropics
Nestling growth
Plumage color
Sexual dimorphism