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Edición Especial en Memoria de Daniel González-Acuña



REVISTA CHILENA DE ORNITOLOGÍA

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La *Revista Chilena de Ornitología* (RChO) publica semestralmente (junio y diciembre) artículos inéditos sobre diversos aspectos de la historia natural, ecología, biología, conservación de aves, conducta y evolución. Esto incluye estudios sobre el rol de las aves en la sociedad (e.g., etno-ornitología, ornitología económica, conflicto aves-humanos, educación ambiental). La revista da especial énfasis a las aves neotropicales, pero artículos de otras regiones son bienvenidos. Los idiomas oficiales de la RChO son el castellano y el inglés. La RChO publica trabajos en cuatro modalidades: Artículos, Comunicaciones Breves, Revisiones/Opiniones y Comentarios de Libros.

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En la portada, sietecolores (*Tachuris rubrigastra*) en Laguna Santa Elena, región del Ñuble, Chile. Fotografía: Daniel González-Acuña. El sietecolores fue una de las especies favoritas de Daniel, dedicando varios años a comprender su biología reproductiva.


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DANIEL GONZÁLEZ-ACUÑA, EL PROFESOR, COLEGA Y AMIGO CARISMÁTICO Y GENEROSO QUIEN EXPANDIÓ EL CAMPO DE LA ORNITOLOGÍA CHILENA

Daniel González-Acuña, a charismatic and generous teacher, colleague and friend who expanded the field of Chilean ornithology

RICARDO A. FIGUEROA¹ & LUCILA MORENO S.²

¹Editor Jefe Revista Chilena de Ornitología, Unión de Ornítólogos de Chile.

²Editor Asistente Revista Chilena de Ornitología, Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Chile.

Correspondencia: Ricardo A. Figueroa, revistachilenaornitologia@aveschile.cl, ra_figueroa_rojas@yahoo.com



Daniel González-Acuña fue el primer editor jefe de la *Revista Chilena de Ornitología*, iniciada en 2016. La-

mentablemente, Daniel falleció el 28 de diciembre de 2020 en la plenitud de su cargo debido a una implacable enfermedad. Su partida fue inesperada y profundamente triste. Debido a su vitalidad para vivir y trabajar, su fallecimiento nos causó una pena inconmensurable que persistirá por siempre en quienes fuimos sus colegas y amigos. Mediante esta edición especial le rendimos un homenaje por su enorme vocación en todo lo que él hizo, particularmente por su fuerte compromiso como editor de nuestra revista.

Además de los artículos en su memoria, en esta editorial destacamos las grandes virtudes de Daniel como persona, naturalista, veterinario, parasitólogo y editor. Mucho de nuestro relato lo hemos tomado de una editorial y dos obituarios dedicados previamente a Daniel (Figueroa 2020, Pizarro *et al.* 2020, Muñoz-Leal *et al.* 2021).

Daniel, la persona

Daniel fue más que un editor, más que un veterinario, más que un académico, más que un científico, más que un profesor, más que tutor y más que un ornitólogo; él fue un tipo excepcional. Su personalidad carismática, espíritu generoso, conversación transparente y humor abundante inspiró a sus estudiantes y colegas e hizo cómodo y regocijante trabajar con él. Daniel transmitió su amor y la pasión por lo que hacía, siempre con simpatía y empatía. Él fue extremadamente colaborativo y amable,

por lo cual muchos de sus colegas, nacionales e internacionales, se convirtieron en sus amigos íntimos. Daniel recibía consejos y sugerencias con increíble humildad. Sus atributos inspiraron una confianza absoluta en quienes trabajamos con él. Sin duda, su espíritu aventurero y deportista contribuyeron a forjar esa personalidad singular. Daniel practicó activamente el maratonismo y montañismo. Estas actividades deportivas revelaban y fortalecían su espíritu de lucha y esfuerzo persistente por alcanzar sus metas. Cuando Daniel supo de su enfermedad, prefirió olvidar la carga que eso significaba y optó por vivir plenamente. Él “abrazó” intensamente cada día de su vida.

Daniel, el naturalista

Daniel nació naturalista. Desde niño le encantaba explorar la naturaleza. Su conexión con el mundo natural lo condujo a convertirse en un asiduo viajero y explorador. Donde sea que fuere, Daniel exhibió una curiosidad persistente y gran capacidad de asombro. Sus viajes por el mundo le permitieron captar y absorber las características de diversos lugares, culturas y animales. Él documentó sus viajes y aventuras con fotografías sorprendentes. Guiado por su espíritu naturalista, Daniel aprovechó su actividad veterinaria y sus estudios parasitológicos para documentar diversos aspectos de la historia natural y ecología básica de la fauna chilena, incluyendo aves, mamíferos, reptiles e insectos. Él transmitió su espíritu naturalista a sus alumnos de pregrado, estimulándolos a realizar sus tesis sobre aspectos desconocidos de varias especies de animales chilenos. El espíritu naturalista de Daniel iba más allá de su quehacer académico. Él comunicó muchas de sus aventuras y hallazgos naturalistas a través de artículos de prensa, ilustraciones fotográficas y calendarios basados en fauna silvestre. Daniel, siempre generoso, repartió gratuitamente lotes de esos calendarios a sus estudiantes, colegas y amigos.

Daniel, el ornitólogo

Daniel fue un ornitólogo de corazón. Ya en 1986, él se convirtió en un miembro fundador de la Asociación Ornitológica de Chile (AOCH), ahora Aves Chile (Unión de Ornitólogos de Chile). Daniel, ya siendo un parasitólogo, fue el primer académico de la Facultad de Ciencias Veterinarias de la Universidad de Concepción en crear la asignatura de Ornitología. A pesar de su carga laboral, él se dio el tiempo y energía para promover el conocimiento y estudio de las aves nativas más allá de la parasitología. Con esto, él enriqueció la formación de varias generaciones de estudiantes. Varios de sus estudiantes han contribuido ahora con diversas publicaciones acerca de las aves chilenas. Daniel era un apasionado colaborador con sus amigos ornitólogos,

siendo capaz de escalar árboles de gran talla para acceder a los nidos del peuquito (*Accipiter chilensis*). Mediante sus estudios de campo y laboratorio, Daniel contribuyó notablemente a profundizar el conocimiento acumulado sobre la historia natural de nuestras aves nativas. Sus publicaciones en el campo de la ornitología incluyeron la distribución, dieta, reproducción, conducta, morfología y parásitos de aves granívoras, aves dulceacuícolas, aves marinas y aves rapaces de distintas localidades de Chile.



Daniel González-Acuña en terreno formando “bandadas mixtas” con sus estudiantes y colegas.

Daniel, el veterinario

Como veterinario, Daniel siempre mantuvo su vocación por el cuidado, protección y rehabilitación de la fauna silvestre. En el año 2004, él creó el Centro de Rescate y Rehabilitación de Fauna en el campus Chillán de la Universidad de Concepción. Este centro ha funcionado con gran regularidad gracias a que Daniel gestionó la donación de recursos y financiamiento mediante la organización periódica de cursos de capacitación en manejo

y medicina de fauna Silvestre. Desde su creación, los integrantes del centro han atendido y rehabilitado centenas de animales silvestres. Además, el Centro ha servido como una base de entrenamiento para los estudiantes de Medicina Veterinaria e hizo posible el desarrollo de investigaciones relevantes en el ámbito clínico de animales silvestres. Mediante publicaciones periódicas de casos clínicos de animales atendidos en el centro, Daniel contribuyó desde las ciencias veterinarias a la educación para la conservación de las especies silvestres. Debido a estos logros, Daniel recibió el reconocimiento de la Municipalidad de Chillán en 2017 y el reconocimiento de la Municipalidad de Bulnes en 2019.

Daniel, el parasitólogo

Daniel mostró un interés amplio y genuino por la fauna parasitaria. Al volver a Chile después de obtener su doctorado en Alemania, Daniel levantó a pulso la investigación sobre los parásitos de la fauna silvestre chilena. En sus primeros años como investigador, él incluso trabajó con sus estudiantes en un pequeño “sucucho” estrecho y helado de un gimnasio en el campus Chillán de la Universidad de Concepción. Como muchos investigadores vocacionales, Daniel puso dinero de su bolsillo para financiar sus estudios y a sus estudiantes colaboradores. En pocos años, él publicó decenas de artículos de relevancia global en colaboración con sus estudiantes y colegas de varios países. Recién ahí, las autoridades de la universidad reconocieron que su trabajo estaba creando un nicho de investigación con gran proyección.

Las publicaciones de Daniel abarcaron la taxonomía, distribución, diversidad y ecología básica de un amplio espectro de grupos de parásitos. Junto a sus estudiantes y colegas, él estudió ácaros, pulgas, piojos, garrapatas, helmintos y esporozoos sanguíneos de aves, mamíferos y reptiles chilenos. Sus hallazgos documentados incluyen la descripción de 30 especies nuevas de ácaros, 11 especies nuevas de pulgas, cinco especies nuevas de garrapatas y cuatro especies nuevas de piojos. La experiencia e información acumulada en el campo de la parasitología le capacitaron para abordar la investigación sobre la biología de los vectores de enfermedades zoonóticas transmisibles. Mediante sus investigaciones en el campo de parasitología, Daniel expandió el campo de la ornitología chilena.

La productividad científica de Daniel fue sorprendente. Él produjo más de 300 artículos científicos, dos libros y 23 capítulos de libros. Además, realizó 338 presentaciones en congresos nacionales e internacionales. Gracias a su experiencia, creatividad y persistencia, Daniel logró el financiamiento del Fondo Nacional de Ciencia y Tecnología de Chile (FONDECYT), Instituto An-

tártico Chileno (INACH) y del Fondo de Equipamiento Científico y Tecnológico (FONDEQUIP).

Indiscutiblemente, Daniel fue uno de los parasitólogos contemporáneos más influyentes en Latinoamérica. Él colaboró en varios otros proyectos interdisciplinarios más allá de su campo específico de investigación. Debido a su productividad científica, las autoridades de la Universidad de Concepción le otorgaron el premio Dr. Álvaro Blanco B. 2013. Este premio lo reciben quienes logran la más alta productividad en los últimos 20 años de vida académica. Indudablemente, el destacado trabajo de Daniel marcó un periodo prolífico en el estudio de los parásitos neotropicales. Sus logros científicos constituyen una referencia para los parasitólogos emergentes.

Daniel, el editor

El trabajo editorial es totalmente voluntario y requiere una enorme carga de altruismo. La tarea de editor involucra tiempo y compromiso que muchas veces nos lleva a extender nuestra jornada laboral o a restar horas a nuestra vida familiar. Cuando Daniel asumió la dirección de nuestra revista, él sabía que tenía un tremendo desafío por delante. Él debió enfrentar todos los problemas que el editor jefe de una revista ornitológica latinoamericana enfrenta hoy (e.g., carencia de revisores, retraso de las revisiones, escasez de artículos en extenso). Sin embargo, Daniel puso una energía y entusiasmo desbordantes en conducir nuestra revista y sobrellevar los desafíos inherentes a la tarea editorial.

Al iniciar su tarea como editor jefe, Daniel coordinó el proceso de transformar nuestro ex *Boletín Chileno de Ornitología* en una revista científica con periodicidad regular en sus publicaciones y con un proceso riguroso de revisión de los manuscritos. Al mismo tiempo, él estableció un canal de comunicación cálido y fluido con los autores y revisores. Como muchos anhelábamos, convertimos a la *Revista Chilena de Ornitología* en el “espacio prometido” para la ornitología nacional. Poco a poco, nuestra revista alcanzó mayor visibilidad y un sitio destacado entre otras revistas ornitológicas latinoamericanas.

El mayor anhelo de Daniel fue lograr la indización de nuestra revista. Es decir, cumplir con las normas internacionales de calidad que rigen a las revistas científicas. Un aspecto relevante (quizá el único relevante) de los sistemas de indización es que permiten valorar a una revista científica por la madurez de la comunidad científica que la sostiene y por el vínculo que esa revista establece entre la ciencia y la sociedad. Esta idea estaba incrustada en el espíritu y la mente de Daniel.

Después de un año de lanzada la *Revista Chilena de Ornitología*, Daniel decidió someterla a una evaluación para ingresarla al sistema de indización Scielo-Chile

(Scientific Electronic Library Online = Biblioteca Electrónica Científica en Línea) el cual administra la Agencia Nacional de Investigación y Desarrollo (ANID). Debido a que no cumplíamos con una docena de requisitos, no logramos la indización (González-Acuña 2017). Daniel nos advirtió explícitamente que la ruta a la indización es escarpada. Las exigencias de la ANID son “draconianas”. No obstante, perseguiremos la excelencia independiente de cualquier sistema elitista de indización. En la medida que nuestro equipo editorial logre que los autores produzcan artículos de alta calidad científica y comunicacional, nuestra revista alcanzará legítimamente un mayor prestigio. En nuestra opinión, eso es fundamental para atraer a más autores y alcanzar una mayor audiencia. Un prestigio obtenido de manera legítima es superior a cualquier etiqueta o métrica de aparente calidad.

Daniel quería que la *Revista Chilena de Ornitología* esté en la mente de cada ornitólogo. Por supuesto, ese es también nuestro anhelo. Siguiendo el legado de Daniel, convocamos a todos los ornitólogos chilenos a que hagamos de la *Revista Chilena de Ornitología* una revista con la máxima madurez editorial, un amplio reconocimiento por parte la comunidad científica y naturalista, y la consolidemos como un instrumento de comunicación y difusión científica. Confiamos en que esta edición especial es un paso adelante en ese camino.

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DANIEL GONZÁLEZ-ACUÑA, A CHARISMATIC AND GENEROUS TEACHER, COLLEAGUE, AND FRIEND WHO EXPANDED THE FIELD OF CHILEAN ORNITHOLOGY

Daniel González-Acuña, el profesor, colega y amigo carismático y generoso quien expandió el campo de la ornitología chilena

RICARDO A. FIGUEROA¹ & LUCILA MORENO S.²

¹Editor Jefe Revista Chilena de Ornitología, Unión de Ornítólogos de Chile.

²Editor Asistente Revista Chilena de Ornitología, Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Chile.

Correspondencia: Ricardo A. Figueroa, revistachilenaornitologia@aveschile.cl, ra_figueroa_rojas@yahoo.com



Daniel González-Acuña was the first editor-in-chief of the *Revista Chilena de Ornitología*, which began in

2016. Sadly, Daniel passed away on 28 December 2020 in the fullness of his tenure due to an unrelenting illness. His departure was unexpected and deeply saddening. Because of his vitality to live and work, his demise caused us immeasurable grief that will forever linger in those of us who were his colleagues and friends. Through this special edition, we pay tribute to his enormous vocation in everything he did, particularly for his strong commitment as editor of our journal.

In addition to the articles in his memory, this editorial highlights Daniel's great virtues as a person, naturalist, veterinarian, parasitologist, and editor. We have taken much of what we tell from an editorial and two obituaries previously dedicated to Daniel (Figueroa 2020, Pizarro *et al.* 2020, Muñoz-Leal *et al.* 2021).

Daniel, the person

Daniel was more than an editor, more than a veterinarian, more than an academic, more than a scientist, more than a teacher, more than a tutor, and more than an ornithologist; he was an exceptional guy. His charismatic personality, generous spirit, transparent narrative, and abundant humor inspired his students and colleagues and made him comfortable and joyful to work with. Daniel conveyed their love and passion for all he did, always with sympathy and empathy. He was overly collaborative and kind, by which many of his national and international colleagues became close friends.

Daniel received advice and suggestions with incredible humility. His attributes inspired absolute confidence in all who worked with him. Undoubtedly, his adventurous and sporty spirit contributed to his unique personality. Daniel was active runner and mountain climber. These sports activities revealed and strengthened his fighting spirit and persistent effort to achieve his goals. When Daniel learned of his illness, he preferred to forget the burden it meant and chose to live fully. He intensely “embraced” every day of his life.

Daniel, the naturalist

Daniel was born a naturalist. As a child, he loved to explore nature. Due to his connection to the natural world, Daniel became an assiduous traveler and explorer. Wherever he was, Daniel exhibited persistent curiosity and a capacity for wonder. His travels through the world allowed him to capture and absorb the characteristics of diverse places, cultures, and animals. He documented his travels and adventures with amazing photographs. Because of his naturalist spirit, Daniel took advantage of his veterinary activity and parasitological studies to document various aspects of the natural history and basic ecology of Chilean fauna, including birds, mammals, reptiles, and insects. He transmitted his naturalist spirit to his undergraduate students, stimulating them to carry out their theses on the unknown aspects of several Chilean animal species. His naturalist spirit went beyond his academic work. Daniel communicated many of his adventures and findings through newspaper articles, photographic illustrations, and wildlife-based calendars. Daniel, ever generous, gifted lots of calendars to his students, colleagues, and friends.

Daniel, the ornithologist

Daniel was an ornithologist at heart. In 1986, he became a founding member of the Ornithological Association of Chile (AOCH), now Aves Chile (Union of Ornithologists of Chile). Daniel, already a parasitologist, was the first academic at the Faculty of Veterinarian Sciences of the Universidad de Concepción to create the first course on Ornithology. Despite his workload, beyond parasitology he gave himself the time and energy to promote the knowledge and study of native birds. With this, he enriched the formation of several generations of students. Several of his students have now contributed to various publications on Chilean birds. Daniel was a passionate collaborator with his ornithologist friends, able to climb large trees to access the nests of the Chilean Hawk (*Accipiter chilensis*). Through his field and laboratory studies, Daniel contributed notably to deepening the accumulated knowledge of the natural

history of our native birds. His publications in the field of ornithology included the distribution, diet, reproduction, behavior, morphology, and parasites of granivorous birds, freshwater birds, seabirds, and birds of prey from different localities in Chile.



Daniel González-Acuña in the field forming “mixed flocks” of students and colleagues.

Daniel, the veterinarian

As a veterinarian, Daniel always maintained his vocation for the care, protection, and rehabilitation of wild animals. In 2004, he established the Wildlife Rescue and Rehabilitation Center at the Chillán campus of the Universidad de Concepción. This center has functioned due to Daniel’s efforts to get donations and funding through the periodic organization of wildlife management and medicine courses. Since its creation, the staff have treated and rehabilitated hundreds of wild animals. In addition, the Center has served as a training base for veterinary medicine students and has made possible the development of relevant research in

the clinical field of wildlife. Through Daniel's periodic publications of clinical cases of animals treated at the Center, the veterinary sciences have contributed to the conservation of wild species. Due to these achievements, Daniel received recognition from the Municipality of Chillán in 2017 and recognition from the Municipality of Bulnes in 2019.

Daniel, the parasitologist

Daniel showed a broad and genuine interest in wildlife parasites. Returning to Chile after earning his doctorate in Germany, Daniel took his research on wildlife parasites into his own hands. In his early years as a researcher, he even worked with his students in a cramped, freezing "cubbyhole" of a gymnasium on the Chillán campus of the Universidad de Concepción. Like many vocational researchers, Daniel took money out of his own pocket to fund his research and student collaborators. Within a few years, he published dozens of articles of global relevance in collaboration with his students and colleagues from several countries. Only then did the university authorities recognize his work was a relevant research niche.

Daniel's publications covered the taxonomy, distribution, diversity, and basic ecology of a broad spectrum of parasite groups. Together with students and colleagues, he studied mites, fleas, lice, ticks, helminths, and blood sporezoans of Chilean birds, mammals, and reptiles. His documented findings include the description of 30 new species of mites, 11 new species of fleas, five new species of ticks, and four new species of lice. The experience and information gained in parasitology enabled him to research the biology of vectors of transmissible zoonotic diseases. Through his research in parasitology, Daniel expanded the field of Chilean ornithology.

Daniel's scientific productivity was astonishing. He produced over 300 articles, 23 book chapters, and two books. In addition, he made 338 presentations at national and international conferences. Due to his experience, creativity, and persistence, Daniel obtained funding from the Chilean National Science and Technology Fund (FONDECYT), the Chilean Antarctic Institute (INACH), and the Scientific and Technological Equipment Fund (FONDEQUIP).

Unquestionably, Daniel was one of the most influential contemporary parasitologists in Latin America. He collaborated on several other interdisciplinary projects beyond his specific field of research. Due to his high scientific productivity, the authorities of the Universidad de Concepción awarded him the Dr. Álvaro Blanco B. 2013 Award. This recognition goes to those investigators achieving the highest productivity during

the last 20 years of academic life. Daniel's outstanding work marked a prolific period in Neotropical parasites research. His scientific achievements constitute a reference for emerging parasitologists.

Daniel, the editor

Editorial work is entirely voluntary and requires an enormous burden of altruism. The labor of an editor involves time and commitment that often leads us to extend our working day or subtract hours from our family life. When Daniel took over the editorship of our journal, he knew he had a tremendous challenge ahead of him. He had to face all the problems that the editor-in-chief of a Latin American ornithological journal faces today (e.g., lack of reviewers, delay of reviews, shortage of full-length articles). However, Daniel put unbounded energy and enthusiasm into leading our journal and coping with the challenges inherent in the editorial task.

At the beginning of his labor as editor-in-chief, Daniel coordinated the transformation of our former *Boletín Chileno de Ornitología* into a scientific journal with regular periodicity in its publications and with a rigorous process of manuscript review. At the same time, Daniel established a friendly and fluid communication channel with authors and reviewers. As many of us longed for, we turned the *Revista Chilena de Ornitología* into the "promised space" for national ornithology. Step by step, our journal achieved greater visibility and a prominent place among other Latin American ornithological journals.

Daniel's greatest desire was to achieve the indexing of our journal. That is, to comply with the international quality standards that govern scientific journals. A relevant aspect (perhaps the only relevant one) of indexing systems is that they allow us to value a scientific journal by the maturity of the scientific community that supports it and by the link journals establish between science and society. That idea was in Daniel's spirit and mind.

After a year of launching the *Revista Chilena de Ornitología*, Daniel decided to submit it to an evaluation for incorporating it into the Scielo-Chile indexing system (Scientific Electronic Library Online), which administers the National Agency for Research and Development (ANID). Because we did not comply with a dozen requirements, we did not achieve indexing (González-Acuña 2017). Daniel explicitly warned us that the route to indexing is steep. ANID's demands are "draconian." Nevertheless, we will pursue excellence independent of any elitist indexing system. To the extent that our editorial team succeeds in getting authors to produce articles of high quality scientific and communicational, our journal will legitimately achieve greater prestige. In our opinion, this is fundamental to attracting more authors and reach-

ing a wider audience. A legitimately obtained prestige is superior to any label or metric of apparent quality.

Daniel wanted *Revista Chilena de Ornitología* to be on the mind of every ornithologist. Of course, that is also our wish. Following Daniel's legacy, we call on all Chilean ornithologists to make the *Revista Chilena de Ornitología* a journal with the highest editorial maturity, with wide recognition by the scientific and naturalist community, and to consolidate it as an instrument of scientific communication and dissemination. We are confident that this issue is a step forward on that path.

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¡DISFRUTEN ESTA EDICIÓN ESPECIAL!

Estimados lectores, colegas y amigos:

En esta edición especial encontrarán cuatro artículos y cuatro comunicaciones breves dedicados a Daniel González-Acuña, nuestro primer editor jefe, quien falleció en la plenitud de su carrera científica y editorial. Agradezco a todos quienes tuvieron la generosidad de enviarnos sus manuscritos y la inmensa paciencia por esperar esta edición especial. Entre los autores hay varios exestudiantes de pregrado y posgrado, colegas nacionales y extranjeros, y amigos de Daniel. Entre los autores extranjeros hay colegas de Argentina, Brasil, Canadá, China y Estados Unidos, lo cual refleja en parte las conexiones que Daniel dejó a través de sus diversas investigaciones. Las contribuciones de todos estos autores constituyen solo un pequeño reconocimiento al extenso legado profesional y científico de Daniel. Algunos manuscritos quedaron pendientes y los incluiremos en futuras ediciones. Los invito entonces a disfrutar la lectura de todos los artículos y a fascinarse con los hallazgos documentados en ellos.

ARTÍCULOS

Más allá de las rejas: usando los centros de rehabilitación de animales silvestres como laboratorios parasitológicos

Terry D. Galloway destaca las ventajas y desventajas de usar animales procedentes de centros canadienses de rehabilitación de fauna silvestre para el estudio de los organismos ectoparásitos. Terry nos relata que durante 20 años tuvo la oportunidad de muestrear los ectoparásitos de > 12 000 animales provenientes de distintos centros de rehabilitación. Sustentado en su trabajo de largo plazo y un tamaño de muestra envidiable, Terry nos cuenta acerca de las facilidades y dificultades en la obtención de muestras de ectoparásitos de los animales en rehabilitación. En condiciones ventajosas, los investigadores tendrán acceso a diversos hospedadores con buena salud y origen geográfico conocido, obtendrán tamaños de muestras adecuados y no deberán sacrificar animales. En condiciones menos ventajosas, los investigadores obtendrán tamaños limitados de muestras, no conocerán el origen de los hospedadores, y se enfrentarán a infestaciones sesgadas y contaminación cruzada. Además, los investigadores podrían exponerse a patógenos emergentes. Como sea, los centros de rehabilitación de vida silvestre ofrecen a los parasitólogos la oportunidad de conducir estudios que

contribuyan a incrementar nuestro conocimiento sobre la ecología de los ectoparásitos.

La diversidad invisible: la fauna parasitaria oculta en los búhos de bosque

Pablo Oyarzún-Ruiz y sus coautores relatan sus hallazgos acerca de la parasito-fauna metazoaria presente en una muestra de búhos de bosque o concones (*Strix rufipes*) provenientes del centro-sur de Chile. Aunque el número de búhos analizados fue pequeño, la muestra arrojó una alta diversidad taxonómica de parásitos metazoarios. Los autores encontraron tres especies de insectos ectoparásitos, incluyendo dos especies de piojos masticadores y una especie de mosca hematófaga. Además, ellos registraron seis especies de gusanos endoparásitos, incluyendo dos especies de nemátodos, una especie de cestodo, dos especies de tremátodos y una especie de acantocéfalo. Es relevante que los autores hayan encontrado una baja carga de parásitos ya que una alta infestación implicaría problemas de salud para los concones. Viéndolo desde el lado positivo, los concones constituirían el “hogar” de varias especies de parásitos nativos, contribuyendo a mantener la diversidad de especies crípticas en los ecosistemas boscosos. Los hallazgos de Pablo y coautores podrían ser solo la punta de la hebra en lo que nos falta por conocer acerca de la relación entre la fauna parasitaria y los búhos de bosque.

¿Nada que temer? Ausencia de rickettsias patogénicas en las garrapatas aviares del bosque atlántico

Julio César de Souza Jr. y sus coautores documentan los resultados de un estudio enfocado a detectar rickettsias en garrapatas aviares en una zona del bosque atlántico al sur de Brasil. Las rickettsias son bacterias transmitidas por piojos, pulgas y garrapatas. Algunas especies de rickettsias presentes en las garrapatas causan la fiebre manchada en humanos. Dado que las aves silvestres pueden actuar como hospederos primarios de garrapatas que acarrean rickettsias patogénicas, los autores indagaron sobre la participación de las aves silvestres en la transmisión de la fiebre manchada. Para esto, los autores capturaron aves en varios sitios, recolectaron sus garrapatas y analizaron muestras de larvas, ninfas y adultos de estos últimos en busca de rickettsias. Entre las 39 especies de aves capturadas, diez hospedaron a la garrapata *Amblyomma longirostre*, la única especie de garrapata encontrada. La única es-

pecie de rickettsia presente en las garrapatas fue *Rickettsia amblyommatis*. Ya que esta especie de rickettsia no causa la fiebre manchada, los resultados de Julio y su equipo indican que las aves locales no dispersan la enfermedad en el área estudiada. Este estudio es pionero en explorar la relación aves-garrapatas-rickettsias en el Neotrópico. Quedamos a la espera de más estudios.

En la vida íntima y familiar de Fiu

Quizá varios de nuestros lectores recuerden que el sietecolores (*Tachuris rubrigastra*) fue la mascota de los Juegos Panamericanos y Parapanamericanos realizados este año en Santiago de Chile. Para la ocasión, el sietecolores recibió el nombre de “Fiu”, una onomatopeya de su canto. A pesar de la combinación distorsionada de colores, Fiu se convirtió en un símbolo llamativo que atrajo el cariño de la gente. Al parecer, la fuerza de sus colores fue la razón. Sus múltiples colores representaron la diversidad de los seres humanos. Hasta la realización de los Juegos Panamericanos, quizá muy pocas personas conocían al sietecolores. La curiosidad popular hizo que algunos de nuestros colegas ornitólogos fueran invitados por los medios de comunicación a que relaten cómo era la vida de Fiu. Eso fue tremendamente positivo para nosotros ya que nos permitió conectar a las aves silvestres con el interés de la gente.

El sietecolores fue una de la especie de aves que más fascinaba a Daniel. Mucho antes de que Fiu fuera famoso, Daniel y su equipo, incluyéndome, condujeron un estudio acerca de la biología reproductiva del sietecolores. Durante cuatro años nos inmiscuimos en la vida íntima y familiar de varias parejas de esta especie en una laguna natural en el centro-sur de Chile. Detectamos que la nidificación fue marcadamente estacional, con más actividad a mediados de primavera. Las hembras pusieron 1-4 huevos dentro de su nido cónico hecho de juncos y los incubaron durante 14-19 días. Cada pareja alimentó a sus polluelos con insectos acuáticos, mayormente con matapiojos (odonatos), hasta que dejaron el nido entre 2-3 semanas después de nacidos. En general, las parejas construyeron sus nidos en sitios con mayor densidad de juncos. Cerca de la mitad de las parejas monitoreadas produjo un polluelo volantón. Es decir, el éxito de nidificación fue $\approx 50\%$. Nuestros hallazgos no solo revelan los aspectos profundos de la historia natural del sietecolores, sino que estamos seguros de que serán fundamentales en futuras acciones de conservación de este colorido y carismático tiránido.

COMUNICACIONES BREVES

Ampliando la piojo-diversidad de los patos y gansos chilenos

Diego Alonso y sus coautores documentan sus hallazgos

sobre la diversidad taxonómica de piojos masticadores en varias especies de patos y gansos chilenos. Sus muestras provinieron de una veintena de localidades entre el extremo norte y el extremo sur de nuestro país. Los autores encontraron ocho especies de piojos en el conjunto de anátidos analizados. El pato jergón grande (*Anas georgica*) y el caiquén (*Chloephaga picta*) contuvieron la mayor riqueza de piojos. Diego y sus coautores encontraron varias asociaciones entre piojos y anátidos que no estaban documentadas. Además, ellos ampliaron el rango de distribución de algunas especies de piojo. Poco a poco vamos conociendo la piojo-fauna hospedada en nuestras aves nativas. El trabajo de los autores no solo contribuye a conocer la diversidad de los piojos aviares, sino también incrementa nuestro conocimiento acerca de la diversidad de los insectos chilenos.

Mas reservas de hábitats, más hábitats para aves

Gabriela Contreras y coautores documentan los resultados de un estudio sobre la diversidad de aves en la Reserva Nasampulli, un área protegida privada creada para preservar el bosque de araucarias (*Araucaria araucana*). Sus objetivos fueron determinar la riqueza de especies de aves dentro de la reserva y detectar especies con prioridad de conservación de acuerdo con la normativa chilena. Ellos detectaron 40 especies de aves. Casi la mitad de estas fueron especies paserinas. Entre estas últimas hubo cuatro especies propias del sotobosque. Además, los autores registraron cuatro especies dependientes de bosques con prioridad de conservación. Estas fueron tres especies de aves rapaces y una especie de carpintero. Los resultados de Contreras y coautores son preliminares, pero podrían ser relevantes para establecer un eventual corredor de hábitats para las aves nativas a lo largo de la franja boscosa andina.

Mmmm...;Otra vez conejos!

Uno de los tantos lugares que Daniel y su equipo visitaron fue el archipiélago Juan Fernández. Durante su estadía allá, ellos aprovecharon la oportunidad de recolectar una veintena de regurgitados de nuco (*Asio flammeus*) para indagar algo más sobre su dieta. El análisis de las muestras reveló que los nucus depredaron preeminentemente sobre conejos europeos (*Oryctolagus cuniculus*) y secundariamente sobre petreles (*Pterodroma* spp.). Tales hallazgos coincidieron con los de un estudio realizado 14 años antes, lo cual refuerza la idea de que los nucus tienen un fuerte vínculo trófico con los conejos en el archipiélago. Sin embargo, considerando que los petreles son numerosos en el archipiélago, estos podrían convertirse en un recurso trófico primario de los nucus ante una erradicación completa de los conejos. Probar esta hipótesis será un tremendo desafío para quien quiera intentarlo. Por ahora, lo prove-

choso es que los hallazgos incrementan un poquito más lo poco que sabemos acerca de la ecología trófica de nuestros búhos isleños.

El piojo de Danito

Daniel R. Gustafsson & Sarah E. Bush describen una nueva especie de piojo masticador cuyo hospedador es el momoto cejazul (*Eumomota superciliosa*). Ellos dedican su hallazgo a Daniel González-Acuña, nombrando a la nueva especie *Motmotnirmus danielalfonsoi*. De esta manera, los autores reconocen la dedicación de Daniel González-Acuña durante 20 años al estudio de los piojos masticadores. Los autores también clarifican la posición taxonómica del piojo masticador *Motmotnirmus guatemalensis* sugiriendo que su hospedero natural es el momoto diademado (*Momotus lessonii*).

Después de revisar la primera versión del manuscrito, les propuse a los autores que intentaran otorgar un nombre común a *M. danielalfonsoi*. Mi intención era disponer de un nombre fácil de recordar para los lectores que no están familiarizados con la nomenclatura taxonómica usada para los piojos. Sin embargo, eso no

era tan fácil y descartamos la idea. Mientras tanto, aquí lo nombro cariñosamente el “piojo de Danito”, ya que así le decíamos a Daniel algunos de sus amigos. Daniel y Sara encontraron que el “piojo de Danito” tiene rasgos bastante diferentes de aquellas especies del mismo género, coincidiendo con la forma de ser de Daniel.

¡A volar con la lectura!

Ricardo A. Figueroa
Editor Jefe

Colegas que colaboraron como revisores para esta edición. Los apellidos están en orden alfabético.

Facundo Barbar (Argentina), José Iannacone (Perú), Fabián Jaksic (Chile), Carlos Landaeta-Aqueveque (Chile), Lucila Moreno Salas (Chile), Sebastián Muñoz Leal (Chile), Ricardo Palma (Nueva Zelanda), Jaime Rau (Chile), Marcelo Savendra (Chile) e Ignacio Troncoso (Chile).

Revisor del idioma inglés

Roy May (EE. UU).

ENJOY THIS SPECIAL ISSUE!

Dear readers, colleagues, and friends:

In this special issue, you will find four articles and four short communications dedicated to Daniel González-Acuña, our first editor-in-chief, who passed away at the peak of his scientific and editorial career. I thank all those who were generous enough to send us their manuscripts and for their immense patience in waiting for this issue. Among the authors are several former undergraduate and graduate students, national and foreign colleagues, and friends of Daniel. Among the foreign authors are colleagues from Argentina, Brazil, Canada, China, and the United States, reflecting in part the connections Daniel made through his diverse research. The contributions by these authors constitute only a minimal recognition of Daniel's extensive professional and scientific legacy. Still, some manuscripts could not be included, and we will publish them in future issues. I invite you to enjoy reading these articles and to be fascinated by all the findings documented here.

ARTICLES

Beyond the fence: using wildlife rehabilitation centers as parasitological laboratories

Terry D. Galloway highlights the advantages and disadvantages of using animals from Canadian wildlife rehabilitation centers to study ectoparasitic organisms. Terry reports that for 20 years, he had the opportunity to sample the ectoparasites of > 12 000 animals from various rehabilitation centers. Based on his long-term work and an envied sample size, Terry tells us about the ease and difficulties in obtaining ectoparasite samples from rehabilitation animals. Under advantageous conditions, researchers will have access to diverse hosts with good health and known geographic origin, will get adequate sample sizes, and will not have to sacrifice animals. Under less advantageous conditions, researchers will obtain limited sample sizes, will not know the origin of hosts, and will face biased infestations and cross-contamination. In addition, they could be at risk of emergent pathogens. However, wildlife rehabilitation centers offer parasitologists the opportunity to conduct studies that contribute to increasing our knowledge of ectoparasite ecology.

Invisible diversity: the parasitic fauna hidden in forest owls

Pablo Oyarzún-Ruiz and his co-authors report their findings about the metazoan parasite fauna in a sample of Rufous-legged Owls (*Strix rufipes*) from central-southern Chile. Although the number of owls analyzed was small, the sample showed a high taxonomic diversity of metazoan parasites. The authors found three species of ectoparasitic insects, including two species of chewing lice and one species of blood-sucking fly. Additionally, they recorded six species of endoparasitic worms, including two species of nematodes, one species of cestode, two species of trematodes, and one species of acanthocephalan. It is relevant that the authors found a low parasite load since a high infestation would imply health problems for Rufous-legged Owls. On the positive side, Rufous-legged Owls would constitute the home of several species of native parasites, contributing to maintaining the diversity of cryptic species in forest ecosystems. The findings of Pablo and co-authors could be just the tip of the thread in what we still need to know about the relationship between parasitic fauna and forest owls.

Should we not fear? Absence of pathogenic rickettsiae in avian ticks from the Atlantic forest

Julio César de Souza Jr. and his co-authors document the results of a study focused on detecting rickettsiae in avian ticks in an area of the Atlantic Forest in southern of Brazil. Rickettsiae are bacteria transmitted by lice, fleas, and ticks. Some species of rickettsia present in ticks cause spotted fever in humans. Since wild birds can act as primary hosts for ticks that carry pathogenic rickettsiae, the authors investigated the role of wild birds in carrying spotted fever. For this, the authors captured birds in several sites, collected their ticks, and analyzed samples of larvae, nymphs, and adults of the latter in search of rickettsiae. Among the 39 species of birds captured, ten hosted the tick *Amblyomma longirostre*, the only tick species found. The only rickettsia species present in ticks was *Rickettsia amblyommatis*. Since this rickettsia species does not transmit spotted fever, Julio and his team's results indicate that birds would not spread the disease in the area studied. This study is a pioneer in exploring the bird-tick-rickettsia relationship in the Neotropics. We are

waiting for more studies.

In Fiu's intimate and family life

Perhaps several of our readers remember that the Many-colored Rush-tyrant (*Tachuris rubrigastra*) was the mascot of the Pan American and Parapan American Games held this year in Santiago of Chile. For the occasion, the Many-colored Rush-tyrant received the name Fiu, an onomatopoeia of its song. Despite its distorted color combination, Fiu became a striking symbol that attracted people's love. Conceivably, the strength of its colors was the reason. The multiple colors of Fiu represent the diversity of human beings. Until the Pan American Games, perhaps very few people knew the Many-colored Rush-tyrant. Popular curiosity led some of our ornithological colleagues to be invited by the media to tell what Fiu's life was like. That was tremendously positive for us as it connected wild birds with citizenship interests.

The Many-colored Rush-tyrant was one of the species of birds that most fascinated Daniel. Long before Fiu was famous, Daniel and his team that included me, studied the breeding biology of Many-colored Rush tyrants. For four years, we surveyed the intimate and family life of several pairs of this species in south-central Chile. We detected that nesting was markedly seasonal, with more activity in mid-spring. The females laid 1-4 eggs inside their conical nest made of reeds and incubated them for 14-19 days. Parents fed their chicks with aquatic insects (mostly dragonflies) until they left the nest 2-3 weeks after hatching. In general, pairs built their nests in sites with a higher density of reeds. About half of the monitored pairs produced a fledgling chick. That is, nesting success was $\approx$ 50%. Our findings not only reveal profound aspects of the natural history of the Many-colored Rush-tyrant, but we are sure that they will be fundamental in future conservation actions for this colorful and charismatic Tyranid.

SHORT COMMUNICATIONS

Expanding the louse-diversity of Chilean ducks and geese

Diego Alonso and his co-authors document their findings on the taxonomic diversity of chewing lice in several Chilean duck and goose species. Samples came from around twenty localities distributed between the northern and southern extremes of the country. The authors found eight species of lice in the sample of anatids analyzed. The Yellow-billed Pintail (*Anas georgica*) and Upland Goose (*Chloephaga picta*) contained the highest richness of lice. Diego and his co-authors found several associations between lice and anatids up to now not documented. In addition, they expanded the distribution range of

some louse species. Step by step, we are getting to know the louse fauna hosted on our native birds. The authors' work contributes to understanding the diversity of avian lice and increases our knowledge about the diversity of Chilean insects.

More habitat reserves, more bird habitats

Gabriela Contreras and co-authors document the results of a study on bird diversity in the Nasampulli Reserve, a private protected area created to preserve the Araucaria (*Araucaria araucana*) forest. Its objectives were to determine the bird species richness within the reserve and detect species with conservation priority by Chilean Law. They detected 40 species of birds. Almost half of these were passerine species. Among the latter, there were four typical species of the undergrowth. In addition, the authors recorded four forest-dependent species with conservation priority. These were three raptor species and one species of woodpecker. The results of Contreras and co-authors are preliminary but could be relevant to establishing an eventual habitat corridor for native birds along the Andean forest belt.

Mmmm..., rabbits again!

One of the many places that Daniel and his team visited was the Juan Fernández archipelago. During their stay there, they took the opportunity to collect about twenty pellets of Short-eared owls (*Asio flammeus*) to find out more about their diet. Analysis of the samples revealed that Short-eared owls preyed preeminently on European rabbits (*Oryctolagus cuniculus*) and secondarily on petrels (*Pterodroma* spp.). These findings coincided with those from a study carried out 14 years earlier, which reinforces the idea that Short-eared owls have a strong trophic link with rabbits in the archipelago. However, considering that petrels are numerous there, they could become a primary food for the Short-eared Owls in the event of a complete eradication of rabbits. Testing this hypothesis will be a tremendous challenge for anyone who wants to try it. For now, the beneficial thing is that the findings further increase the little we know about the trophic ecology of our island owls.

Danito's louse

Daniel R. Gustafsson & Sarah E. Bush describe a new species of chewing louse whose host is the Turquoise-browed Motmot (*Eumomota superciliosa*). They dedicate their finding to Daniel González-Acuña, naming the new species *Motmotnirmus danielalfonsoi*. In this manner, authors acknowledge Daniel González-Acuña's 20-year dedication to the study of chewing lice. Daniel and Sara also clarify the taxonomic position of the chewing

louse *Motmotnirmus guatemalensis* by suggesting that its natural host is the Lesson's Motmot (*Momotus lessonii*).

After reviewing the first version of the manuscript, I suggested to the authors that they try to give a common name to *M. danielalfonsoi*. I intended to have an easy-to-remember name for readers unfamiliar with the taxonomic nomenclature used for lice. However, that was not so easy, and we discarded the idea. For now, here I affectionately name it "Danito's louse," as that is what some of his friends used to call Daniel. Daniel and Sara found that the "Danito's louse" has very different traits from those species of the same genus, coinciding with Daniel's way of being.

Let's fly with reading!

Ricardo A. Figueroa
Editor-in-Chief

**Colleagues who collaborated as reviewers for this issue.
The last names are in alphabetical order.**

Facundo Barbar (Argentina), José Iannacone (Perú), Fabián Jaksic (Chile), Carlos Landaeta-Aqueveque (Chile), Lucila Moreno Salas (Chile), Sebastián Muñoz Leal (Chile), Ricardo Palma (New Zealand), Jaime Rau (Chile), Marcelo Saavedra (Chile) and Ignacio Troncoso (Chile).

English reviewer
Roy May (U.S.A.).

UTILIZATION OF ANIMALS FROM CANADIAN WILDLIFE REHABILITATION HOSPITALS TO STUDY THE TAXONOMY AND ECOLOGY OF PARASITIC LICE (PHTHIRAPTERA) AND OTHER ECTOPARASITES

Uso de animales tratados en centros canadienses de rehabilitación de fauna silvestre para estudiar la taxonomía y ecología de piojos parásitos (Phthiraptera) y otros ectoparásitos

TERRY D. GALLOWAY

Department of Entomology, University of Manitoba, Winnipeg, Canada, Manitoba, R3T 2N2.

Correspondence: Terry.Galloway@umanitoba.ca

ABSTRACT. – I aim to examine the advantages and disadvantages of sourcing wildlife from Canadian rehabilitation hospitals to study ectoparasite ecology and parasitology. A survey conducted in Manitoba, Canada, has relied heavily on salvaged wildlife (> 12 400 hosts) through collaboration with wildlife hospitals from 1993 to 2023. The advantages of this approach included access to a considerable bird and mammal diversity (296 species). Sample sizes for many species were large, and individuals came from a wide geographic area. I salvaged animals euthanized because of casualties or which died in care. Thus, I did not have to sacrifice animals for rigorous ectoparasite sampling. Because animals became available opportunistically, it was only possible for me to sample small numbers ($n \leq 10$) of many species, and I had no control over where or when samples arose. It is necessary to consider biases from juvenile animals and, in some cases, from animals sick or injured for an unknown time. Although most hosts had comprehensive data on provenance, persons occasionally submitted animals with missing data. Hospital staff always exercised care to avoid cross-contamination of ectoparasites where many species arrived and avoid potentially infectious pathogens. In conclusion, wildlife rehabilitation hospitals are a valuable resource for ectoparasite research.

KEY WORDS: biodiversity, ecology, host-parasite interactions, parasitology.

RESUMEN. – Examino las ventajas y desventajas de usar animales procedentes de hospitales canadienses de rehabilitación para estudiar la ecología y parasitología de ectoparásitos. Un estudio en Manitoba, Canadá, incluyó animales recuperados entre 1993 y 2023 mediante la colaboración con hospitales de rehabilitación (> 12 400 hospedadores). Gracias a esto accedí a una considerable diversidad de aves y mamíferos (296 especies). La muestra de muchas especies era grande y los individuos procedían de una amplia zona geográfica. Ya que recuperé animales eutanizados o que murieron en cuidados médicos, no debí sacrificar animales para mostrar rigurosamente ectoparásitos. Dado que la disponibilidad de animales fue variable, solo pude muestrear pequeños números ($n \leq 10$) de muchas especies, y no tuve control sobre dónde o cuándo surgieron las muestras. Hay que considerar el sesgo causado por los animales jóvenes y los que estuvieron enfermos o heridos un tiempo desconocido. Aunque la mayoría de los hospedadores tuvieron datos completos de su procedencia, hubo algunos con datos incompletos. El personal del hospital tuvo cuidados para evitar la contaminación cruzada de ectoparásitos y el contagio con patógenos infecciosos cuando había muchas especies. En conclusión, los hospitales de rehabilitación de fauna silvestre son un recurso valioso para estudiar ectoparásitos.

PALABRAS CLAVES: biodiversidad, ecología, interacciones huésped-parásito, parasitología.

INTRODUCTION

As Miriam Rothschild pointed out in the Foreword, Adrian

Marshall's book (1981) opened up, "...a fascinating world for a new generation of biologists." Since that time,

there have been increasing numbers of entomologists increasingly engaged in the exploration of ectoparasites and their relationships with their hosts. There is little doubt that parasitic lice (Phthiraptera) make up the majority of species among ectoparasitic insects. In fact, there are genera of chewing lice that still hold a vast, undescribed diversity of species (e.g., Valim & Weckstein 2013, Bush *et al.* 2016, Gustafsson & Bush 2017). Daniel González-Acuña was one such biologist who strived to expand our knowledge of these ectoparasites. It is with respect for his interests that I acknowledge his many contributions to ectoparasite ecology and taxonomy and submit the following account.

In the late 1980s, I was a member of the Scientific Committee of the Biological Survey of Canada (<https://biologicalsurvey.ca/>). The objectives of one project in which I was involved were to survey the status of our knowledge of the ectoparasites of vertebrates in Canada and make recommendations going forward (Galloway & Danks 1991). Striking among the findings was that, in general, information about ectoparasites was seriously deficient. In fact, specialists have recorded only $\approx 50\%$ of the described species of parasitic lice and only $\approx 2\%$ of parasitic astigmatid mites expected to infest known hosts in Canada. Specialists have recommended that these groups should be targeted, and that entomologists should adopt an integrated approach involving ornithologists and mammalogists.

In 1993, the Manitoba Wildlife Rehabilitation Organization (MWRO, now Wildlife Haven Rehabilitation Centre, Île des Chênes) moved into their new facilities at the Glenlea Research Farm of the Faculty of Agricultural and Food Sciences at the University of Manitoba. On my first visit with the MWRO hospital director, Brian Ratcliff, we arranged opportunities for me to collect ectoparasites from wildlife presented at their rehabilitation hospital. Over time, I was given wildlife individuals that either succumbed following submission or had been euthanized because of the seriousness of their condition on arrival. Since that time, I have examined more than 12 465 individuals, including birds and mammals. Most samples were from the MWRO, the Prairie Wildlife Rehabilitation Centre (PWRC, St. Adolphe), and other sources in Manitoba. From these experiences, my objective in this paper is to describe the advantages and disadvantages associated with sourcing wildlife from rehabilitation hospitals for the study of ecology and taxonomy of ectoparasites. However, I somewhat limit presented data to parasitic lice. For a more comprehensive review of various additional methods of collecting ectoparasites see Marshall (1981) and Clayton & Walther (1997).

ADVANTAGES OF SALVAGED ANIMALS FROM WILDLIFE REHABILITATION HOSPITALS

Access to diverse host animals

Wildlife rehabilitation hospitals regularly receive injured and variously affected animals of considerable variety. Once aware of the presence of local hospitals, the public will kindly submit or report almost any species of host. Over 30 years, I have examined 296 host species in Manitoba for ectoparasites, including 248 species of birds and 48 species of mammals. With widespread awareness comes the greater likelihood that uncommon, rarely examined species of hosts or even threatened and endangered species may become available. Examples among these during the current survey are Common Nighthawk (*Chordeiles minor*; $n = 235$) and Eastern Whip-poor-will (*Antrostomus vociferus*; $n = 13$) (Galloway 2006, Galloway & Lamb 2015, Kuabara *et al.* 2020), Barn Swallow (*Hirundo rustica*; $n = 101$), Chimney Swift (*Chaetura pelagica*; $n = 8$), Least Bittern (*Ixobrychus exilis*; $n = 3$), and Golden-winged Warbler (*Vermivora chrysoptera*; $n = 1$).

Good quality of host animals

To guarantee an accurate assessment of ectoparasite populations, it is crucial to examine the host as soon as possible after acquisition. Because some ectoparasites may leave a host shortly after death, an examination of the live host is preferable. However, there are few options available for collecting methods of ectoparasites at this time. Animals submitted to rehabilitation hospitals are often alive, though in many cases injured, so permanent ectoparasites such as lice and most parasitic mite species remain on the host. Some ectoparasites may abandon the host during triage. Trained hospital staff use care handling their patients, and those animals that require euthanasia or that die in care are immediately bagged individually and frozen by the staff. So, this protocol contributes to minimizing ectoparasites lost. We must keep in mind that the ectoparasite number on subsequent examination represents a minimum population size. This is particularly the case with mobile, temporary ectoparasites such as hippoboscids, fleas, and ticks.

Adequate sample sizes

Adequate sample sizes are paramount in discovering species of ectoparasites that infest their hosts at low prevalence and reaching sound conclusions about quantitative aspects of ectoparasite infestation. In the Manitoba survey, 53.4% ($n = 158$) of the species examined had a sample size of more than ten individuals (Fig. 1). Some of the most common species, such as Eastern Cottontail (*Sylvilagus floridanus*; $n = 392$), House Sparrow (*Passer domesticus*; $n = 457$), American Robin (*Turdus migra-*

torius; n = 574), and Rock Pigeon (*Columba livia*; n = 811), were represented in large numbers. This allowed an investigation of population biology of their permanent ectoparasites, such as parasitic lice (Galloway 2012, Galloway *et al.* 2021, Galloway & Lamb 2014, 2015, Lamb & Galloway 2016, 2018, 2019).

Determination of the host's geographic distribution

Animals which ultimately reach rehabilitation hospitals may be most representative of the immediate area of the hospital. For example, 67.3% of all animals examined in Manitoba were from Winnipeg. However, many animals arrive at the hospital from considerable distances. Submitted animals came from more than 300 different locations around the province. Some animals arrived from as far away as Churchill, a transition zone from boreal forest to Arctic tundra more than 1000 km north of Winnipeg. Because of the wide distribution of individuals, species from different ecological zones become available for study, as well as the likelihood of increased host diversity. I must point out that most bird species examined in the Manitoba study are migratory and may only be transient in the location where they were injured. For species nesting in northern tundra or boreal forests, their brief period of occupation in the south of the province during spring and autumn may be the only time when they are likely to be submitted to rehabilitation hospitals.

Estimation of the total ectoparasite population

Once animals die, it is possible to examine them using

more invasive methods. Vigorous washing is one of the most efficient means of collecting most ectoparasites (Clayton & Drown 2001). If the objective is to determine the spatial distribution of ectoparasites on the host body, one can remove individual body regions and wash them separately. By this method, one can identify populations of ectoparasites in each body region (Grossi & Galloway 2022). Alternatively, one can remove and dissolve the skin or hide as another means of determining near-total ectoparasite populations (*e.g.*, Choe & Kim 1987). It is also easy to examine birds for nasal mites (*e.g.*, Knee & Galloway 2017, Knee *et al.* 2008), quill mites (*e.g.*, Bochkov & Galloway 2001, 2004), and skin mites (*e.g.*, Harpirhynchidae; Bochkov & Galloway 2004, 2013), species less easily accessed through examination of live hosts.

In either case, one can pass samples through a fine-mesh screen (90 μ in this study) to retain all ectoparasites in a sample (Fig. 2) and preserve them in ethanol. Then, one can sort specimens using a stereomicroscope. Ectoparasites of all sizes and degrees of pigmentation are visible under magnification, countable and removable from the sample. Early instars and teneral individuals of parasitic lice are often small and weakly pigmented (*e.g.*, *Anatoecus* and *Goniocotes*). One can sort specimens using a white or black background to enhance contrast and facilitate sorting efficiency.

No animals are sacrificed

Ethical considerations often preclude random collection of most species of wildlife. Exceptions include exotic, in-

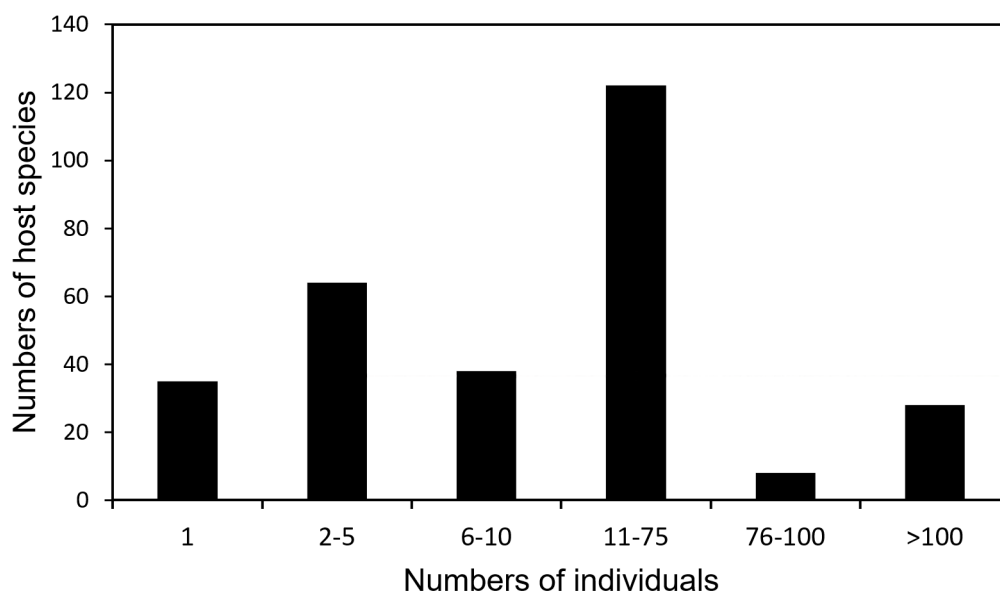


Figure 1. Distribution of 296 species of hosts (birds = 248; mammals = 48) according to numbers of individuals of each species examined for ectoparasites in Manitoba, Canada, 1993-2021.



Figure 2. Sample washed from a Pileated Woodpecker (*Dryocopus pileatus*) onto a 90 μ brass sieve. The sample is rinsed into a bottle, upper left, and preserved with 95% ethanol for later sorting and removal of ectoparasites (Photo by Jordan Bannerman).

troduced species, game and fur-bearing animals, and nuisance species. In general, native wild species come under some level of protection and regulation from government agencies. Wildlife hospitals are regulated under protocols set by federal and provincial guidelines in Canada and may be allowed to admit virtually all species to their facilities. Animals euthanized or that died naturally can then be examined for ectoparasites, though still under the authority of regulatory agencies, which require permits and proper reporting and disposal. The primary benefits come from the ability to evaluate a wide variety of wild species without the necessity to kill wild animals and negatively affect their populations. A bonus is that the hosts can be deposited in museum collections as vouchers after being examined for ectoparasites.

DISADVANTAGES OF SALVAGED SPECIMENS FROM WILDLIFE REHABILITATION HOSPITALS

Sample size limitations

While 53.4% of species examined in this study had a sample size of more than ten specimens each, a considerable

number of species had a sample size of ≤ 10 specimens ($n = 138$ species; Fig. 1). Of these, 34 species were represented by only one specimen, from 13 of which no ectoparasites were collected: Parasitic Jaeger (*Stercorarius parasiticus*), Baird's Sandpiper (*Calidris bairdii*), Semipalmated Sandpiper (*Calidris pusilla*), Spotted Sandpiper (*Actitis macularius*), Barn Owl (*Tyto alba*), Bobolink (*Dolichonyx oryzivorus*), Golden-winged Warbler, Northern Mockingbird (*Mimus polyglottos*), Orchard Oriole (*Icterus spurius*), Scarlet Tanager (*Piranga olivacea*), Veery (*Catharus fuscescens*), Yellow-throated Warbler (*Setophaga dominica*), and Pygmy Shrew (*Sorex hoyi*).

Small sample sizes may occur because host species are less common, vagrant, or occur less frequently where people are likely to encounter injured individuals. Even when small numbers of a host species are available for examination, there is the opportunity to collect undocumented ectoparasites and contribute to knowledge of local faunal diversity. However, robust assessment of infestation parameters and patterns of seasonal infestation requires larger sample sizes. Where species of ectoparasites have low prevalence, their presence may go undetected in the

region unless larger sample sizes are attainable. In collaboration with rehabilitation hospitals, where the availability of various species of hosts is unpredictable, patience and persistence are required, perhaps over many years.

Uncertainty of the geographic origin and temporal distribution of samples

For specific ecological studies, it is often preferable that samples come from a clearly defined location within a clearly defined timeline. However, this is not possible because of the opportunistic nature of hosts from rehabilitation hospitals. As described above, 33.7% of hosts examined in this study came from more than 300 widely scattered locations other than Winnipeg and mostly near small towns. Because many species of birds in Manitoba are migratory, they are available for study only during relatively short seasons as they travel into and out of the province or to more northern breeding locations. Consequently, it may take several years to accumulate enough data from a sufficiently large sample of hosts to allow for suitable analysis. That was the case for several studies on Common Nighthawk (Galloway 2006, Galloway & Lamb 2015), owls (Galloway & Lamb 2019, Lamb & Galloway 2019), Bald Eagle (*Haliaeetus leucocephalus*; Lavallée *et al.* 2020), and thrushes (Galloway *et al.* 2021).

Biases in the infestation intensity

Although some animals submitted to wildlife rehabilitation facilities are healthy and fit, such as the case of young animals abandoned by parents, the majority are in some way incapacitated. Incapacitation may result from traumatic injury (*e.g.*, window strike, cat mauling, vehicle collision), starvation, sickness, poisoning, or hypothermia. In addition, larger animals are often emaciated and dehydrated. The length of time from when a host could no longer care and groom for itself, and thus where there may be an impact on its populations of ectoparasites, is rarely known or recorded. Such bias is unlikely to alter the prevalence of infestation significantly since hosts will have maintained the infestation at the time of their incapacitation. However, the impact on infestation intensity warrants greater concern, especially if the host has been incapacitated for a lengthy period, sufficient time for ectoparasites to have passed through one or more reproductive cycles. Hosts with severe traumatic injuries are unlikely to survive long in the wild, and such animals are not suitable for release into the wild. These animals are usually euthanized shortly after assessment during triage.

Occasionally, animals with particular deformities may support an unusually high infestation intensity. For example, a juvenile Double-crested Cormorant (*Phalacrocorax auritus*) with a deformed beak under an emaciated

condition near Lac du Bonnet, Manitoba, had an infestation of 1228 adult *Pectinopygus farallonii*. This unusually high infestation level could partially be attributable to the deformed bill as it would have diminished the cormorant's ability to preen and obtain food.

Younger animals tend to predominate in submissions to rehabilitation hospitals for most host species (*e.g.*, Galloway 2012, Grossi 2013). These are typically young-of-the-year animals with little experience on their own, which are particularly vulnerable to attack by predators and accidents. The extent to which this may affect the prevalence and intensity of infestation is demanding to establish quantitatively. That requires knowing infestation parameters in parents and siblings, the host's age, or the efficiency of grooming in each host species. Nonetheless, this creates a factor of bias in a study.

Deficiencies in collection data

Precise locality data are always preferable for collections of any organisms. Unfortunately, this is not always the case for hosts submitted to rehabilitation hospitals. Sometimes, people even leave animals on the doorstep after hours when there are no staff to record pertinent information. Occasionally, submitted hosts come from a veterinary clinic or a friend of the person(s) who found the injured animal. Sometimes, the person who found the animal may have kept it under less-than-ideal conditions. Although most rehabilitation hospitals have standardized submission forms soliciting critical information, important data may not always be available.

Cross-contamination

Wildlife rehabilitation hospitals may take in considerable numbers of different species in a year and even over a day. At certain times of the year (*e.g.*, during migration), a hospital may receive many animals that require immediate care. As a result, at peak periods, staff may be faced with examining and treating a considerable number of animals in a short period. During these periods, there is a greater risk of cross-contamination. This can follow repeated use of a towel or blanket or ectoparasites falling from a host onto a surface where they may later transfer to a different host. This is an insidious risk a researcher must always consider as a possibility, especially where an atypical ectoparasite species appears on a host.

A species of louse found on an unlikely host (*e.g.*, a pelican louse on a passerine bird) is almost certainly an accidental contaminant. However, cross-contamination may not be so apparent when an ectoparasite is an undescribed species of a genus associated with a possible host (*e.g.*, an undescribed species of *Brueelia* on a passerine). Predators often become infested with ectoparasites

from their prey. However, in a wildlife hospital setting, it may not be definitively possible to determine whether this was a natural transfer from prey to predator or a case of contamination in the hospital facility. It may be possible over time to confirm host-parasite associations by repeated collections from that same host species. However, this may not always be possible. The best defense is for staff to be well-trained and well-informed about the possibility of cross-contamination and incorporate best practices to minimize the risk of occurrence.

Exposure to pathogens

As is the case whenever handling wildlife, there is a risk of exposure to potential pathogens. In Manitoba, where staff have examined > 12 000 animals, strict laboratory protocols are in place to minimize exposure. Protective clothing, gloves, and face shield are standard practice when processing animals. However, an outbreak of Highly Pathogenic Avian Influenza occurred in many parts of North America. Rehabilitation hospitals in Manitoba introduced preventative protocols to minimize the chances of infection entering and spreading within their facilities. Birds could no longer be transferable to other laboratory facilities. Although there is a low risk the Avian Influenza virus infecting humans, no avian species were admitted to laboratory facilities for examination for ectoparasites at the University of Manitoba during the outbreak.

CONCLUSIONS

Since Marshall (1981), there has been tremendous progress in the taxonomy, systematics, and ecology of ectoparasites. Yet there is an ample gap in our knowledge of regional diversity and population dynamics, especially among parasitic lice (Galloway & Lamb 2021). Wildlife rehabilitation hospitals can offer an opportunity for parasitologists to address this gap.

Human activities increasingly affect wildlife in close contact, often with catastrophic impacts on host animals. Animals suffer injuries in collisions with human-built structures, including windows in buildings, wires, lights, and towers. Wild animals can suffer mutilations by bites of domestic cats and dogs. Accidental poisoning and oil spills in terrestrial and aquatic systems are a risk to the well-being of many species. Many host animals suffer injuries or die because of collisions with vehicles. In response to these impacts on wildlife populations and with increasing response to the need for wildlife conservation, rehabilitation hospitals are becoming increasingly abundant in many countries around the world. There are nearly 100 such facilities across Canada designed to care for sick and injured wildlife. Some facilities accept all species, native and introduced (e.g., Wildlife Haven Re-

habilitation Hospital, Îles des Chênes, Manitoba), while others specialize in certain species groups (e.g., Canadian Raptor Conservancy, Vittoria, Ontario).

Wildlife rehabilitation hospitals may accept a wide diversity of species (see above), sometimes in considerable numbers. The Wildlife Haven Rehabilitation Hospital in Manitoba received more than 3000 animals to their services in 2021. Respectful and considerate collaboration with personnel at wildlife rehabilitation facilities offers parasitologists opportunities to access species hard to obtain by other means. The number of parasitologists taking advantage of these opportunities seems to be increasing (Appendix 1), with beneficial results for our knowledge of these species.

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Appendix 1. Selected references in chronological sequence to studies on parasitic lice (Phthiraptera) where bird and mammal hosts were obtained through wildlife rehabilitation hospitals.

Taxon	No. of individuals	Location	Reference
Accipitriformes	Not indicated	Spain	Pérez-Jiménez <i>et al.</i> (1988)
Accipitriformes Falconiformes Strigiformes	55	Hungary	Solt (1998)
Passeriformes	64	Manitoba, Canada	Galloway (1999)
Accipitriformes Falconiformes Strigiformes	35	California, U.S.A.	Morishita <i>et al.</i> (2001)
Accipitriformes Anseriformes Charadriiformes Columbiformes Galliformes Passeriformes Pelecaniformes Piciformes Procellariiformes Suliformes	Not indicated	Florida, U.S.A.	Holt (2002)
Accipitriformes Apodiformes Charadriiformes Ciconiiformes Columbiformes Galliformes Passeriformes Pelecaniformes Procellariiformes Strigiformes Suliformes	Not indicated	Florida, U.S.A.	Holt (2003)
Gruiformes	35	Manitoba, Canada	Galloway (2004)
Accipitriformes Charadriiformes Ciconiiformes Pelecaniformes Strigiformes	Not indicated	Florida, U.S.A.	Holt (2005)
Caprimulgiformes	103	Manitoba, Canada	Galloway (2006)
Columbiformes	322	Manitoba, Canada	Galloway & Palma (2008)
Accipitriformes Falconiformes	Not specified	Chile	González-Acuña <i>et al.</i> (2008)
Accipitriformes Anseriformes Ciconiiformes Falconiformes Gruiformes Passeriformes Pelecaniformes Strigiformes	24	Hungary	Rékási (2008)
Carnivora	35	Netherlands	Morick <i>et al.</i> (2009)
Pelecaniformes Suliformes	83	Manitoba, Canada	Galloway (2011)
Lagomorpha	285	Manitoba, Canada	Galloway (2012)
Anseriformes	590	Manitoba, Canada	Grossi (2013)
Columbiformes	659	Manitoba, Canada	Galloway & Lamb (2014)

Podicipediformes Suliformes Pelecaniformes Anseriformes Accipitriformes Falconiformes Galliformes Gruiformes Charadriiformes Columbiformes Cuculiformes Strigiformes Caprimulgiformes Apodiformes Coraciiformes Piciformes Passeriformes	Not specified	Manitoba, Saskatchewan and Alberta, Canada	Galloway <i>et al.</i> (2014)
Anseriformes	757	Manitoba, Canada	Grossi <i>et al.</i> (2014)
Passeriformes	192	Manitoba, Canada	McNally (2014)
Caprimulgiformes	178	Manitoba, Canada	Galloway & Lamb (2015a)
Columbiformes	553	Manitoba, Canada	Galloway & Lamb (2015b)
Gruiformes	45	Manitoba, Canada	Galloway (2016)
Piciformes	547	Manitoba, Canada	Galloway & Lamb (2016)
Piciformes	596	Manitoba, Canada	Lamb & Galloway (2016)
Accipitriformes Anseriformes Bucerotiformes Charadriiformes Gruiformes Passeriformes Pelecaniformes Phoenicopteriformes Strigiformes Suliformes	Not specified	Portugal	Tomás <i>et al.</i> (2016)
Piciformes	491	Manitoba, Canada	Galloway & Lamb (2017)
Carnivora	1	Turkey	Taşçi <i>et al.</i> (2017)
Accipitriformes Bucerotiformes Cuculiformes	Not indicated	Turkey	Dik & Kandir (2018)
Piciformes	478	Manitoba, Canada	Lamb & Galloway (2018)
Strigiformes	697	Manitoba, Canada	Galloway & Lamb (2019)
Strigiformes	508	Manitoba, Canada	Lamb & Galloway (2019)
Accipitriformes	147	Manitoba, Canada	Lavallée <i>et al.</i> 2020
Suliformes	15	Brazil	Antonello <i>et al.</i> (2020)
Perissodactyla	1	Turkey	Dik <i>et al.</i> (2020)
Caprimulgiformes	Not indicated	Manitoba, Canada	Kuabara <i>et al.</i> (2020)
Accipitriformes	1	Bolivia	Mollericonna <i>et al.</i> (2020)
Columbiformes	162 ^a	Canada	Grossi & Proctor (2020)
Sphenisciformes	171	South Africa	Snyman <i>et al.</i> (2020)

Accipitriformes Bucerotiformes Ciconiiformes Columbiformes Coraciiformes Cuculiformes Falconiformes Pelecaniformes Phoenicopteriformes Strigiformes	79	Turkey	Dik & Kandir (2021)
Coraciiformes	51	Manitoba, Canada	Galloway (2021)
Passeriformes	774	Manitoba, Canada	Galloway <i>et al</i> (2021)
Accipitriformes Falconiformes Strigiformes	75	Italy	Gherardi <i>et al.</i> (2021)
Pelecaniformes	23	China	Gustafsson <i>et al.</i> (2021) ^b
Carnivora	55	Netherlands	Hirzmann <i>et al.</i> (2021)
Piciformes	2	Manitoba, Canada	Palma & Galloway (2021)
Pelecaniformes	54	Chile	Salazar-Silva (2021)
Anseriformes	28	Manitoba, Canada	Grossi and Galloway (2022)
Suliformes	15	Brazil	Antonello <i>et al.</i> (2022)

^aSome rock pigeons in this study came from rehabilitation hospitals, but the authors did not specify the exact number. ^bThis study was conducted in a captive breeding facility and is included here because of the importance of the discovery of the lice infesting the host species.

METAZOAN PARASITES OF RUFIOUS-LEGGED OWLS (*STRIX RUFIPES*) FROM ÑUBLE AND BIOBÍO REGIONS, CHILE

Parásitos metazoos de concones (*Strix rufipes*) provenientes de las regiones del Ñuble y Biobío, Chile

PABLO OYARZÚN-RUIZ¹, CRISTIÁN TORRES², ALEXANDRA GRANDÓN-OJEDA³, CAROLINA SILVA-DE LA FUENTE⁴, ARMANDO CICCHINO⁵, CHRISTIAN GONZÁLEZ⁶ & SEBASTIÁN MUÑOZ-LEAL²

¹Departamento de Patología y Medicina Preventiva, Universidad de Concepción, Chillán, Chile.

²Departamento de Ciencia Animal, Universidad de Concepción, Chillán, Chile.

³School of Biological Sciences, University of Bristol, Bristol Life Sciences Building, 24 Tyndall Avenue, Bristol, BS8 1TQ, United Kingdom.

⁴Escuela de Medicina Veterinaria, Departamento de Ciencias Agrarias y Forestales, Universidad Católica del Maule, Curicó, Chile.

⁵Universidad Nacional de Mar del Plata, Mar del Plata, Argentina.

⁶Instituto de Entomología, Universidad Metropolitana de Ciencias de la Educación, Santiago, Chile.

Correspondence: Pablo Oyarzún-Ruiz, pablooyarzunruiz@gmail.com

ABSTRACT. - Metazoan parasites of Chilean owls are scarcely known. We provide data about metazoan parasites of the Rufous-legged Owl (*Strix rufipes*), a forest-dependent species. Between 2012 and 2018, we examined for parasites eight Rufous-legged Owl carcasses from Ñuble and Biobío regions, south-central Chile. Seven out of eight owls hosted at least one parasite species. We found three ectoparasite species and six endoparasite species. Among ectoparasites were two lice species and one hippoboscids fly species. Among endoparasites were two nematode species, one tapeworm species, two trematode species, and one acanthocephalan species. We recorded the louse *Kurodaia magna* for the first time in Chile. This louse species and the helminths *Procyrnea spinosa*, *Centrorhynchus spinosus*, *Neodiplostomum travassosi*, *Capillaria* sp., Paruterinidae gen. sp., and Echinostomatidae gen. sp., represent new host-parasite associations. The record of hippoboscids flies is significant because they are vectors for hemoparasites. Additional studies are necessary to determine if the low richness of helminths in Rufous-legged Owls depends on the ecological traits of this owl species.

KEYWORDS: helminths, hippoboscids fly, lice, Neotropical owls.

RESUMEN. - Los parásitos metazoarios de las lechuzas chilenas son escasamente conocidos. Aportamos datos sobre los parásitos metazoarios del concón (*Strix rufipes*), una especie dependiente de bosques. Entre 2012 y 2018, examinamos en busca de parásitos ocho cadáveres de concones provenientes de las regiones del Ñuble y Biobío, centro-sur de Chile. Siete de los ocho búhos hospedaban al menos una especie de parásito. Encontramos tres especies de ectoparásitos y seis especies de endoparásitos. Entre los ectoparásitos encontramos dos especies de piojos y una especie de mosca hipoboscida. Entre los endoparásitos había dos especies de nemátodos, una especie de tenia, dos especies de trematodos y una especie de acantocéfalo. Registramos por primera vez en Chile el piojo *Kurodaia magna*. Esta especie de piojo y los helmintos *Procyrnea spinosa*, *Centrorhynchus spinosus*, *Neodiplostomum travassosi*, *Capillaria* sp., Paruterinidae gen. sp., y Echinostomatidae gen. sp., representan nuevas asociaciones hospedador-parásito. El registro de moscas hipoboscidas es significativo porque son vectores de hemoparásitos. Son necesarios estudios adicionales para determinar si la baja riqueza de helmintos en el concón depende de los rasgos ecológicos de esta especie de búho.

PALABRAS CLAVE: búhos Neotropicales, helmintos, mosca hipoboscida, piojos.

INTRODUCTION

The Rufous-legged Owl (*Strix rufipes*) inhabits mostly dense and mature native forest remnants in central and southern Chile and southern Argentina (Figueroa *et al.* 2017). Anthropogenic activities such as deforestation, agriculture, and poaching threaten its population viability (Raimilla *et al.* 2012, Figueroa *et al.* 2017, Pavez 2019).

Knowledge about Chilean owls is limited as there is little data about their biology, ecology, and, notably, parasitic fauna (Raimilla *et al.* 2012, Figueroa *et al.* 2017, Moreno & González-Acuña 2015, Oyarzún-Ruiz & González-Acuña 2021). The few publications about the parasites of Chilean owls describe mostly ectoparasites (Clayton 1990, González-Acuña *et al.* 2006). Yamaguti (1963) and Grandón-Ojeda *et al.* (2018) identified endo and ectoparasites in the Magellanic Horned Owl (*Bubo magellanicus*). Thus, the number of parasitological studies of Chilean owls is small if we compare them to Chilean hawks and falcons (Moreno & González-Acuña 2015, Oyarzún-Ruiz & González-Acuña 2021).

Metazoan parasites are among the least-known parasitic fauna of the Rufous-legged Owl. A few authors mention helminths such as *Centrorhynchus nahuelhuapensis* (Acanthocephala) and *Thelazia longicaudata* (Nematoda) from Argentina (Schuermans-Stekhoven 1951, Steinauer *et al.* 2020), and *Centrorhynchus conspectus* from Chile (Yamaguti 1963). Other authors have found two ectoparasite species in Rufous-legged Owls from Chile: the louse *Strigiphilus syrnii* (Ischnocera, Philopteridae) and a hippoboscid fly (Hippoboscidae) (Bequaert 1954, Clayton 1990, González-Acuña *et al.* 2006). Dubois (1988) described the trematode *Australapatemon magnacetabulum* (Digenea: Strigeidae) parasitizing the Rufous-legged Owl from Paraguay. Nevertheless, the “Paraguayan Rufous-legged Owls” population is now a separate species: the Chaco Owl (*Strix chacoensis*; König & Weick 2008). Therefore, only three helminth species, one louse species, and one hippoboscid fly species are recognizably parasites of the Rufous-legged owls.

Parasite infection is potentially detrimental to wild animal fitness. However, to anticipate the potentially damaging effects of parasites in wild animals, it is essential to establish parasite diversity and prevalence (Krone & Cooper 2002, Atkinson *et al.* 2008, Santoro *et al.* 2010). Here, we report a recent survey of metazoan parasites in the Rufous-legged Owl in central and southern Chile. We aim to contribute to filling information gaps about host-parasite associations for this owl species.

MATERIAL AND METHODS

Between 2012 and 2018, we examined eight Rufous-legged Owl carcasses from unspecified localities in Ñuble and Biobío regions, central and southern Chile. The causes of death were diverse, including collisions with vehicles, poaching, and euthanasia at the Wildlife Rehabilitation Center at Universidad de Concepción, Chillán, Chile. All specimens were frozen at -20°C until we performed the parasitological examination.

We collected ectoparasites by directly inspecting the feathers and skin of the head, wings, rectrices, and body. Additionally, we applied the “dust-ruffling” technique to collect additional ectoparasites (Walther & Clayton 1997). The nasal cavity was washed by nasal flushing with a tap water-soap solution following the modified Yunker’s technique by Wilson (1964). After washing, we dissected the nasal turbinates, orbital cavities, and nares to retrieve additional nasal parasites (Fain 1957). We made a nasal flushing inspection and nasal cavity dissection under a stereomicroscope NexiusZoom (Euromex, Netherlands). All collected ectoparasites were fixed and preserved in ethanol 70%.

For lice processing, we executed the following protocol: (i) clearing with 20% KOH, (ii) dehydrating in a series of ethanol concentrations (40%, 80% and 100%), (iii) clearing in clove oil, and (iv) mounting with Canada balsam (Palma 1978, Price *et al.* 2003, Oyarzún-Ruiz & González-Acuña 2020). For the specific lice identification, we followed the keys by Price & Beer (1963), Clayton & Price (1984), and Price *et al.* (2003). We identified the hippoboscid flies by directly observing them under the stereomicroscope. Additionally, we obtained images using a scanning electron microscope (SEM; Hitachi-SU 3500 equipment) at the Universidad de Concepción. For the specific fly identification, we followed Bequaert (1950, 1954), Maa (1966), and Santos *et al.* (2014).

Helminths were collected following the procedures by Lutz *et al.* (2017), including the prospection of eyes, subcutaneous tissue, respiratory system, aerial sacs, esophagus, gastrointestinal tract, liver, gallbladder, and kidneys. All retrieved helminths were washed in saline, fixed and preserved in ethanol 80%. We mounted nematodes and acanthocephalans in temporary preparations and cleared them with glycerin-ethanol 80% for one week at least. In the case of tapeworms and trematodes, we stained them with Alum carmine stain, then dehydrated them in a series of ethanol concentrations (70-100% ethanol), cleared them with clove oil, and finally mounted them in permanent preparations with Canada balsam.

(Lutz *et al.* 2017, Oyarzún-Ruiz & González-Acuña 2020). We deposited all parasite specimens in the collection of Laboratorio de Parásitos y Enfermedades de Fauna Silvestre, Universidad de Concepción in Chillán.

For the specific identification of nematodes and acanthocephalans, we followed the keys by Yamaguti (1961, 1963), Anderson *et al.* (2009), Smales (2013), Oyarzún-Ruiz *et al.* (2016), and Bagnato *et al.* (2018). We identified tapeworms and trematodes following Yamaguti (1959), Khalil *et al.* (1994), Gibson *et al.* (2002), Jones *et al.* (2005), and Lunaschi & Drago (2005). During the owl necropsy, we also looked for macroscopic lesions caused by helminth parasites to establish pathological consequences of the infections.

The parasitological descriptors of prevalence (P), intensity (I), range (R), mean intensity ($\bar{I}_m$), and mean abundance ($\bar{A}_m$) were estimated and interpreted according to Bush *et al.* (1997). Prevalence is the proportion of infected hosts by a particular parasite among all the hosts studied for that parasite. Intensity of infection refers to the number of individuals of a specific parasite species among the infected hosts. Range considers the minimum and maximum number of individuals for a particular parasite. Mean intensity is the number of individuals of a given parasite species divided among all the hosts parasitized by that parasite species. Meanwhile, mean abun-

dance is the same number of parasite individuals divided among all the examined hosts, infected or not with the parasite.

RESULTS

Seven of eight Rufous-legged Owls examined had at least one species of metazoan parasites. We retrieved 364 ectoparasites from the seven parasitized owls, among which we identified two lice species and one hippoboscoid fly species (Table 1, Fig. 1). We detected no feather or nasal mite from the examined owls.

Three Rufous-legged Owls hosted 72 helminths in their gastrointestinal tract, among which we identified two nematode taxa and three platyhelminth taxa: one unidentified tapeworm and two trematode species (Table 1, Fig. 1). Some taxa were not assigned to a specific taxon because of the absence of male worms as occurred with *Capillaria* sp. (Capillariidae), or because the poor state of preservation of worms as consequence of freezing such as the tapeworm Paruterinidae gen. sp. and the trematode Echinostomatidae gen. sp.

The louse *S. syrnii* was the most common ectoparasite, although the mean intensity and abundance were higher in the louse *Kurodaia magna* (Menoponidae). The acanthocephalan *Centrorhynchus spinosus* (Centrorhynchiidae), the nematode *Procyrnea spinosa* (Habronematidae),

Table 1. Metazoan parasites retrieved from Rufous-legged Owls (*Strix rufipes*) collected in several localities from Ñuble and Biobío regions, central and southern Chile. Abbreviations: n = number of parasitized individuals; P = prevalence (proportion of infected hosts by a particular parasite among all the hosts examined for that parasite); I = intensity de infection (number of individuals of a specific parasite species among the infected hosts); $\bar{I}_m$ = mean intensity of infection (number of individuals of a given parasite species divided by all the hosts parasitized by that parasite species); $\bar{A}_m$ = mean infection abundance (number of parasite individuals divided among all the examined hosts, infected/infested or not); R = range (minimum and maximum number of individuals of an specific parasite species).

Parasite species	n	P	I	$\bar{I}_m$	$\bar{A}_m$	R	Site of isolation
Chewing lice							
<i>Kurodaia magna</i>	5	62.5	253	50.6	31.6	1-197	Body feathers
<i>Strigiphilus syrnii</i>	7	87.5	108	15.42	13.5	1-60	Body feathers
Hippoboscoid fly							
<i>Ornithoica vicina</i>	1	12.5	3	3	0.4	3	Inside ears
Helminths							
Nematodes							
<i>Capillaria</i> sp.	1	12.5	1	1	0.1	1	Gizzard
<i>Procyrnea spinosa</i>	2	25	44	22	5.5	11-33	Gizzard
Platyhelminths							
Cestodes							
Paruterinidae gen. sp.	2	25	2	1	0.3	1	Duodenum
Trematodes							
Echinostomatidae gen. sp.	1	12.5	1	1	0.1	1	Duodenum
<i>Neodiplostomum travassosi</i>	1	12.5	21	21	2.6	21	Duodenum
Acanthocephalans							
<i>Centrorhynchus spinosus</i>	2	25	2	1	0.3	1	Jejunum-ileum ^a

^aThese two sections of the small intestine were dissected together.

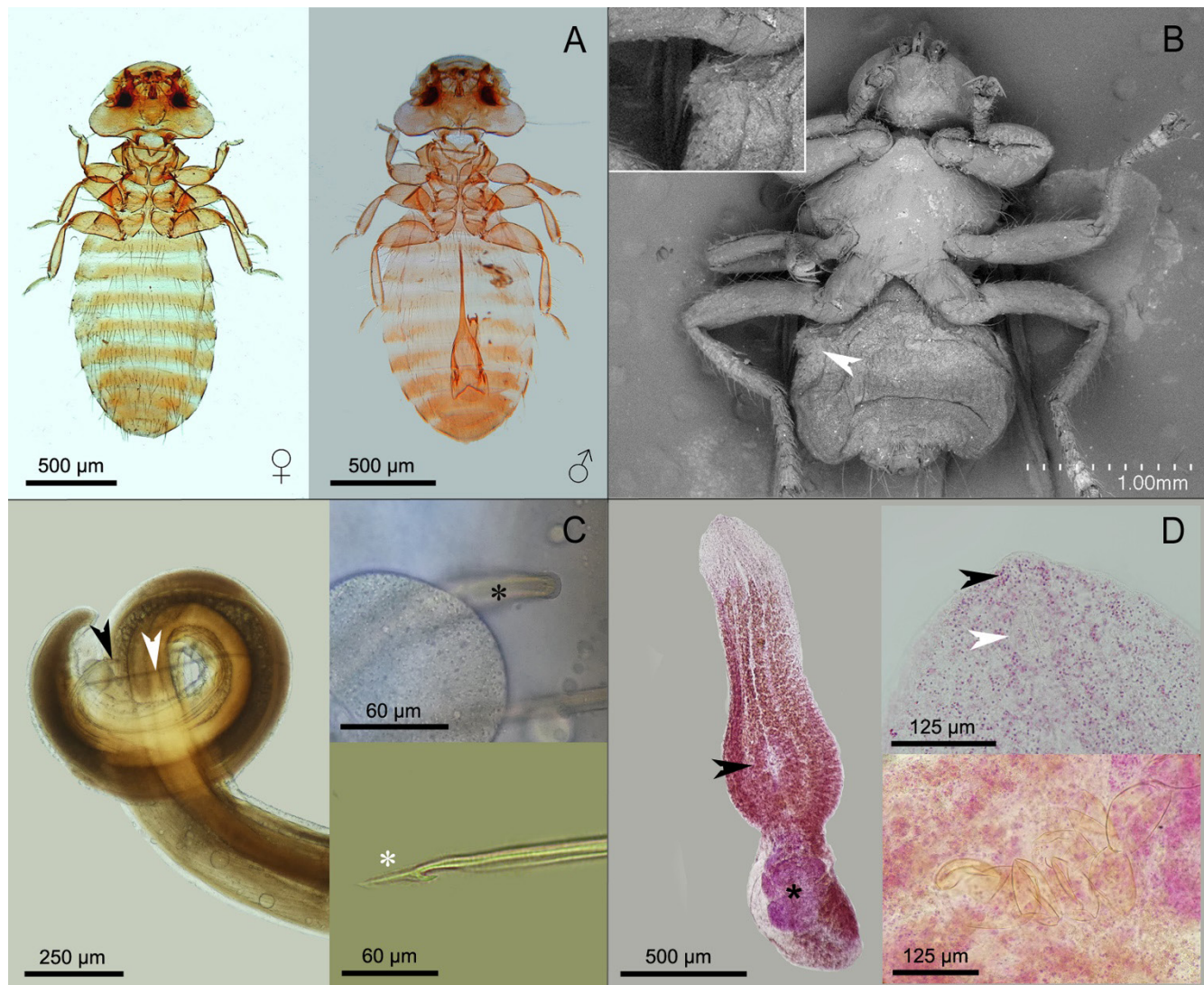


Figure 1. Metazoan parasites isolated in the Rufous-legged Owls from Ñuble and Biobío regions, central and southern Chile. **Ectoparasites:** **A.** Ventral view of the louse *Kurodaia magna* including female and male specimens. **B.** Ventral view of the hippoboscid fly *Ornithoica vicina*. Note the presence of a spinous tubercle next to the spiracle (white arrow). Inserted image: close-up to the tubercle. **Endoparasites: helminths.** **C.** The nematode *Procyrnea spinosa*; posterior end of male worm. Note the two spicules; the right spicule is short (black arrow) with a rounded tip (upper right side), and the left spicule is slender (white arrow) with an arrow-shaped tip (bottom left side). **D.** The trematode *Neodiplostomum travassosi*; *in toto* worm, where the tribocytic organ (black arrow) and gonads in the posterior third of body (*) are evident. Upper right side: note the small rounded oral sucker (black arrow) followed by the pharynx (white arrow). Bottom right side: Note the presence of a reduced number of eggs inside uterus.

and an unidentified tapeworm were most prevalent among helminths. However, *P. spinosa* and the trematode *Neodiplostomum travassosi* (Diplostomidae) showed the highest mean intensity and abundance (Table 1).

DISCUSSION

Our study represents up to date the most complete parasitological survey of the Rufous-legged Owl. Previous publications report findings of only a few parasite taxa (e.g., Schuurmans-Stekhoven 1951, González-Acuña *et al.* 2006, Steinauer *et al.* 2020). Thus, our results contribute to filling the information gaps about the parasitic

fauna of an elusive Neotropical owl species.

Ectoparasite diversity in Rufous-legged Owls

We found that lice were the most frequent taxa among the metazoan parasites of Rufous-legged Owls. That agrees with patterns of parasite diversity elsewhere (e.g., Hunter *et al.* 1994, Price *et al.* 2003, González-Acuña *et al.* 2006, Atkinson *et al.* 2008). Lice of the genus *Kurodaia* typically parasitize American owls (Price *et al.* 2003). *Kurodaia magna* parasitize several North American owl species, including the Northern Barred Owl (*Strix varia*), Spotted Owl (*Strix occidentalis*), and Great Horned Owl

(*Bubo virginianus*) (Price & Beer 1963, Hunter *et al.* 1994, McAllister *et al.* 2019). Other *Kurodaia* species isolated from owls distributed in Chile are *Kurodaia (Conciella) subpachygaster* in Barn Owl (*Tyto alba*) and *Kurodaia (Conciella) caputonis* in Austral-pygmy Owl (*Glaucidium nana*) (González-Acuña *et al.* 2006, Moreno & González-Acuña 2015). Thus, the finding of *K. magna* in the Rufous-legged Owl constitutes an additional host-parasite association (see González-Acuña & Palma 2021).

The louse *S. syrni* is a common ectoparasite of the Great Gray Owl (*Strix nebulosa*), Northern Barred Owl, Spotted Owl, and Great Horned Owl from North and Central America and Eurasia (Clayton & Price 1984, Hunter *et al.* 1994). However, Clayton (1990) and González-Acuña *et al.* (2006) found *S. syrni* in the Rufous-legged Owl from southern Chile. Lice of the genus *Strigiphilus* are ubiquitous in Chilean owls, and each owl species hosts a *Strigiphilus* species (Moreno & González-Acuña 2015, Grandón-Ojeda *et al.* 2018, González-Acuña & Palma 2021).

The hippoboscids *Ornithoica vicina* is restricted to the Americas, parasitizing bird species within ten orders (Maa 1966, Santos *et al.* 2014). Among its avian hosts are several owl species, including species of the genus *Strix*. In North America, *O. vicina* parasitizes Northern Barred Owls and Spotted Owls (Bequaert 1954, Hunter *et al.* 1994, Nelder & Reeves 2005) and in South America, parasitizes Mottled Owls (*Strix virgata*) and Rusty-barred Owls (*Strix hylophila*) (Bequaert 1954, Graciolli & Carvalho 2003). *Ornithoica vicina* also parasitizes other Neotropical owl species such as the Ferruginous Pygmy-Owl (*Glaucidium brasilianum*), Striped Owl (*Pseudoscops clamator*), Stygian Owl (*Asio stygius*), White-throated Screech Owl (*Megascops albogularis*), Burrowing Owl (*Athene cunicularia*), and Barn Owl (Bequaert 1954, Vaz & Teixeira 2016). Other Neotropical hosts include storks, falcons, passerines, and flickers (Tonn & Arnold 1963, Arnold 1970, Graciolli & Carvalho 2003, Santos *et al.* 2014, Vaz & Teixeira 2016).

Long before us, Bequaert (1954) isolated *O. vicina* from a Rufous-legged Owl collected in southern Chile. Thus, our findings constitute an additional record of this fly species in the Rufous-legged Owl. The presence of *O. vicina* in a Rufous-legged Owl's ears is explainable because this fly species prefers to lay its eggs in that organ (Hunter *et al.* 1994). In Chile, hippoboscids flies appear rarely to parasitize owls. *Ornithomyia remota* is another hippoboscids fly species parasitizing the Austral-Pygmy Owl (Bequaert 1950). The limited collection of hippoboscids flies could be explained because of their small size, being easily overlooked during the inspection of birds (Bequaert 1954). Considering that *O. vicina* parasitizes

a broad spectrum of avian hosts (Bequaert 1954, Maa 1966), this fly species may be present in other Chilean owl species.

The finding of a hippoboscids fly is remarkable since these ectoparasites are uncommon in Neotropical raptors (Bequaert 1954, Vaz & Teixeira 2016). Hippoboscids flies are vectors for hemoparasites such as *Haemoproteus*, which could be potentially harmful to owls (Krone & Cooper 2002, Atkinson *et al.* 2008). Additional surveys are necessary to determine whether hippoboscids flies transmit hemoparasites to native owls, considering that high fly infestation causes severe lesions in nestlings (Hunter *et al.* 1994).

Endoparasite diversity in Rufous-legged Owls

Regarding the nematodes of the genus *Capillaria* retrieved from Rufous-legged Owls, we could not identify them to the species level because all were female worms. Male worms are necessary to identify the species of the genus *Capillaria* (Anderson *et al.* 2009). Although we could not identify the specimens of *Capillaria* at the level species, they may have been *Capillaria tenuissima*. This nematode species parasitizes several owl species, including Little Owl (*Athene noctua*), Long-eared Owl (*Asio otus*), Tawny Owls (*Strix aluco*), Short-eared Owl, Great Horned Owl, Northern Barred Owl, and Barn Owl (Kinsella *et al.* 2001, Krone & Cooper 2002, Borgsteede *et al.* 2003, Sanmartín *et al.* 2004). Its life cycle is unknown, but earthworms could act as intermediate hosts (Oyarzún-Ruiz *et al.* 2016). In Chile, *C. tenuissima* parasitizes Magellanic Horned Owls (Grandón-Ojeda *et al.* 2018), Chimango Caracaras (*Milvago chimango*), and Harris's Hawks (*Parabuteo unicinctus*) (Oyarzún-Ruiz *et al.* 2016, 2022). Thus, it represents the first record of the genus *Capillaria* in the Rufous-legged Owl.

The nematode *P. spinosa* is a cosmopolitan species inhabiting mainly the stomach of diurnal and nocturnal birds of prey (Illescas Gomez *et al.* 1993, Borgsteede *et al.* 2003, Oyarzún-Ruiz *et al.* 2016). Species of this genus have an indirect life cycle with coleopterans and orthopterans as intermediate hosts (Santoro *et al.* 2012). Other species parasitizing owls are *Procyrnea excisiformis*, *P. leptoptera*, *P. longispiculata*, and *Procyrnea* sp. (Ramalingam & Samuel 1978, Taft *et al.* 1993, Borgsteede *et al.* 2003, Ferrer *et al.* 2004, Sanmartín *et al.* 2004, Santoro *et al.* 2012). In Chile, *P. spinosa* is present in Chimango Caracaras (Oyarzún-Ruiz *et al.* 2016), although González-Acuña *et al.* (2011) found unidentified specimens of *Procyrnea* in American Kestrels (*Falco sparverius*). In consequence, our finding *P. spinosa* represents a new host-parasite association.

Based on our analysis, the isolated tapeworms

belonged to the Paruterinidae family. The two genera in this family which parasitize birds of prey are *Paruterina* and *Cladotaenia* (Yamaguti 1959, Khalil *et al.* 1994, Sanmartín *et al.* 2004). In Chile, several authors have found specimens of *Cladotaenia* in American Kestrels and Harris's Hawks (González-Acuña *et al.* 2011, Oyarzún-Ruiz *et al.* 2022). The *Paruterina* and *Cladotaenia* species use small mammals as intermediate hosts (Yamaguti 1959). Thus, like other raptor species, the Rufous-legged Owl could have acquired Paruterinidae tapeworms by consuming small mammals. Our record of Paruterinidae is the first in the Rufous-legged Owl and the third among Neotropical birds of prey. Specific identification of these tapeworms remains pending (Oyarzún-Ruiz *et al.* 2022).

We classified one of the trematodes isolated from a Rufous-legged Owl within the family Echinostomatidae. There are scarce records of echinostomes in owls. A few cases are *Echinostoma apiculatum* in Tawny Owls, *E. revolutum* in Eurasian Eagle-Owls (*Bubo bubo*), Long-eared Owls, and Tawny Owls from Europe (Ewald & Crompton 1993, Sitko 2001, Borgsteede *et al.* 2003), *E. revolutum* and *E. trivolvis* in Great Horned Owls from North America (Ramalingam & Samuel 1978, Taft *et al.* 1993). There are no previous records of echinostomes parasitizing Neotropical owls. However, species of *Echinostoma*, *Microparyphium*, *Paryphostomum*, and *Prionosoma* genera are present in Neotropical vultures and hawks (Fernandes *et al.* 2015). Echinostomes seem to be less prevalent in owls in comparison with other flukes (Ramalingam & Samuel 1978, Taft *et al.* 1993, Sitko 2001), which could be a consequence of their complex life cycles (Ramalingam & Samuel 1978, Atkinson *et al.* 2008).

Unlike echinostomes, the trematode *N. travassosi* appears more common in Neotropical owls. This trematode species parasitizes Spectacled Owls (*Pulsatrix perspicillata*), Crested Owls (*Lophotrix cristata*), Burrowing Owls, and *Strix* owls from Argentina and Brazil (Dubois 1937, Drago *et al.* 2015). However, *N. travassosi* is not restricted to owls. Other avian hosts include Red-billed Toucans (*Ramphastos tucanus*), Neotropic Cormorants (*Phalacrocorax brasilianus*), Southern Crested Caracaras (*Caracara plancus*), and Savanna Hawks (*Buteogallus meridionalis*) (Dubois 1937, Lunaschi & Drago 2005, Drago *et al.* 2014). Moreover, *N. travassosi* was recently found in the Harris's Hawk from Chile (Oyarzún-Ruiz *et al.* 2022). Although the *N. travassosi*'s life cycle is unknown, species of this genus have an indirect life cycle, with amphibians as intermediate hosts and reptiles and mammals as paratenic hosts (Gibson *et al.* 2002). There are other *Neodiplostomum* species present in Neotropical owls, such as *N. conicum* in Short-eared Owls and Rusty-barred Owls, *N. reflexum* in Great Horned Owls, and *Neo-*

diplostomum sp. in Magellanic Horned Owls from Chile (Fernandes *et al.* 2015, Grandón-Ojeda *et al.* 2018). Thus, this finding represents a new host-parasite association and the second record in Chilean territory.

The only acanthocephalan species we isolated from Rufous-legged Owls was *C. spinosus*, which parasitizes mainly owls. However, Kinsella *et al.* (2001) suggested that diurnal raptors are additional definitive hosts of *C. spinosus*. Some hosts in the Americas are the Swallow-tailed Kite (*Elanoides forficatus*), Eastern Screech-Owl (*Megascops asio*), Great Horned Owl, and Northern Barred Owl (Kinsella *et al.* 2001, Coulson *et al.* 2010), and a probable Galapagos Hawk (*Buteo galapagensis*) (Van Cleave 1940). Other *Centrorhynchus* species present in Neotropical owls are *C. tumidulus* in Tropical Screech-Owl (*Megascops choliba*) and Barn Owl from Brazil, *C. millerae* in Tropical Screech-Owl, and *Centrorhynchus* sp. in Burrowing Owl and Barn Owl from Argentina, Nicaragua, and Paraguay (Schmidt & Neiland 1966, Smales 2013, Drago *et al.* 2015).

There are previous records of cystacanths encysted in the tissues of Neotropical reptiles and amphibians, which could act as paratenic hosts for *Centrorhynchus* (Puga & Torres 1999, Drago *et al.* 2015). The Rufous-legged Owl hosts *C. conspectus* in Chile (Yamaguti 1963) and *C. nahuelhuapensis* in Argentina (Steinauer *et al.* 2020). The Magellanic Horned Owl is an additional definitive host of *C. spinosus* in Chile (Grandón-Ojeda *et al.* 2018), while the Andean fox (*Lycalopex culpaeus*) is an accidental host (Oyarzún-Ruiz *et al.* 2020). The present finding represents a new host-parasite association.

The helminth species richness in the Rufous-legged Owls we examined is low in comparison with other owl species studied from other countries. The helminth species richness in other owl species can vary from eight to 16 species (Ramalingam & Samuel 1978, Taft *et al.* 1993, Ferrer *et al.* 2004, Sanmartín *et al.* 2004). The low helminth species richness we found is possibly an artifact of our small sample size and the limited geographical area considered in this study.

Several authors have suggested that prey-specialist owls would harbor a lower richness of helminth in comparison to generalist species (Ewald & Crompton 1993, Kinsella *et al.* 2001, Ferrer *et al.* 2004, Sanmartín *et al.* 2004, Santoro *et al.* 2010, 2012). The overall diet of the Rufous-legged Owl consists chiefly of rodents (Figueroa *et al.* 2017, Pavez 2019), which would turn out in a lower richness of helminths. However, Rufous-legged Owls strongly increase predation upon invertebrates during spring and summer (Figueroa *et al.* 2017). The evidence suggests that seasons and different populations of certain owl species across a geographic distribution could influ-

ence the parasite communities because of differences in the predation of distinct prey taxa (Hoberg *et al.* 1989, Kinsella *et al.* 2001). Future studies considering a larger sample size from different localities and seasons could elucidate if prey types influence the helminth species richness in the Rufous-legged Owl.

Some of the endoparasites taxa recorded in our study cause pathological changes and health impairment in birds of prey (*e.g.*, *Procyrnea*, *Neodiplostomum*, *Capillaria*, and tapeworms; Krone & Cooper 2002, Santoro *et al.* 2010). However, the recorded parasitic loads were lower in comparison with such studies. Although we did not conduct a histopathological analysis, we found no severe lesions associated with helminth presence. Notwithstanding the above, further studies considering clinical and histopathological analyses are necessary to assess the potential impact of these and other parasites on the health of these birds (Krone & Cooper 2002, Atkinson *et al.* 2008).

A call to contribute to the study of parasites in raptors

For now, our values of parasitological descriptors are preliminary. A more comprehensive study is necessary to increase the robustness of the parasitological descriptors computed in our study. We encourage ornithologists to participate in parasite samplings in birds of prey, not only from carcasses but also through the collection of ectoparasites while handling these birds. This collaboration would enhance knowledge about the parasitic fauna of owls and other birds of prey. This is particularly necessary in the case of birds of prey which are under legal protection, and because obtaining proper samples is a difficult achievement (Sanmartín *et al.* 2004, Moreno & González-Acuña 2015).

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DETECTION OF *RICKETTSIA* IN TICKS COLLECTED ON WILD BIRDS IN FOREST AREAS OF BLUMENAU, SANTA CATARINA, SOUTHERN BRAZIL

Detección de rickettsias en garrapatas recolectadas en aves silvestres en áreas boscosas de Blumenau, Santa Catarina, sur de Brasil

JULIO CESAR DE SOUZA JR¹, ISABELLA PEREIRA PESENATO², ANA CAROLINA GUZTZAZKY¹, CARLOS EDUARDO ZIMMERMANN¹, FELIPE DA SILVA KRAWCZAK³, MARCELO BAHIA LA-BRUNA² & THIAGO FERNANDES MARTINS^{2,4}

¹Department of Veterinary Medicine, Blumenau Regional University, Blumenau, SC, Brazil.

²Department of Preventive Veterinary Medicine and Animal Health, Faculty of Veterinary Medicine and Animal Science, University of São Paulo, São Paulo, SP, Brazil.

³Department of Veterinary Medicine, Sector of Preventive Veterinary Medicine, School of Veterinary and Animal Science, Federal University of Goiás, Goiânia, GO, Brazil.

⁴Pasteur Institute, State Department of Health of São Paulo, São Paulo, SP, Brazil.

Correspondence: Thiago Fernandes Martins, thiagodogo@hotmail.com

ABSTRACT.- Wild birds infested with ticks could contribute to the transmission of spotted fever caused by rickettsiae. We investigated the prevalence of ticks and tick-borne rickettsial agents in birds from the Atlantic rainforest in Santa Catarina state, southern Brazil. The sampled birds were captured live by the authors using mist nets. We identified tick species by morphological traits confirming identity through amplification of 16S rRNA gene fragment. *Rickettsia* bacteria were identifiable through the amplification of *gltA* and *ompA* genes. We captured 105 individuals among 39 bird species, with 12% of individuals ($n = 13$) and 25.6% of species ($n = 10$) infested by ticks. All collected ticks were immature *Amblyomma longirostre*. Infestation ranged from 1 to 3 ticks per individual, with a mean intensity of tick infestation of 1.7 ± 0.82 . Seven of the 14 larvae subjected to molecular analysis hosted the bacterium *Rickettsia amblyommatis*, which is not involved in spotted fever transmission. Because we did not find rickettsial agents transmitting Brazilian spotted fever in avian ticks, our results indicate a reduced contribution of wild birds in the ecoepidemiology of the disease within the studied forest region.

KEYWORDS: *Amblyomma longirostre*, Atlantic rainforest, Brazilian spotted fever, *Rickettsia amblyommatis*.

RESUMEN.- Las aves silvestres infestadas con garrapatas podrían contribuir en la transmisión de la fiebre manchada causada por rickettsias. Investigamos la prevalencia de garrapatas y bacterias rickettsiales en las aves del bosque Atlántico, estado de Santa Catarina, sur de Brasil. Las aves muestreadas fueron capturadas vivas por los autores mediante redes de niebla. Identificamos a las especies de garrapatas por sus rasgos morfológicos, confirmando su identidad mediante la amplificación del fragmento del gen 16S rRNA. Las bacterias *Rickettsia* fueron identificables mediante la amplificación de los genes *gltA* y *ompA*. Capturamos 105 individuos entre 39 especies de aves, con 12% de los individuos ($n = 13$) y 25,6% de las especies ($n = 10$) infestados por garrapatas. Todas las garrapatas recolectadas fueron *Amblyomma longirostre* inmaduras. Encontramos 1-3 garrapatas por individuo, con una intensidad media de infestación de $1,7 \pm 0,82$. Siete de las 14 larvas sometidas a análisis molecular hospedaron *Rickettsia amblyommatis*, la cual no transmite la fiebre manchada. Ya que no encontramos agentes rickettsiales causantes de la fiebre manchada brasileña en garrapatas aviares, nuestros resultados indican una contribución reducida de las aves silvestres en la eco-epidemiología de la enfermedad en la región forestal estudiada.

PALABRAS CLAVE: *Amblyomma longirostre*, bosque atlántico, fiebre manchada brasileña, *Rickettsia amblyommatis*.

INTRODUCTION

Ticks are ectoparasites of various animal hosts, including mammals, birds, reptiles, and amphibians (Anderson & Magnarelli 2008). They are in the interest of public health because their only nutrition comes from the blood of their hosts, which can suffer inflammatory or spoiling consequences after attachment. In case of large infestations, ticks cause dermatitis and anemia. In addition, ticks act as vectors for various pathogenic microorganisms such as viruses, protozoa, and bacteria that can cause disease or even death in the vertebrate host (Jongejan & Uilenberg 2004, Barros-Battesti *et al.* 2006, Sonenshine & Roe 2014).

Rickettsia are vector-borne bacteria comprising five main groups: bellii, canadensis, typhus, transitional, and spotted fever (Weinert *et al.* 2009). The bellii and canadensis groups harbor the tick-borne agents *Rickettsia bellii* and *Rickettsia canadensis*, respectively, which are considered non-pathogenic (Eremeeva *et al.* 2005; Ogata *et al.* 2006). The typhus group harbors *Rickettsia typhi* and *Rickettsia prowazekii*, which are responsible for causing murine typhus and epidemic typhus, being transmitted by fleas and lice, respectively (Blanton *et al.* 2016, Chekanova & Shpynov 2020). The transitional group harbors bacteria with traits similar to two or more groups, such as *Rickettsia felis* which can cause a disease similar to the spotted fever rickettsiae but is transmitted by fleas (Douglas *et al.* 2021). Finally, the spotted fever group harbors tick-borne rickettsiae that include several pathogenic agents, such as *Rickettsia rickettsii*, *R. parkeri*, *R. africae*, *R. sibirica*, and *R. conorii*, which cause spotted fever diseases in different regions of the world (Socolovschi *et al.* 2009).

Spotted fever is an emerging disease at a local scale transmitted by ixodid ticks. In São Paulo state, the first record of the disease occurred in 1929 (Fiol *et al.* 2010). In this state, there are numerous fatal cases of Brazilian spotted fever, the most severe form of spotted fever (Angerami *et al.* 2009, Labruna 2009). This disease is attributable to the bacteria *R. rickettsii*. In Santa Catarina state, the first documented spotted fever cases were in 2003. Santa Catarina is the second state in Brazil with the highest incidence of cases of spotted fever, mainly in the Vale do Itajaí region. In this state, however, infected patients presented milder symptoms, and no case evolved to death (Angerami *et al.* 2009). That was because the spotted fever cases of Santa Catarina have been attributable to *R. parkeri*, a tick-borne bacteria with non-fatal effects (Medeiros *et al.* 2011, Barbieri *et al.* 2014, Krawczak *et al.* 2016).

As emerging diseases intensify, it is necessary to maintain epidemiological surveillance to know their etiological agents and vectors. Such actions are essential

to monitor circulating diseases and to take preventive measures (de Oliveira *et al.* 2016, Krawczak *et al.* 2016). Because of their high geographical mobility, wild birds can carry infected ticks from one place to another. Thus, wild birds could be relevant in the ecoepidemiology of Brazilian spotted fever. Birds can act as primary hosts for immature stages of the tick *Amblyomma aureolatum*, a known vector of *Rickettsia rickettsii* (Pacheco *et al.* 2012, Lugarini *et al.* 2015). Our primary objective was to evaluate the role of wild birds in the ecology of spotted fever within the forested landscape of Blumenau. Specifically, we aimed to identify and quantify tick species infesting birds and to determine the presence of *Rickettsia* bacteria within these ticks.

MATERIALS AND METHOD

Study area

All sites included in our study are within Blumenau municipality (26°54'32"S, 49°04'20"W), Santa Catarina state, southern Brazil. Sites are within the Atlantic Rainforest biome, with the formation of dense ombrophilous forests. Rainfall is frequent and well-distributed throughout the year, but rainfalls are more intense in the summer. Thus, a high humidity combines with an increased temperatures (Sevegnani & Schroeder 2013). The region's temperatures range from 16° C in winter to 31.9° C in summer, and the relative humidity is around 84% (Gomes *et al.* 2021).

We conducted bird captures and tick collections from January to May 2015 in four sites (Fig. 1) with different extents and degrees of conservation. These sites were Círculo de Orquidófilos de Blumenau, São Francisco de Assis Municipal Natural Park, Campus V of the Blumenau Regional University, and Serra do Itajaí National Park.

Círculo de Orquidófilos is a 1-ha area inside an urban matrix, where several bird species and large and medium-sized trees inhabit (*e.g.*, figs and palm trees; Cruz & Zimmermann 2011). São Francisco de Assis Municipal Natural Park is a protection site covering about 23 ha. The vegetation includes primary and secondary stages of capoeira (encroaching vegetation) with canopy heights of 18 to 22 m (Prefeitura de Blumenau 2022). Campus V is in the Fortaleza Alta neighborhood in the northern part of the city and is about 31 ha in extension. This site comprises pasturelands, animal houses, and the university hospital. About 145 bird species inhabit the campus (Kramer 2011). Serra do Itajaí National Park encompasses the largest remnant of the Atlantic Rainforest, with 57 000 ha of dense forest in an advanced state of regeneration. About 200 bird species would inhabit this park (Zimmerman *et al.* 2003).

Bird capture

On each site, we captured birds using five ornithologi-

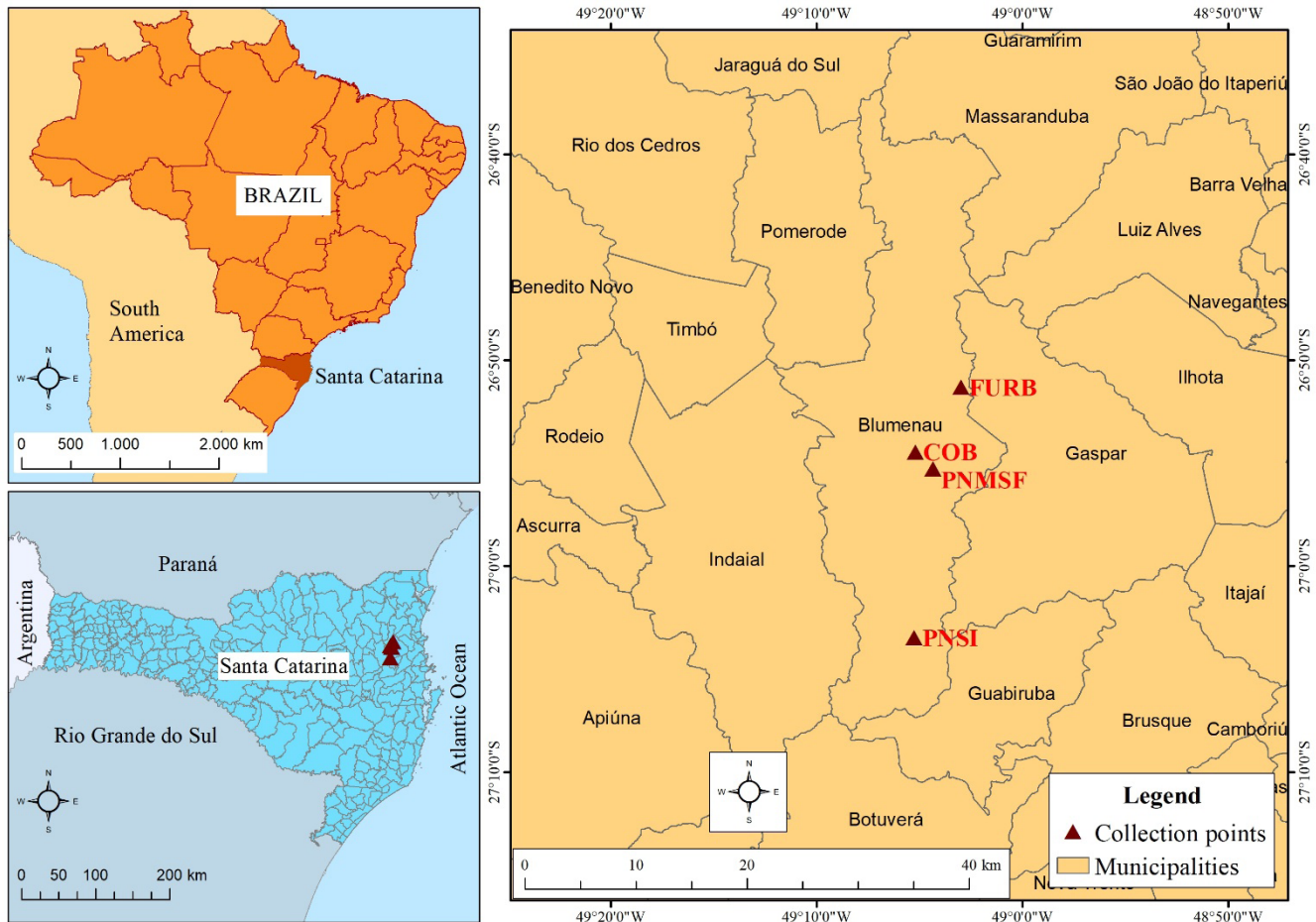


Figure 1. Study localities to determine the presence of *Rickettsia* in ticks retrieved from wild birds captured between January and May 2015 in Santa Catarina state, southern Brazil. FURB = Campus V of the Blumenau Regional University, COB = Círculo de Orquídeas de Blumenau, PNMSF = São Francisco de Assis Municipal Natural Park, PNSI = Serra do Itajaí National Park.

cal mist nets (12 x 2.5 m) made of nylon with a 36 mm mesh. We arranged the mist nets 1 m from each other along a straight line at different points along pre-existing trails. We opened the nets at dawn between 07:00 and 11:00 h and between 14:00 and 17:00 h and inspected them every 20-30 min. The birds captured were removed by a senior bander and taken inside cloth bags to a banding base. This protocol allowed us to speed up the removal of birds from the net, avoiding stress, physical damage, and mortality as we spent less time handling birds in the nets and avoided the hottest hours of the day.

On the banding basis, we first identified bird species using ornithological guides (e.g., Sick 2001, Perlo 2009). Then, we banded each bird on the tarsus with an aluminum ring engraved with alpha-numeric code. After banding, we weighed and inspected plumage and naked parts for the presence of ticks. Finally, we released each bird in the same collection site. We calculated the capture effort (Table 1) using the following formulas: capture ef-

fort = total capture surface in m² x exposure time in hours x number of repetitions (see Straube & Bianconi 2002).

Collection and identification of ticks

We extracted ticks manually with the aid of tweezers. After removal, we preserved ticks in absolute alcohol inside microtubes labeled with the data of the location and bird species. We stored all samples in the Parasitology Laboratory of Campus I in the Blumenau Regional University for later identification in the Laboratory of Parasitic Diseases of the School of Veterinary Medicine and Animal Science of the University of São Paulo.

When we collected more than one tick of the same species in the same bird, we set one tick apart to serve as a voucher in the National Tick Collection Danilo Gonçalves Saraiva (Coleção Nacional de Carrapatos Danilo Gonçalves Saraiva) at the University of São Paulo. We identified nymphs at the species level according to the key by Martins *et al.* (2010). In the case of larvae, we

determined species using molecular biology techniques and optical microscopy according to Barros-Battesti *et al.* (2005). For molecular identification, we submitted larvae individually to DNA extraction by the boiling technique, as described by Horta *et al.* (2007). We applied the polymerase chain reaction (PCR) to amplify a mitochondrial 16S rRNA gene fragment. For this, we used the Taq PCR Master Mix, which we placed in microtubes with water plus the buffer solution and the previously extracted DNA, and we took it to a thermal cycler for genetic material amplification. After this process, we performed electrophoresis in a 1.5% agarose gel to verify that we correctly extracted the tick DNA.

Detection of *Rickettsia*

For the detection of *Rickettsia*, previously extracted DNA was processed in the real-time PCR reaction (qPCR) using the primers CS-5 (forward) and CS-6 (reverse). These primers amplify a 147 bp fragment of the *gltA* gene present in all *Rickettsia* species (Labruna *et al.* 2004, Guedes *et al.* 2005). We performed the reaction as described in Labruna *et al.* (2004). We tested the positive samples in the qPCR screening for the rickettsial *ompA* gene that encodes the protein *ompA* that is part of the external membrane of the spotted fever group rickettsiae (Eremeeva *et al.* 2006). To this end, we used DreamTaq Green PCR Master Mix (ThermoFisher, Waltham, MA) with subsequent amplification in a thermocycler and reading in 1.5% agarose gel. In each set of reactions, we included negative control tubes containing water and a positive control tube containing *Rickettsia vini* DNA that belongs to the spotted fever group but does not have active circulation in the Brazilian territory.

We purified PCR products using ExoSAP-IT (USB Corp., Cleveland, OH). Then, we conducted DNA sequencing in an ABI automated sequencer (Applied Biosystems/Perkin Elmer, model ABI Prism 3500 Genetic, Foster City, CA). The DNA sequences were analyzed using the BLAST program to verify homology with *Rickettsia ompA* sequences previously deposited in GenBank.

RESULTS

We captured 105 birds belonging to 39 species distributed in 20 families and six orders. The most frequent species were within the Passeriformes order, accounting for 84.6% of all captured individuals and 74.4% of all identified species ($n = 29$ species). The Thraupidae family was the most diverse and numerous, with seven species and 20 individuals captured. Other families richer in species were Turdidae, with seven species and 15 individuals, and Trochilidae, with five species and eight individuals. The most frequent species were Rufous-bellied Thrush (*Turdus rufiventris*) and Ruby-crowned Tanager (*Tachyphonus coronatus*), each with eight individuals, followed by Golden-crowned Warbler (*Basileuterus culicivorus*) with seven individuals, Grey-hooded Flycatcher (*Mionectes rufiventris*), and Violaceous Euphonia (*Euphonia violacea*), each with five individuals.

Thirteen individuals among ten species of birds hosted ticks (Table 2). The frequency of tick infestation in individuals and species in the different areas sampled varied between 10.0-17.6% and 18.7-27.2%, respectively (Table 2). Seven of 10 captured bird species hosted ticks (Table 3). Infested birds only hosted ticks in immature stages (21 larvae and one nymph). The infestation level ranged from 1 to 3 ticks per infested bird (Table 3). The mean intensity of tick infestation per bird was 1.7 ± 0.82 . Ticks were often in the bird's head, mainly in the peri-ophthalmic region. Only one White-necked Thrush (*Turdus albicollis*), captured in the Orchidophiles Club of Blumenau, hosted ticks in the neck region (Fig. 2).

All ticks collected were *Amblyomma longirostre*. We deposited voucher specimens (1 nymph, seven larvae) in the National Tick Collection and received the accession numbers CNC-3095 to CNC-3102. We submitted the other 14 larvae to DNA extraction to check for pathogens. Fifty percent of larvae ($n = 7$) were positive for *Rickettsia* bacteria. The amplicons of these larvae yielded *ompA* partial sequences 100% identical to corresponding sequences of *R. amblyommatis* available in GenBank (KX137901).

Table 1. Field effort to capture birds potentially infested with ticks by using mist nets (12 x 2.5 m) in four Atlantic rainforest sites in Blumenau municipality, Santa Catarina State, Brazil. The purpose of tick extraction was to detect pathogenic tick-borne bacteria (*e.g.*, *Rickettsia*). Captures were between January and May 2015.

Capture site	N° nets	Total surface of capture (m ²)	Exposition time (h)	Hours-mist nets
Orchidophiles Club	5	150	19	2850 m ² x h
Campus V Regional University	5	150	13	1950 m ² x h
Serra do Itajaí National Park	5	150	8	1200 m ² x h
São Francisco de Assis Park	5	150	8	1200 m ² x h
Total effort				7200 m ² x h

DISCUSSION

In our study sites, the mean prevalence and intensity of tick infestation in wild birds was 12% and 2%, respectively. These infestation values were similar to those found in wild birds across South America, including Brazil (Ogrzewalska *et al.* 2011, Santolin *et al.* 2012, Sanches *et al.* 2013, Luz & Faccini 2013, Flores *et al.* 2014, Ramos *et al.* 2015, Lugarini *et al.* 2015, Luz *et al.* 2017, Zeringóta *et al.* 2017, Lima *et al.* 2018, Ramirez *et al.* 2020, Rocha *et al.* 2021).

Amblyomma longirostre, the only tick species present in sampled birds, has the habit of parasitizing birds. In their immature stages, they parasitize mainly passerines, and adults parasitize porcupines (Labruna *et al.* 2004, Ogrzewalska *et al.* 2008, Fecchio *et al.* 2020). This species notably represents the most encountered tick parasitizing birds (Labruna *et al.* 2007, Ogrzewalska *et al.* 2008, Pacheco *et al.* 2012). Like other investigators, we found *A. longirostre* parasitizing several bird species within a locality (Maturano *et al.* 2015, Nogueira *et al.* 2022).

Other avian tick species commonly found in as-

sociation with *Amblyomma longirostre* are *Amblyomma nodosum*, *A. calcaratum*, *A. sculptum*, *A. triste*, *A. aureolatum*, and *A. ovale* (Ogrzewalska *et al.* 2011, Ramos *et al.* 2015, Araújo *et al.* 2019, Ramirez *et al.* 2020). *A. aureolatum* and *A. ovale* are involved in the spotted fever cycle, acting as vectors of *Rickettsia* bacteria. These tick species are present in the municipality of Blumenau (Barbieri *et al.* 2014), parasitizing canids and howler monkeys (Lavina *et al.* 2011). There are few reports of these tick species in wild birds (Pacheco *et al.* 2012).

Globally, *Rickettsia amblyommatis* is present in 34 tick species, most within the genus *Amblyomma*. About 83% of the ticks hosting *R. amblyommatis* were within the genus *Amblyomma*. Previous studies revealed that *Amblyomma americanum* has the highest prevalence of *R. amblyommatis*, comprising $\approx 27.8\%$ of the documented tick species. The tick *A. longirostre* seems to be the second most common species infected with *R. amblyommatis*, representing approximately 10% of the reported cases (Richardson *et al.* 2023).

In our study sites, the infection rate of ticks with

Table 2. Tick infestation in wild birds captured between January and May 2015 in four Atlantic Rainforest sites in Blumenau municipality, Santa Catarina State, Brazil.

Capture sites	% infestation among individuals (infested/captured)	% infestation among species (infested/captured)
Orchidophiles Club	15.7 (3/19)	22.2 (2/9)
Campus V Regional University	17.6 (3/17)	27.3 (3/11)
Serra do Itajaí National Park	10.0 (3/30)	18.7 (3/16)
São Francisco de Assis Park	10.2 (4/39)	19.0 (4/21)
Total	12.4 (13/105)	25.6 (10/39)

Table 3. Bird species infested with ticks and number of *Rickettsia*-infected ticks per bird species between January and May 2015 in four Atlantic Rainforest sites in Blumenau municipality, Santa Catarina State, Brazil.

Capture site	Bird species	% infestation among individuals (infested/captured)	Nº ticks and stage found	Nº ticks in- fected with <i>Rickettsia</i>
Orchidophiles Club	Lesser Woodcreeper (<i>Xiphorhynchus fuscus</i>)	50 (1/2)	3 larvae	-
	White-necked Thrush (<i>Turdus albicollis</i>)	100 (2/2)	1 nymph, 1 larva	1 (larva)
Campus V Regional University	Ochre-collared Piculet (<i>Picumnus temminckii</i>)	33.3 (1/3)	1 larva	1
	Euler's Flycatcher (<i>Lathrotriccus euleri</i>)	50 (1/2)	2 larvae	-
	Ruby-crowned Tanager (<i>Tachyphonus coronatus</i>)	16.6 (1/6)	1 larva	-
Serra do Itajaí National Park	Grey-hooded Flycatcher (<i>Mionectes rufiventris</i>)	50 (1/2)	2 larvae	1
	Golden-crowned Warbler (<i>Basileuterus culicivorus</i>)	100 (1/1)	2 larvae	1
	Violaceous Euphonia (<i>Euphonia violacea</i>)	100 (1/1)	2 larvae	1
São Francisco de Assis Park	Sepia-capped Flycatcher (<i>Leptopogon amaurocephalus</i>)	100 (1/1)	2 larvae	1
	Grey-hooded Flycatcher (<i>Mionectes rufiventris</i>)	33.3 (1/3)	3 larvae	-
	Rufous-browed Peppershrike (<i>Cyclarhis gujanensis</i>)	50 (1/2)	1 larva	1
	Golden-crowned Warbler (<i>Basileuterus culicivorus</i>)	33.3 (1/3)	1 larva	-

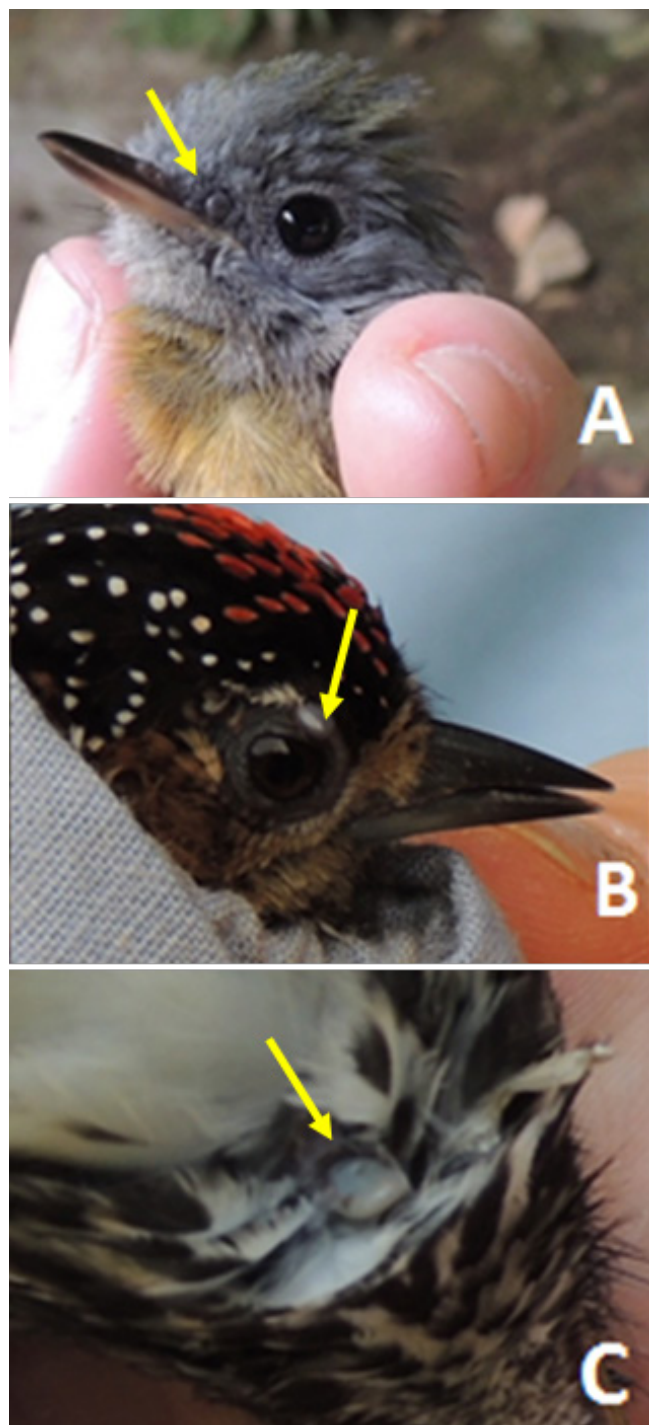


Figure 2. Some wild bird species parasitized by *Amblyomma* ticks in the Atlantic Rainforest biome, Blumenau municipality, Santa Catarina state, southern Brazil. A. Grey-hooded Flycatcher (*Mionectes rufiventris*). B. Ochre-collared Piculet (*Picumnus temminckii*). C. White-necked Thrush (*Turdus albicollis*). Photographs: Ana Carolina Guztzaky.

spotted fever group *Rickettsia* was 50%, close to the value obtained by Ogrzewalska et al. (2010). *Rickettsia amblyommatis* can infect between 10-100% of individuals within a tick population (Labruna 2009). Luz et al. (2017)

found that 34.7% of ticks were positive for *R. amblyommatis* in the Atlantic Rainforest in Rio de Janeiro state. Rocha et al. (2021) detected only 9.1% of the ticks hosted spotted fever group *Rickettsia* in the Atlantic Rainforest in the Bahia state. A relevant discovery is that *Amblyomma longirostre* from wild birds can simultaneously host *R. amblyommatis* and *R. bellii*, being reported for the first time by Abreu et al. (2019). This fact suggested that *R. bellii* may be a component of the bioecology of tick-borne rickettsial infections, including their potential role in rickettsiosis exclusion effect.

Burgdorfer et al. (1974) described the bacterium *Rickettsia amblyommatis* for the first time in ticks *Amblyomma americanum* from the Tennessee state, U.S.A. Subsequently, Burgdorfer et al. (1981) discovered the occurrence of transstadial perpetuation and transovarian transmission of *R. amblyommatis* in *A. americanum*. They found that the infection of ovarian tissues ranged from 30 to 100% between individuals. Thus, the tick *A. americanum* could transmit the bacterium *R. amblyommatis* through all its developmental stages.

The pathogenicity of *Rickettsia amblyommatis* to humans is still under discussion. Guinea pigs exposed to experimental infection developed clinical signs such as fever, scrotal edema, and dermatitis where the tick was attached, being signs compatible with the *Rickettsia parkeri* strain from the Atlantic Rainforest region (Levin et al. 2018, Snellgrove et al. 2021). In Brazil, several animals possess antibodies to *R. amblyommatis*, including domestic dogs (Costa et al. 2017) and wild animals (de Sousa et al. 2018). In Blumenau, Medeiros et al. (2011) found *Amblyomma longirostre* adult ticks infected with *R. amblyommatis*, and several persons were positive serologically for this bacterium species (Barbieri et al. 2014).

Our study provided novel findings regarding ticks *Amblyomma longirostre* infesting birds and the infection of immature tick stages with *Rickettsia amblyommatis* in Santa Catarina state, southern Brazil. These findings underscore the role of avian hosts in shaping the dynamics of tick species hosting *Rickettsia*. Because of its multiple displacements, many bird species infested with ticks of the genus *Amblyomma* could be pivotal in promoting the dispersion, viability, and stability of rickettsial agents within diverse ecosystems. However, the absence of tick species that effectively transmit Brazilian spotted fever suggests a reduced contribution of wild birds to the ecoepidemiology of the disease in our study localities.

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BREEDING BIOLOGY OF THE MANY-COLORED RUSH-TYRANT (*TACHURIS RUBRIGASTRA*) IN A NATURAL LAGOON IN THE ÑUBLE REGION, SOUTH-CENTRAL CHILE

Biología reproductiva del siete colores (*Tachuris rubrigastra*) en una laguna natural de la región del Ñuble, centro-sur de Chile

DANIEL GONZÁLEZ-ACUÑA^{1,†}, FRANCISCA RAVANAL¹, CARLOS BARRIENTOS², KAREN ARDILES¹, LUCILA MORENO¹, LUIS GONZALO TORRES-FUENTES¹ & RICARDO A. FIGUEROA³

¹Facultad de Ciencias Veterinarias, Universidad de Concepción, Casilla 537, Chillán, Chile.

²Facultad de Recursos Naturales y Medicina Veterinaria, Universidad Santo Tomás, Concepción, Chile.

³Unión de Ornitólogos de Chile, Valdivia, Chile.

Correspondencia: Ricardo A. Figueroa, ra_figueroa_rojas@yahoo.com

ABSTRACT.- Between 2005 and 2009, we studied the breeding biology of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) in a 2-ha tall-rush patch in south-central Chile. We monitored the nesting activity by visiting 59 active nests at 2-3 days intervals. Nesting was markedly seasonal, concentrating during spring months. Tyrants built pensile, conical open-cup nests with tall-rush fibers and firmly attached them to live tall-rush stems or other plants. Pairs nested clumped (distance among nests = 4.7 ± 3.1 m [mean $\pm$ SD]) in well-protected vegetation bands (distance from shore-line = 101.2 ± 162.3 m, tall-rush density = 237.2 ± 100.6 m²). The mean clutch size was 2.7 ± 0.5 eggs. Eggs were oval-shaped (16 ± 1.3 mm x 12 ± 0.9 mm) and white-colored. Incubation lasted 16.1 ± 1.4 days. Nestlings left the nest at 15.1 ± 2.9 days old and when fully feathered. Parents fed nestlings mostly with aquatic insects (92.5% of all prey individuals), with dragonflies being the primary prey (55.2%). By the Mayfield method, the overall nesting success was 0.47. We hope our findings will guide future conservation actions for this rush-specialist tyrant species.

KEY WORDS: Chick growth, clumped nesting, clutch size, nesting success, nestling feeding, territorial tolerance.

RESUMEN.- Entre 2005 y 2009 estudiamos la biología reproductiva del sietecolores (*Tachuris rubrigastra*) en un juncal de 2 ha en el centro-sur de Chile. Monitoreamos la actividad de nidificación visitando 59 nidos activos a intervalos de 2-3 días. La nidificación fue marcadamente estacional, concentrándose durante los meses de primavera. Los sietecolores construyeron nidos cónicos con copa abierta usando fibras de juncos, sujetándolos firmemente a tallos vivos de juncos. Las parejas anidaron agrupadas (distancia entre nidos = $4,7 \pm 3,1$ m [media $\pm$ DE]) en sitios bien protegidos (distancia desde la playa = $101,2 \pm 162,3$ m; densidad de tallos = $237,2 \pm 100,6$ m²). El tamaño de la puesta fue de $2,7 \pm 0,5$ huevos. Los huevos fueron ovalados ($16 \pm 1,3$ mm x $12 \pm 0,9$ mm) y blancos. La incubación duró $16,1 \pm 1,4$ días. Los polluelos dejaron el nido a los $15,1 \pm 2,9$ días, cuando estaban completamente emplumados. Los padres alimentaron a los polluelos con insectos acuáticos (92,5% de todas las presas), siendo las libélulas las presas principales (55,2%). El éxito global de nidificación medido por el método Mayfield fue de 0,47. Esperamos que nuestros hallazgos orienten futuras acciones de conservación de este tiránido dependiente de juncuales.

PALABRAS CLAVES: Alimentación de los polluelos, desarrollo de los polluelos, éxito de nidificación, nidificación agrupada, tamaño de puesta, tolerancia territorial.

INTRODUCCIÓN

Knowing the natural history of water birds is pivotal to understanding their adaptation and tolerance to human activities and mitigating the negative impacts of humans on freshwater ecosystems (Kushlan 1993, Weller 1994, 1999). Specific information about the breeding habits and habitats of water birds facilitates the necessary actions for eventual habitat management or restoration.

Many-colored Rush-tyrants (*Tachuris rubrigastra*) are endemic to southern South American wetlands, mainly inhabiting lentic water systems (*e.g.*, lakes, lagoons, ponds, marshes, and swamps) with dense and extensive emerging vegetation (Ridgely & Tudor 1994, Figueroa *et al.* 2001, Fitzpatrick 2004, Tejeda *et al.* 2020). The breeding biology of Many-colored Rush-tyrants is scarcely known (Clock 2020). Much of the available information consists of short descriptive reports and occasional observations on nest building, egg features, and reproductive behavior (*e.g.*, Housse 1945, Goodall *et al.* 1957, Narosky *et al.* 1983, de la Peña 2005, Fitzpatrick 2004).

So far, Barrionuevo & Montes (2015) and Reynoso *et al.* (2023) have provided the most complete descriptions of the breeding habits of Many-colored Rush-tyrants. Together, these authors provided information on nest and egg characteristics, incubation period, nesting microhabitat, reproductive success, and some observations on parental behavior and nestling size in Peruvian wetlands. However, Barrionuevo & Montes (2015) and Reynoso *et al.* (2023) restricted their study to only one breeding period. To our knowledge, there are no studies based on successive reproductive periods. Therefore, we do not know how phenology and reproductive success change over several

years. Moreover, there are only occasional observations on the feeding and development of nestlings.

Here, we report the results of a long-term study on the breeding biology of Many-colored Rush-tyrants in an agricultural area of south-central Chile. Our objectives were to gather fundamental information about nesting activity, describe reproductive phenology, and detect eventual temporal variations in breeding success. Knowing all these aspects is essential for future conservation and management actions of Many-colored Rush-tyrant populations and their habitats.

MATERIAL AND METHODS

Study area

We conducted our study in Laguna Santa Elena (36°48'S, 72°23'W, 77 m a.s.l.), Ñuble region, south-central Chile. This lagoon is a small body of water (160 ha) located in an agricultural area (Fig. 1) with sugar beet (*Beta vulgaris*), wheat (*Triticum* spp.), and blackberry (*Rubus ulmifolius*) crops, and exotic tree plantations (Monterrey pine [*Pinus radiata*] and eucalyptus [*Eucalyptus* spp.]). On the lagoon edge is a vegetation strip composed of native and introduced plants, including wild herbs, shrubs, and trees. The composition of the shrub layer includes yellow bush lupine (*Lupinus arboreus*) and romerillo (*Baccharis racemosa*) thickets. The tree layer comprises native species such as myrtle (*Luma apiculata*), boldo (*Peumus boldus*), roman cassie (*Acacia caven*), litre (*Lithraea caustica*), maqui (*Aristotelia chilensis*), and patagua (*Crinodendron patagua*), and introduced species such as Monterrey pine, Australian blackwood (*Acacia melanoxylon*), silver wattle (*A. dealbata*), Simon's poplar (*Populus simonii*), Hum-



Figure 1. Aerial view of the laguna Santa Elena, Bulnes, Ñuble region, south-central Chile. The study of the breeding biology of Many-colored Rush-tyrants was within the area demarcated in red. Photograph: Fernando González S.

boldt's willow (*Salix humboldtiana*), Babylon willow (*S. babylonica*), and basket willow (*S. viminalis*). The aquatic vegetation covering the lagoon edges is composed of tall-rush (*Juncus procerus*), common water hyacinth (*Eichhornia crassipes*), water fern (*Azolla filiculoides*), and parrot's feather (*Myriophyllum aquaticum*). The climate is Mediterranean humid, with cool, rainy winters and hot summers (di Castri & Hajek 1976).

Field procedures

We monitored the breeding activity of Many-colored Rush-tyrants in an extensive patch of tall rush (≈ 2 ha) in the central part of the lagoon's western edge. We searched for and surveyed nests during four breeding seasons (2005-2009) from early August to late January at intervals of 2-3 days. Two to three observers participated in the field work with each visit. At each visit, the nest location and monitoring were between 07:00 and 19:00 h. Thus, we completed 320 days per 12 h in the field for combined breeding periods (total sampling effort = 3840 h).

We searched for nests using a rowboat, moving slowly throughout the vegetation to avoid habitat damage and minimize the disturbance of nesting pairs. Before entering the tall-rush patch, we observed the patch edge from almost 10 m using binoculars to locate any nest present. Within the patch, we searched for nests by moving slowly through the vegetation, stopping every 5 to 10 m to observe the vegetation around us. After finding one nest, we slowly walked among the tall-rush and tied a colored flag in the upper part of one or several tall-rush stems just above the nest to facilitate its later location. We checked active nests every time we visited the study site. To avoid stressing nesting pairs, we decided not to capture adult individuals. In addition, investing time in capturing breeding individuals would have considerably limited our time to evaluate the nesting activity. Capturing adult individuals by boat involves a much greater logistical deployment than by foot.

During each breeding season, we registered the following life history traits for each monitored breeding pair: (1) reproductive phenology, (2) nest morphometrics, (3) nest location, (4) clutch size (*i.e.*, number of eggs at the incubation onset), (5) egg characteristics, (6) nestling growth, (7) nestling feeding, and (8) breeding success and nest failure.

We evaluated reproductive phenology by registering dates of courtship (*i.e.*, from the first date we registered prey offer, mutual grooming, or copulation until egg laying), egg-laying (*i.e.*, the day when tyrants laid first eggs), incubation (*i.e.*, the time between laying and hatching of first egg), and chick-rearing or nestling period (*i.e.*, the time between hatching and fledging). To detect

nesting activity peaks along the breeding period, we divided each breeding season into three stages: early season (September-October), mid-season (November), and late season (December-January). Among nests detected, we distinguished old and new nests. An old nest was a nest that tyrants built during a previous breeding season, and a new nest was a nest that tyrants built during the current breeding season. Among these, we considered a nest active when it contained newly laid eggs, an incubating adult, or nestlings. When any breeding pair occupied an old nest, we classified it as a reused nest.

Nest characteristics we measured included the (i) nest shape and size, (ii) nest material, and (iii) number of tall-rush stems supporting nests. We only measured nests when the nesting pairs were no longer attending them (*i.e.*, without eggs or nestlings). Spatial variables included: (i) nest height above water (from water surface to lower edge of the nest); (ii) the distance from the nest to the nearest borderline between the tall-rush patch and open water; (iii) nest distance to shoreline (from nest center to shoreline); (iv) distance to the nearest conspecific nest measured from center to center of the cup; (v) distance to nearest nest of other co-nesting passerine species located during our surveys (see Lara *et al.* 2011); and (vi) tall-rush density around nests. To measure distances and heights, we use a metric tape measure (± 1 mm). We measured the tall-rush density around nests by counting the number of stems within a 2-m radius circle.

After hatching, we measured the chick growth each time we visited the study area. We banded 96 newly hatched chicks (2-3 days) throughout the four breeding seasons. However, we could follow the growth of fewer than a third of the banded chicks due to nestling loss by depredation or other causes. We established three age categories: 1-3 days, 6-9 days, and 12-15 days. In each, we measured the body mass, tarsus length, bill length, wing-chord length, tail length, and total length. We measured these variables following Eck *et al.* (2011; details in Fig. 4). We measured nests, eggs, and nestlings using a digital caliper (± 0.01 mm) and weighed eggs and nestlings using a digital balance (± 0.1 g). Handling and banding of nestlings followed the ethical guidelines of animal welfare of the Faculty of Veterinary Sciences of the Universidad de Concepción.

We evaluated the nestling diet by recording the prey offered to nestlings by parents in 16 nests during the breeding period 2005-2006. We took the photos from the boat while stopping 5-10 m from the nest. When a parent arrived with prey to the nest, we photographed it using a digital camera (magnification = 200 mm, lens aperture = 2.8). We quantified the nestling diet on 1350 high-resolution images taken on different days. An entomologist

assisted us in the prey identification.

We evaluated the reproductive success for all nests combined and for individual nests. For individual nests, we measured the (i) mean clutch size per nests, (ii) mean number of hatched eggs per nest, and (iii) mean number of fledglings per nest. For the nests combined, we measured four variables: (i) proportion of hatched eggs (number of eggs hatched/number of eggs laid); (ii) proportion of fledged young following hatching (number of young fledged/number of hatched eggs); (iii) proportion of young that fledged following laying (number of fledged young/number of eggs laid) (Martin-Vivaldi *et al.* 1999); and (iv) proportion of successful nests (number of nests that fledge at least one fledgling/total number of monitored active nests). We considered that a nestling fledged when it moved between the nest and the surrounding vegetation or between the vegetation close to the nest. If a nest was empty after it had nestlings on a previous visit, we searched for fledglings around the nest, identifying them by the band color. We also evaluated productivity based on the number of chicks produced over the entire breeding season (Martin-Vivaldi *et al.* 1999).

Complementarily, we estimated nesting success using the Mayfield (1975) method. This method requires calculating the daily nest loss rate, the probability of daily survival for a nest, and the survival probability for one nest throughout each breeding stage or the entire breeding period. We obtained the daily nest loss rate by dividing the number of nests lost by the exposure time (*i.e.*, the time each nest is under observation) measured in nest-days. We measured the exposure time for incubation by counting the number of nest-days between the first egg-laying date or when we found a nest with eggs for the first time until the day the eggs hatched. For the nestling stage, we counted the number of nest-days between the first egg-hatching date or when we found a nest with nestlings for the first time until the day when the nestlings left or were no lon-

ger in the nest. If a nest failed between two visits with a 2-day interval, we assumed that failure occurred the day after the last visit. If a nest failed between two visits with a 3-day interval, we assumed that failure occurred in the middle of the interval.

The daily nest survival probability results by subtracting the daily nest loss rate from the probability that all nests survive (*i.e.*, 1 minus daily nest loss rate). We calculated the standard error for each daily nest survival value following Johnson (1979). We calculated the probability of overall nest survival separately for the incubation and nestling stages. In each case, we calculated the overall nest survival by raising the daily nest survival probability to a power equal to the mean duration of each breeding stage. Finally, we calculated the nesting success by multiplying the daily nest survival probabilities generated for the incubation and nestling stages.

Statistical procedures

We analyzed our results using descriptive statistics including the arithmetic mean, standard deviation (SD), median and range. For the height and distance measurements, we also included modal values because it allows better detecting typical values. We avoid the use of inferential procedures because our study was essentially descriptive.

RESULTS

Breeding phenology

During our study, we located 75 nests (Table 1). Ten nests were old, and 65 nests were fresh. We found active nests during all breeding stages (Fig. 2, Table 1). Excepting the breeding season 2007-2008, the number of nests located was similar among years (Table 1). Among the nests located, 68 were active, including three reused and 65 new (Table 1). The number of active nests varied over the years (Table 1). Because of the loss of some active nests during the early breeding season, we could not follow all active

Table 1. Number of nests used to evaluate the nesting activity of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. Detected nests included both old and new nests. Old nests correspond to those that remained from the previous breeding season, and new nests correspond to those built during the current breeding season. Active nests included nests under construction, nests with eggs, or nests with nestlings. Reused nests were old nests occupied by any tyrant pair during the current breeding season. Monitored nests were those followed to evaluate the fate of eggs and nestlings.

Breeding season	Detected nests	Old/new nests	Active nests	Reused/new nests	Monitored nests
2005-2006	22	7/15	16	1/15	13
2006-2007	22	3/19	21	2/19	19
2007-2008	8	0/8	8	0/8	8 ^a
2008-2009	23	0/23	23	0/23	19
Total	75	10/65	68	3/65	59

^a All nests failed during the nestling stage due to flooding after of heavy rain.

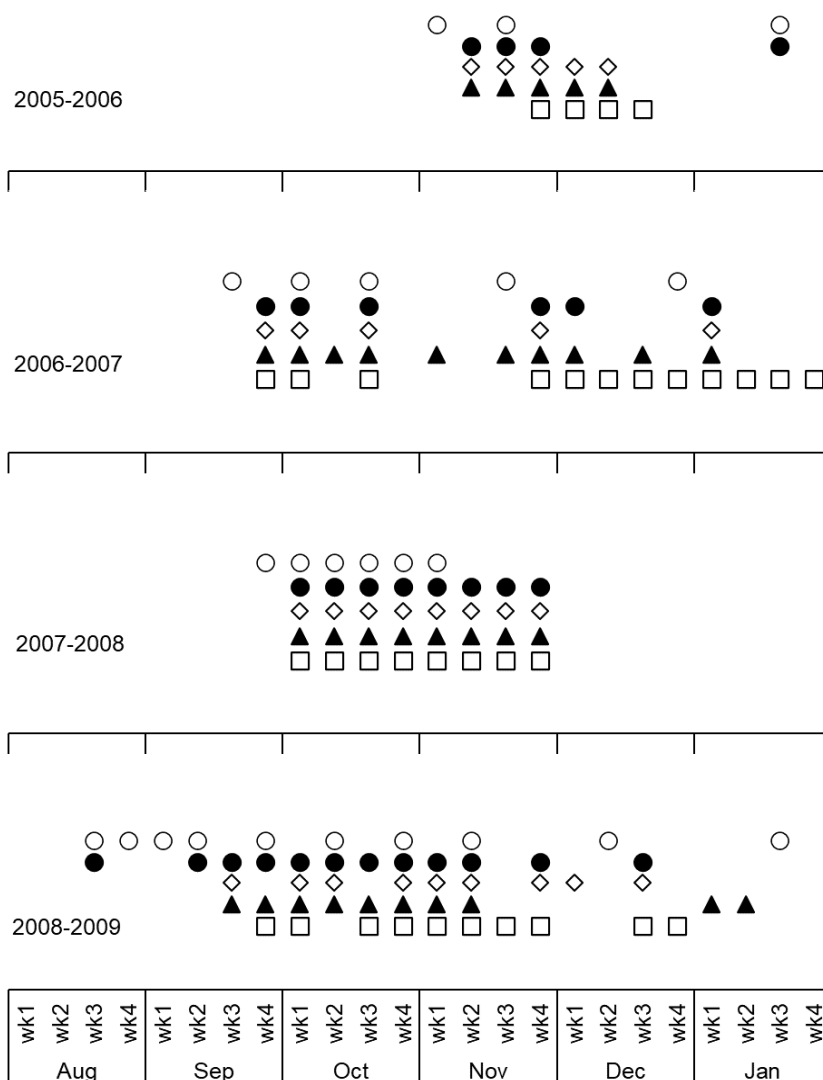


Figure 2. Breeding phenology of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. Month names abbreviated with the three first letter; the letters wk represents weeks. White circles = courtship, black circles = nest building, diamonds = egg laying, black triangles = incubation, white squares = nestlings.

nests to evaluate the fate of eggs and nestlings (Table 1). The maximum length of the breeding season of Many-colored Rush-tyrants was about six months (August-January, Fig. 2), with most nests active from October to December (Fig. 2, Table 2).

Courtship period.- We observed the earliest courtship displays on 17 August 2008 and the latest on 18 January 2006 (Fig. 2). The starting of the breeding activity of each tyrant pair was evidenced by the following events: (i) an increase in plumage color expression; (ii) a courtship ritual in which males made successive leaps over plants around females, often lifting tuft feathers, moving the tail, and repeatedly uttering a monotonous *fuitiu, fuitiu*; (iii) females were more restless and responded to male call's by uttering paused and regular tweets; and (iv) an increased aggressiveness towards conspecific individuals or indi-

viduals of co-nesting species (e.g., Wren-like Rushbird [*Phleocryptes melanops*], Warbling Doradito [*Pseudocolopteryx flaviventris*]).

Nest building.- The earliest nest-building activity we observed was on 20 August 2008 and the latest on 21 January 2005 (Fig. 2). After courtship displays, both pair members often engaged in nest building ($n = 65$ pairs) or repairing old nests ($n = 3$ pairs). Due to the absence of an evident difference in the plumage coloration and naked parts between both sexes, we could not determine which individual was female or male while building the nest. However, we were sure both pair members participated in the nest building as we observed them simultaneously carrying nest material or molding the nest.

To initiate the nest building, the tyrants collected long, fresh strips of tall-rush and elaborated a crown-like

Table 2. Nesting phenology of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. Early season = September-October, mid-season = November, late season = December-January, % = percentage of nests, n = number of nests.

Season	Nests with eggs laid			Total nests
	Early season % (n)	Mid-season % (n)	Late season % (n)	
2005-2006	0 (0)	62.5 (10)	18.8 (3)	13
2006-2007	38.1 (8)	14.3 (3)	38.1 (8)	19
2007-2008	0 (0)	100 (8)	- ^a	8
2008-2009	43.5 (10)	13.0 (3)	26.1 (6)	19
Mean % ± SD	20.4 ± 23.6	47.4 ± 41.9	20.7 ± 15.9	

Season	Nests with eggs hatched			Total nests
	Early season % (n)	Mid-season % (n)	Late season % (n)	
2005-2006	0 (0)	37.5 (6)	18.8 (3)	9
2006-2007	28.6 (6)	14.3 (3)	33.3 (7)	16
2007-2008	0 (0)	25.0 (2)	- ^a	2
2008-2009	26.1 (6)	8.7 (2)	17.4 (4)	12
Mean % ± SD	13.7 ± 15.8	21.4 ± 12.7	17.4 ± 13.6	

Season	Nests with nestlings			Total nests
	Early season % (n)	Mid-season % (n)	Late season % (n)	
2005-2006	0 (0)	25 (4)	18.8 (3)	7
2006-2007	19 (4)	4.8 (1)	28.6 (6)	11
2007-2008	- ^a	- ^a	- ^a	0
2008-2009	21.7 (5)	8.7 (2)	17.4 (4)	11
Mean % ± SD	10.2 ± 11.8	9.6 ± 10.8	16.2 ± 11.9	

^a All nests failed due to flooding after of heavy rain.

circular structure by firmly intertwining the vegetal material. Then, they continued weaving the nest downwards, progressively reducing the structure diameter. The Many-colored Rush-tyrant pairs filled the cup bottom with thin plant fibers until forming a soft lining cup. Tyrants attached nests to live stems of tall-rush (n = 57 nests) or built them on tree branches located in the lagoon border (n = 6 nests). The tyrants took 3–6 days to build nests (mean ± SD = 4 ± 1.1, n = 8 pairs). Although some tyrant pairs nested in old nests after repairing them (Table 1), only two fledged young chicks; the remaining nests failed during egg laying, incubation, or hatching stages.

Egg laying and incubation period.- The earliest egg-laid record was on 14 September 2008, and the latest on 4 January 2006. The female immediately began laying eggs after the plant material composing the nests was dry (plant material turned and straw-colored). By our recording calendar, females laid eggs at 1-day intervals (n = 32

nests). Over the four years of study, the highest proportion of nests with newly laid eggs occurred in the middle of the breeding season (Table 2). Tyrants started incubation after the female laid the first egg, so hatching was asynchronous. Since the plumage coloration patterns are similar for both sexes, we could not determine if both parents participated in the incubation. The average incubation period was 16 days (range = 14–19 days, Table 3).

Egg hatching and nestling period.- Overall, the proportion of hatched eggs was higher in the middle of the breeding season (Table 3). The earliest egg hatching occurred on 2 October 2008, and the latest on 19 January 2005. Nestlings remained on nests for two to three weeks after hatching (mean ± SD = 15.1 ± 2.9 days, range = 11–22 days; Table 4). The earliest record of nestlings leaving the nest was on 5 October 2008, and the latest on 24 January 2005.

Table 3. Incubation period of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) and nestlings period during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. n = number of nests surveyed.

Season	Incubation length			Days at which nestlings leave nest		
	Mean $\pm$ SD	Range	n	Mean $\pm$ SD	Range	n
2005-2006	16.2 $\pm$ 1.5	14-18	4	16.6 $\pm$ 1.1	15-18	5
2006-2007	16.5 $\pm$ 2.1	14-19	11	14.1 $\pm$ 2.8	11-18	8
2007-2008	15.5 $\pm$ 0.7	15-16	7	..a	..a	..a
2008-2009	15.5 $\pm$ 1.0	15-17	6	15.1 $\pm$ 3.9	11-22	11
Total	16.1 $\pm$ 1.4	14-19	28	15.1 $\pm$ 2.9	11-22	24

^a All nests failed due to flooding after of heavy rain.

Table 4. Structural and spatial nest characteristics of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons (2005-2009) in Laguna Santa Elena, Ñuble province, south-central Chile. Measurements included to both old and new nests.

Nest characteristics	N° Nests	Mean $\pm$ SD	Range	Mode
Structure variables				
Nest height (cm) ^a	63	11.4 $\pm$ 2.3	6.5-19.5	12
Maximum nest width (cm) ^b	63	4.7 $\pm$ 0.9	4.2-8	5.5
Maximum diameter of nest entrance (cm)	63	4.4 $\pm$ 1.1	3.5-10.9	4
Minimum diameter of nest entrance (cm)	63	4.0 $\pm$ 0.4	3.3-5	4.1
Cup depth (cm) ^c	63	3.9 $\pm$ 0.7	2.8-4.4	3.9
Number of tall-rush supporting nest	57	1.3 $\pm$ 0.7	1.0-4	1
Diameter of tall-rush supporting nest (cm)	57	2.7 $\pm$ 1.2	0.6-6.2	0.9
Spatial variables				
Height of nest above water surface (cm) ^d	63	48.1 $\pm$ 19.5	17.2-84	46
Nest distance from tall-rush/water borderline (m) ^e	63	20.7 $\pm$ 24.5	0.5-97	0.5
Nest distance from firm ground (m) ^f	63	101.2 $\pm$ 162.3	2-500	100
Linear distance to the nearest tyrant nest (m) ^g	8	4.7 $\pm$ 3.1	1.6-10.4	-
Linear distance to the nearest rushbird nest (m) ^g	16	5.4 $\pm$ 4.2	1.4-15.8	-
Tall-rush density (m ²) ^h	63	237.2 $\pm$ 100.6	95-428	-

Measurement criteria: ^a From the upper edge to the outer lower edge. ^b At the level of the upper edge. ^c From the upper edge to the cup bottom.

^d From the outer bottom edge to the water surface. ^e From nest center to borderline between tall-rush patch and water mirror. ^f From nest center to shoreline. ^g Between nest centers. ^h Within a 2-m radius circle.

Nest morphometrics and location

All nests were pensile conical open-cups (Fig. 3A). The building material included mostly fibers of tall-rush. We only found one nest structure composed of tall-rush fibers intertwined with horsehair. Overall, nests had an open circular entrance and a shallow cup (Fig. 3A, Table 4). Of all measured nests, 57 were on tall-rush stems, four on willow branches, and two on a tall-rush stem plus a willow branch. Among nests attached to tall-rush, 45 wrapped only one stem, 7 to two stems, 4 to three stems, and 1 to four stems. The diameter of tall-rush stems was variable but tended to be relatively stiff and thick (Table 4).

Although ranges were broad, many nests were placed at a low elevation from the water surface, near tall-rush /water borderline, distant from the shoreline, and to a short distance between them (Table 4). Regarding the distance between the nests of tyrants and those of Wren-

like Rushbirds, some were relatively close, and others at farther distances (Table 4). Most tyrant pairs located their nests in sites with high plant density (Table 4).

Clutch size and egg characteristics

The clutch size was uniform over the four years of study (Table 5), reaching a modal value of three eggs (43 of 59 nests). Only a pair laid a maximum of four eggs. Eggs were elliptical (oval-shaped) and small-sized (< 20 mm in length, Table 5). Coloration varied from white to light pinkish, becoming opaque as the incubation progressed. We observed no streaking or spotting on eggshells (Fig. 3B)

Nestling growth

The chicks were born almost entirely naked with closed eyes, strong-yellow lip edges, light pinkish skin, and head,



Figure 3. Nest and eggs of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) in Laguna Santa Elena, Ñuble province, south-central Chile. **A.** Many-colored Rush-Tyrant pairs build a nest pensile conical open-cups, which they weave with fibers of tall-rush and attach to 1-4 tall-rush stems. **B.** Nests have an open circular entrance and a shallow cup. Eggs are oval-shaped, small-sized (length < 20 mm), and white to light pinkish. Photographs. A. Daniel González-Acuña. B. Carlos O. Barrientos.

back, and wings covered with lemon-yellow down (Fig. 4A). Most chicks opened their eyes between 5-8 days old ($n = 84$). At this age, down profusely covered their bodies, and the first feathers had already emerged (Fig. 4B). When 12 days old, nestlings were almost fully feathered but with patches of down on the head and neck ($n = 27$, Fig. 4C). At 15 days old they had their whole body covered with feathers, but with traces of down on the head and neck ($n = 26$). The plumage at that age was pale yellow on the belly and face and dark brown on the back, wings, tail, and nape. Young of 15-days also had a black eye mask, white chin, dark bill with heavy-yellow edges, and pinkish legs. In addition, a thin white line corresponding to the external vexillum was visible upon the wings.

The mass, total length, wing chord length, and tail length of nestlings increased markedly from hatching until fledging (Fig. 5). The growth of tarsi and bill steadied within a few days, after which these slightly increased in size (Fig. 5). Thus, tarsus and bills were the first to reach nearly-adult size.

Nestling feeding

Both parents fed nestlings. Although we did not band adult tyrants and sexes are undistinguishable by plumage coloration, we observed simultaneously both parents delivering prey to nestlings. Most prey delivered to nestlings were aquatic insects (92.5% of all prey individuals), including dragonflies, damselflies, dipterans, scorpion flies, stone-

Table 5. Clutch size and egg size of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. n = number of eggs measured.

Season	Eggs laid	N° Nests	Mean $\pm$ SD (range)					
			Clutch size	Egg length (mm)	Egg width (mm)	n	Egg mass (g)	n
2005-2006	36	13	2.8 ± 0.6 (1-3)	16 ± 0.9 (13-17)	12 ± 1.4 (10-16)	16	1.4 ± 0.2 (0.8-1.6)	20
2006-2007	51	18	2.7 ± 0.7 (1-4)	15 ± 1.6 (12-18)	12 ± 1.2 (9-15)	30	1.3 ± 0.2 (0.8-1.6)	33
2007-2008	24	8	3.0 ± 0.0 (3)	16 ± 1.4 (15-19)	12 ± 1.0 (11-13)	24	1.4 ± 0.4 (0.9-2.1)	24
2008-2009	50	19	2.6 ± 0.5 (2-3)	16 ± 1.3 (12-18)	12 ± 0.6 (11-13)	40	1.2 ± 0.1 (1.0-1.6)	43
Total	161	59	2.7 ± 0.5 (1-4)	16 ± 1.3 (12-19)	12 ± 0.9 (9-16)	110	1.3 ± 0.3 (0.8-2.1)	120

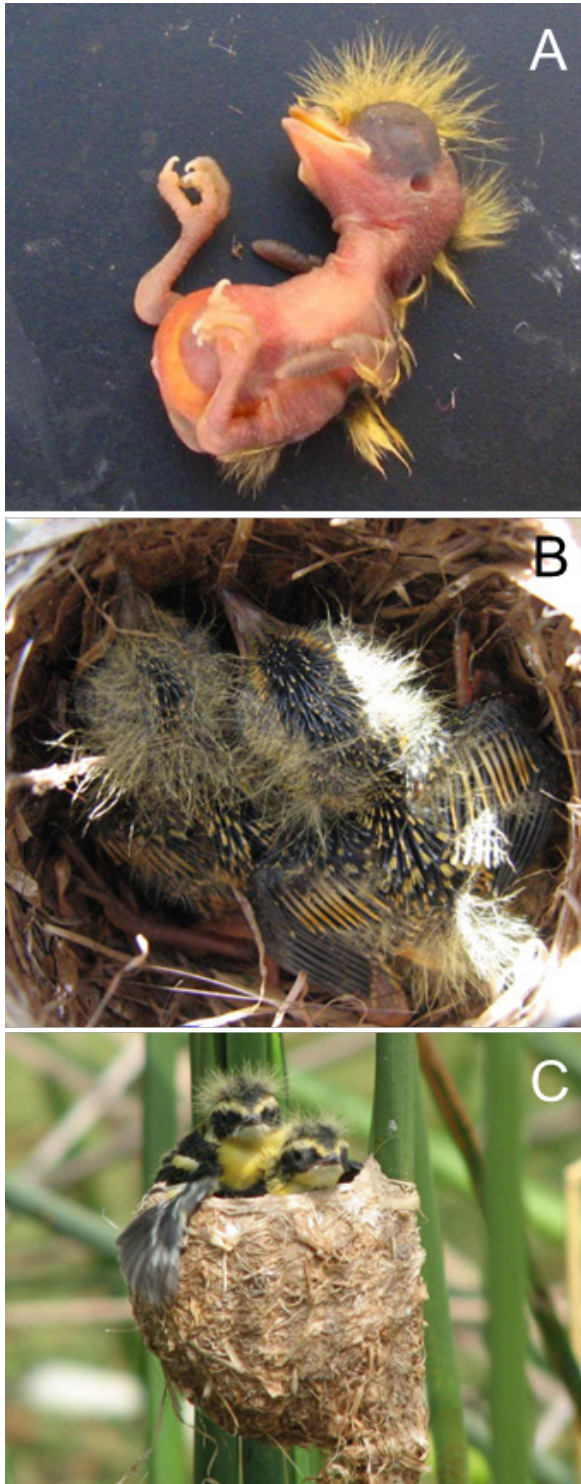


Figure 4. Growth of nestling Many-colored Rush-Tyrants (*Tachuris rubrigastra*) at three age categories from young banded in Laguna Santa Elena, Ñuble Province, south-central Chile. **A.** Newly hatched chicks are entirely naked with closed eyes. In addition, they have strong-yellow lip edges, light pinkish skin, and head, back, and wings covered with lemon-yellow down. **B.** At 6-9 days, they are covered profusely with down, and the first feathers have already emerged. **C.** When 12 days old, nestlings are fully feathered, but with patches of down on the head and neck. Photographs: Carlos O. Barrientos.

flies, and mayflies (Table 6, Fig. 6). Among these, the dragonfly *Oxyagrion rubidium* and crane flies of the genus *Tipula* (Fig. 6A, 6B) together accounted for two-thirds of all prey items (Table 6). Moths, lacewings, locusts, true bugs, ants, and spiders were occasional prey. While fed, the nestlings produced a fecal sac (*i.e.*, excrement encased in a mucous membrane), which the parents immediately removed from the nest.

Reproductive success

Nest failure.- During the breeding season 2007-2008, the early nests ($n = 5$) failed because of unusual and intense spring rains and the breakage of a nearby irrigation channel. The abrupt rise of the water level caused detachment of the nest structure from tall-rush stems. We found a nest floating with two 5-day-old nestlings dead in its interior. From there on, we did not register more nesting events throughout the reproductive season. Other known causes of nest failure included entrance obstruction by nests of the Wren-like Rush-bird ($n = 2$), predation ($n = 1$), and destruction by coypu (*Myocastor coypus*; $n = 2$). Another 26 nests failed due to unknown causes. Throughout the four reproductive periods, 29 nests failed during incubation and 10 during the nestling stage.

Breeding success of combined nests.- Excepting the breeding season 2007-2008, the proportion of hatched eggs and fledged young following hatching was high ($> 60\%$, Table 7). The proportion of fledged young regarding the number of eggs laid reached values around 50% (Table 7). About half of the nests monitored annually fledged at least one young (Table 7). Productivity was similar among breeding seasons: 20 fledglings in 2005-2006, 29 fledglings in 2006-2007, and 28 fledglings in 2008-2009.

Breeding success per nest.- The mean number of eggs hatched per nest was similar between the 2005-2006 and 2006-2007 breeding seasons (Table 8). The mean number of eggs hatched was somewhat lower in the two subsequent breeding seasons. This decrease was most noticeable during the 2007-2008 breeding season (Table 8). The mean number of fledglings per nest was similar between breeding seasons, except for the 2007-2008 season (Table 8). In this latter season, none of the monitored pairs produced fledglings due to the loss of nests by flooding, as mentioned above.

Nesting success measured by the Mayfield method.-

The daily nest survival probability during the incubation and nestling stages was similarly high ($> 90\%$) among breeding seasons (Table 9). However, the nest survival probability during each entire stage varied markedly.

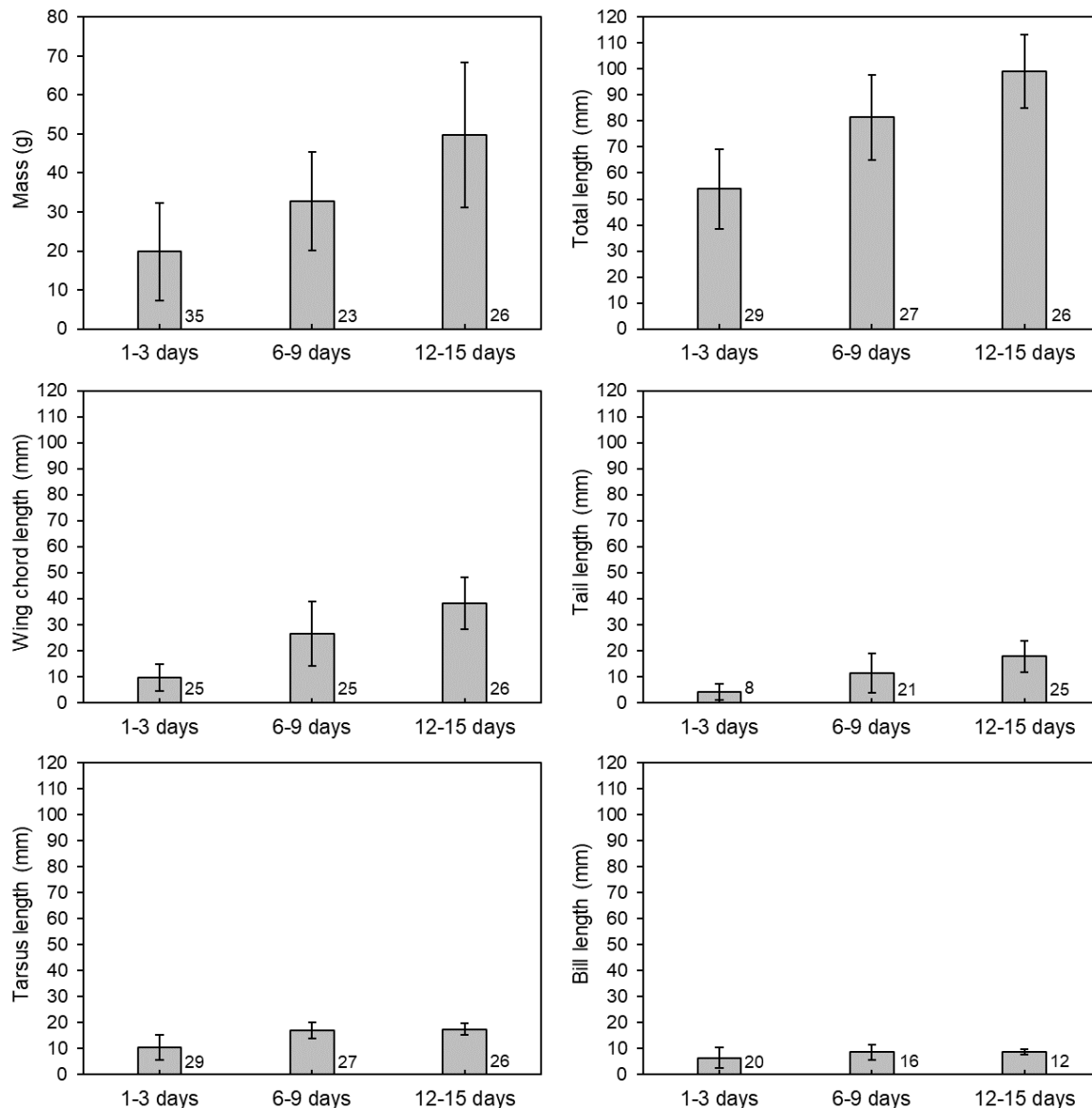


Figure 5. Body size of nestling Many-colored Rush-Tyrants (*Tachuris rubrigastra*) at three age categories from young banded in Laguna Santa Elena, Ñuble Province, south-central Chile. Measurements according to Eck *et al.* (2011). Total length: measured from bill tip to the tip of the longest tail feather. Wing-chord length: measured from carpal joint to the tip of the longest primary feather. Tail length: measured from the base of the innermost rectrices to the tip of the longest tail feather. Tarsus length: measured from the joint between tarsus and toes to the inter-tarsal joint. Bill length: measured from the tip to the proximal edge of the nostrils. Grey bars represent the mean, and error bars are standard deviations. Numbers on the bar side indicate nestlings measured.

During the incubation, the survival probability varied from 0.25 to 0.89, and during the nestling stage varied from 0.62 to 0.88 (Table 9). The nesting success during each entire breeding period ranged from 0.52 to 0.56, with an overall nesting success of 0.44 (Table 9).

DISCUSSION

Breeding phenology and behavior

The breeding activity of the Many-colored Rush-tyrant in Laguna Santa Elena was markedly seasonal, which agrees

with observations in Peruvian wetlands (Barrionuevo & Montes 2015, Reynoso *et al.* 2023). Like in Peruvian mangroves (Reynoso *et al.* 2023), the nest-building and egg-laying in Laguna Santa Elena concentrated particularly during the spring months. Although previous observations in other localities suggest a shorter (3-4 months) or earlier breeding period (Nores & Yzurieta 1980, de la Peña 1987, Rottmann 1995, Barrionuevo & Montes 2015), the reported dates fall within the range dates we registered in our study site. Despite the strong seasonality of the Ma-

Table 6. Invertebrate prey delivered by adult Many-colored Rush-tyrants (*Tachuris rubrigastra*) to nestlings during breeding season 2005-2006 in Laguna Santa Elena, Nuble province, south-central Chile. Authors identified prey based on 1350 digital photographs of parents arriving with food at the nest.

Prey taxa	N° individuals	%
Insects		
Odonata (dragonflies)		
<i>Oxyagrion rubidum</i>	231	36.2
Unidentified imagoes ^a	120	18.7
Unidentified larvae	2	0.3
Diptera (Crane flies, hoverflies)		
<i>Tipula</i> imagoes	166	26
<i>Eristalis</i> larvae	2	0.3
Unidentified imagoes	4	0.6
Mecoptera (scorpionflies)		
Unidentified imagoes	31	5
Plecoptera (stoneflies)		
Unidentified imagoes	29	4.5
Ephemeroptera (mayflies)		
Unidentified imagoes	14	2.2
Lepidoptera (moths)		
Noctuidae imagoes	8	1.3
Neuroptera (lacewings)		
Unidentified imagoes	7	1.1
Orthoptera (grasshoppers)		
Acrididae imagoes	3	0.5
Unidentified imagoes	1	0.1
Hemiptera (bugs)		
Unidentified imagoes	1	0.1
Hymenoptera (ants)		
Formicidae imagoes	2	0.3
Arachnida (spiders)		
Araneae adults	17	2.7
Hirudinea (leeches)		
Unidentified leech	1	0.1
Total individual prey	639	100

^aImagoes = insect adult stage.

ny-colored Rush-tyrant's breeding period, we observed a high nesting asynchrony among pairs during each breeding season. Possibly, this was because of differences in sexual maturity or breeding experience of tyrants (Sargent 1965, Collias & Collias 1984) or some unknown factor.

As in other localities, in our study site some breeding pairs occupied old nests. In Argentina, de la Peña (1983) observed some breeding pairs repairing or reconditioning old nests with fresh plant material or building a

second nest after the loss of the first one. Rottmann (1995) affirms that Many-colored Rush-Tyrants in central Chile may build several nests within the same breeding season. Although we suspected some pairs in Laguna Santa Elena built a new nest during the same season, we could not confirm this as we did not band adult tyrants. Different studies show that nest reuse and construction of more than one nest is common to several Neotropical passerine species inhabiting wetlands (de la Peña 1983, Lara *et al.* 2011, Pretelli & Isacch 2013, Chiaradia *et al.* 2017).

The duration of the laying time in Laguna Santa Elena agrees with some previous reports. In Argentina, de la Peña (2005) found that Many-colored Rush-Tyrants laid the first eggs during mid-September (early spring) and the last ones during early January (early summer). Although in some Peruvian wetlands, the breeding period of Many-colored Rush-Tyrants begins much earlier than in Laguna Santa Elena, the females also lay their eggs over five months (Reynoso *et al.* 2023). The incubation periods of Many-colored Rush-Tyrants in Laguna Santa Elena were within the ranges observed in Peruvian wetlands (11-16 days; Barrionuevo & Montes 2015, Reynoso *et al.* 2023). Thus, the duration of the incubation stage of this tyrant species falls within those of many other open-cup passerine species of southern South America (11-17 days; de la Peña 2013).

The nestling period of Many-colored Rush-Tyrants in our study site also was like that found in some Peruvian wetlands (7-12 days, Reynoso *et al.* 2023). Nonetheless, during some breeding seasons, we detected differences among pairs regarding the age at which nestlings left the nest (11-22 days). We do not know what factors could cause these differences. It is possible that certain ecological (*e.g.*, microclimate, food availability), physiological (*e.g.*, nutritional condition), or behavioral (*e.g.*, parents' experience, variation in parents' dependence) factors were involved (Drent & Daan 1980, Martin 1987, Naef-Daenzer & Keller 1997).

Nest characteristics

The structural characteristics of Many-colored Rush-Tyrant nests in our study site are closely like those observed in other wetlands of southern South America. The nests consist of well-elaborated pensile semi-conical open cups composed exclusively of strips of emergent vegetation (Housse 1945, de la Peña 1983, 1987, Sick 1985, Canevari *et al.* 1991, Narosky & Salvador 1998, Fitzpatrick 2004, Kovacs *et al.* 2006, Barrionuevo & Montes 2015, Reynoso *et al.* 2023). These nest structure characteristics are common to many marshland-specialist passerine species (Collias & Collias 1984). The nest size of Many-colored Rush-Tyrants in our study site was within ranges observed

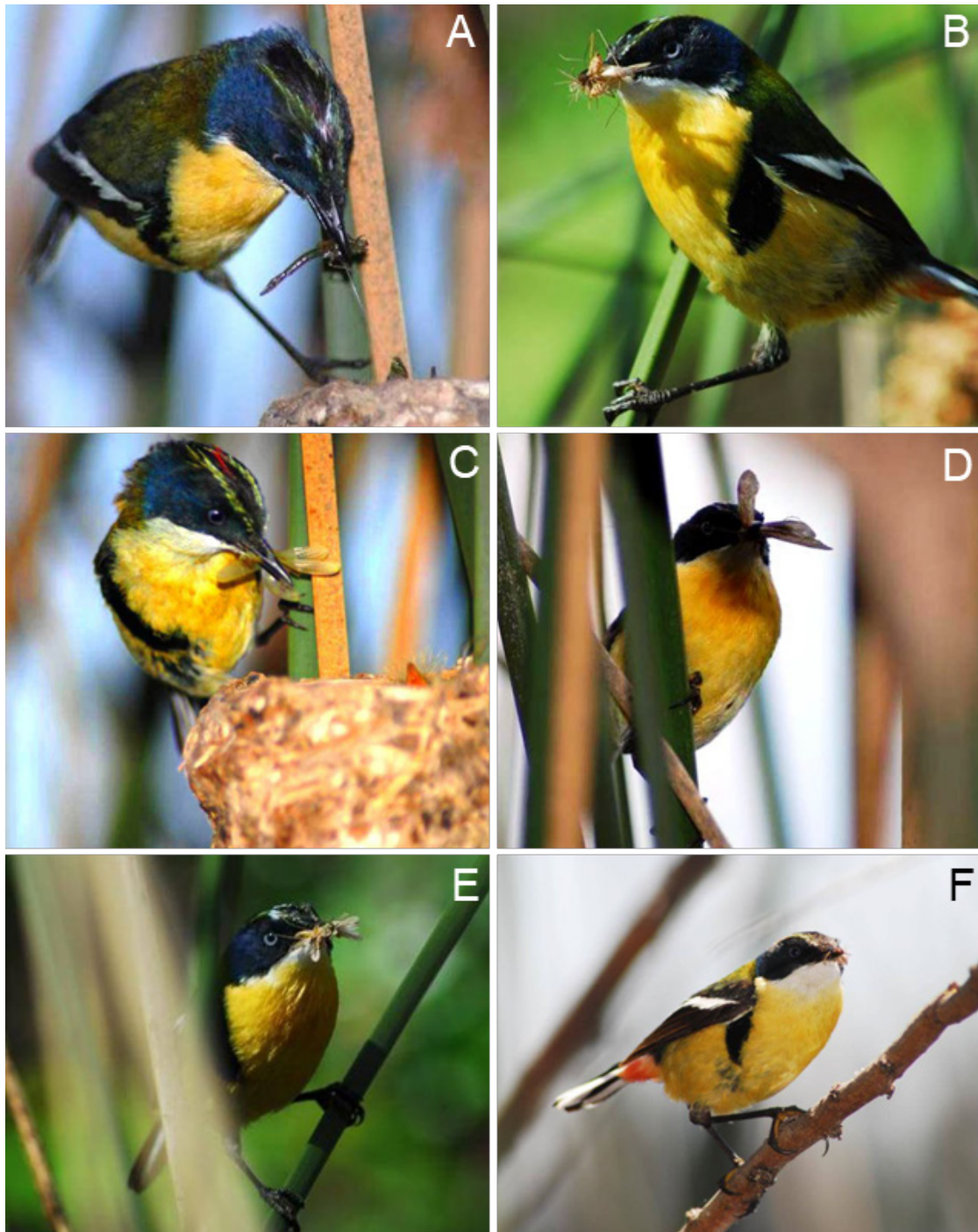


Figure 6. Some invertebrate prey delivered by parent Many-colored Rush-Tyrants to nestlings during breeding season 2005-2006 in Laguna Santa Elena, Ñuble Province, south-central Chile. A. Delivery of an adult dragonfly (*Oxyagrion rubidum*) on 15 November 2006. B. Delivery of an adult crane fly (*Tipula* spp.) on 18 November 2006. C. Delivery of an adult scorpionfly (Mecoptera) on 5 December 2005. D. Delivery of an adult stonefly (Plecoptera) on 12 October 2005. E. Delivery of an adult moth (Lepidoptera) on 11 November 2006. F. Delivery of an adult spider (Aranea) on 20 December 2006. Photographs: Daniel González-Acuña.

in other wetlands (nest height = 3–11 cm, nest width = 3–7 cm, cup deep = 2.5–4.5 cm; Narosky & Salvador 1998, de la Peña 2005, Barrionuevo & Montes 2015, Reynoso *et al.* 2023).

Like in Laguna Santa Elena, the tyrants from oth-

er localities tie their nests mostly on rush stems (Housse 1945, Sick 1985, Canevari *et al.* 1991, Narosky & Salvador 1998, Kovacs *et al.* 2006, de la Peña 2013, Reynoso *et al.* 2023), and rarely on other substrate types (*e.g.*, bulrush, herbs; de la Peña 2013). Although the number of tall-rush

Table 7. Breeding success of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. Percentage of hatched eggs = (n° hatched eggs/ n° eggs laid) $\times$ 100. Percentage of fledged young following hatching = (n° fledglings/ n° hatched eggs) $\times$ 100. Percentage of fledged young following laying = (n° fledglings/ n° eggs laid) $\times$ 100. Nests success = (n° nests that fledged at least one fledgling/ n° nests monitored to know the fate of eggs and nestlings) $\times$ 100.

Season	% Hatched eggs	% Fledglings follow- ing hatching	% Fledglings follow- ing laying	Nests success
2005-2006	75.0 (27/36)	74.1 (20/27)	55.6 (20/36)	53.8 (7/13)
2006-2007	76.5 (39/51)	74.4 (29/39)	56.9 (29/51)	57.9 (11/19)
2007-2008	25.0 (6/24)	- ^a	- ^a	- ^a
2008-2009	64.0 (32/50)	87.5 (28/32)	56.0 (28/50)	57.9 (11/19)
Total	64.6 (104/161)	74.0 (77/104)	47.8 (77/161)	49.1 (29/59)

^a All nests failed due to flooding after heavy rain.

Table 8. Average hatching and fledging success per nest of Many-colored Rush-Tyrants (*Tachuris rubrigastra*) during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. Hatching success corresponds to a mean number of hatched eggs per nest according to nests monitored from the egg laying. Fledging success is the mean number of fledglings per nest according to nests monitored from egg hatching. n = number of nests monitored.

Season	Mean $\pm$ SD (range)			
	Hatched eggs per nest	n	Fledglings per nest	n
2005-2006	2.1 $\pm$ 1.4 (0-3)	13	2.2 $\pm$ 1.3 (0-3)	9
2006-2007	2.1 $\pm$ 1.2 (0-4)	19	1.9 $\pm$ 1.3 (0-3)	16
2007-2008	1.4 $\pm$ 0.8 (0-3)	8	- ^a	-
2008-2009	1.7 $\pm$ 1.4 (0-3)	19	2.3 $\pm$ 1.0 (0-3)	12
Total	1.9 $\pm$ 1.3 (0-4)	59	2.2 $\pm$ 1.2 (0-3)	37

^a All nests failed due to flooding after heavy rain.

Table 9. Nesting success of the Many-colored Rush-Tyrant (*Tachuris rubrigastra*) as estimated by the Mayfield method during four breeding seasons in Laguna Santa Elena, Ñuble province, south-central Chile. n = number of nests included in calculations.

Season	Incubation stage					Nestling stage					
	Daily nest loss rate	Daily survival probability for a nest	Survival probability for one nest during the entire stage	Nest-days	n	Daily nest loss rate	Daily survival probability for a nest	Survival probability for one nest during the entire stage	Nest-days	n	Nesting success during the entire breeding period
2005-2006	0.011	0.989 $\pm$ 0.011	0.839	92	7	0.031	0.969 $\pm$ 0.021	0.621	64	6	0.521
2006-2007	0.007	0.993 $\pm$ 0.007	0.895	145	15	0.031	0.969 $\pm$ 0.015	0.628	131	14	0.562
2007-2008	0.082	0.918 $\pm$ 0.035	0.255	61	7	- ^a	- ^a	- ^a	- ^a	- ^a	- ^a
2008-2009	0.029	0.971 $\pm$ 0.013	0.622	171	17	0.008	0.992 $\pm$ 0.008	0.888	127	12	0.552
Overall	0.026	0.974 $\pm$ 0.007	0.660	469	46	0.022	0.978 $\pm$ 0.008	0.719	322	32	0.475

^a All nests failed due to flooding after heavy rain.

stems supporting the nest tends to be variable within and among localities (some pairs use up to six stems; House 1945), most pairs tie their nests to only one stem (Nores & Yzurieta 1980, Rottmann 1995, Reynoso *et al.* 2023 this study). Possibly, that depends on the stem thickness,

as thicker stems are more resistant to gravity, wind, and water flow. Like other marsh-nesting passerine species (Burger 1985), the Many-colored Rush-Tyrant would attach its nest to more than one stem when one is not strong enough to support a nest. Microclimate factors (*e.g.*, wind,

rain, sun) and resistance of building material can strongly influence how passerines build their nests (Collias & Collias 1984, Bailey *et al.* 2014).

Previous reports indicate that Many-colored Rush-Tyrants locate nests at 30–165 cm above the water surface (Housse 1945, de la Peña 2013, Reynoso *et al.* 2023), which matches our results. Interestingly, the average height from the water surface of the nests measured by de la Peña (2013; mean = 47.8 ± 17.4 cm, mode = 40 cm; $n = 16$) is closely like ours. Thus, tyrants would prefer to build nests at an intermediate height from the water surface. That would simultaneously avoid immediate contact with water and diminish exposure to wind or aerial predators (Collias & Collias 1984, Burger 1985). The location of much of the nest near the tall-rush/open water borderline but distant from the shoreline could be related to mammalian anti-predation tactics (Burger 1985, Picman *et al.* 1988, 1993, 2002).

The proximity among the nests of Many-colored Rush-Tyrants indicates that this species may nest clumped, which implies a high territorial tolerance among nesting pairs after the courtship period. Interestingly, Many-colored Rush-Tyrant pairs were also tolerant toward nearby Wren-like Rushbird nesting pairs. In other wetlands, Many-colored Rush-Tyrants and Wren-like Rushbirds breed clumped within the densest vegetation bands (Burger 1985, Favretto *et al.* 2017, 2022). Similarly, in our study site, both species placed their nests where the tall-rush tended to be densest (Lara *et al.* 2011, this study). Possibly, this clumped nesting resulted from the microhabitat structure, food availability, nest defense, or a combination of them.

Perhaps the nest clumping in denser vegetation bands could provide immediate protection against sun, rain, wind, and predators (Burger 1985, Stewart 1999, Eastman 1999, Weller 1999, Picman *et al.* 2002). Another explanation is that denser vegetation bands had provided Many-colored Rush-Tyrants a high and renewed availability of insect prey (see discussion below). Often, marsh-grassland passerines forage primarily in patches of emergent vegetation (Brush *et al.* 1986, Pretelli *et al.* 2014). The clumped nesting could also eventually have social advantages, such as rapid warning about predators and mutual nest defense (Picman *et al.* 1988, 2002) or facilitate information transfer regarding productive foraging areas by following neighbors on foraging trips (Gori 1988).

Egg characteristics

The Many-colored Rush-Tyrant females laid white eggs that tended to be elliptical. That is something typical in passerine birds (Stoddard *et al.* 2017). The characteristics

of these eggs were like those eggs previously described by other authors (Nores & Yzurieta 1980, Canevari *et al.* 1991, de la Peña 1992, 2005, 2006, Narosky & Salvador 1998, Barrionuevo & Montes 2015, Reynoso *et al.* 2023). Unlike Narosky & Salvador (1998), we did not find eggs with brown spots towards the narrow pole (pointed end). That suggests that eggs in our study site were well calcified as eggshell pigmentation indicates calcium deficiency (Gosler *et al.* 2005).

According to our observations, the pinkish eggshells appear to be related to egg age, being that coloration is typical of eggs laid a few hours earlier. The conservative egg size over the four breeding seasons was likely due to temporally stable nutritional conditions (*e.g.*, invariable availability of food), similarity in physiological traits, or similarity in diet quality of the females (Christians 2002, Figuerola & Green 2005). The conservative egg size could also be a fixed life history trait within the studied population (Christians 2002, Figuerola & Green 2005).

Hatching asynchrony

Asynchronous hatching is usual among altricial birds (Clark & Wilson 1981, Magrath 1990, Stoleson & Beissinger 1995), and it is supposedly a parental strategy for matching offspring number with food availability (*i.e.*, brood-reduction hypothesis; Lack 1947). With asynchronous hatching, the last hatched nestling will be the smallest, and parents could sacrifice it when food availability is scarce. As far as we could observe in our study, none of the smaller nestlings was left to die. That is consistent with our visual perception that the abundance of insect prey was high during each breeding season. It will be necessary to wait for a decline in food availability to verify if Many-colored Rush-Tyrants reduce the number of offspring in such a situation.

Alternative explanations about the role of asynchronous hatching are that it favors earlier fledging of nestlings for increasing brood survival, decreases nestling predation, increases eggs viability, allows taking advantage of a food availability seasonally limited, or decreases the timing of hatching (Perrins 1965, Bryant 1975, Clark & Wilson 1981, Cooke *et al.* 1984, Arnold *et al.* 1987, Watson *et al.* 1993). Some of these hypotheses are relevant in the case of Many-colored Rush-Tyrant pairs, which strongly depend on the availability of ephemeral insects to feed nestlings.

Clutch size

The number of eggs laid by Many-colored Rush-Tyrants in Laguna Santa Elena was like that observed for this species in other wetlands (range = 1–4 eggs; de la Peña 2005, Barrionuevo & Montes 2015, Reynoso *et al.* 2023). How-

ever, in our study site, more than 70% of nesting pairs (43 out of 59) laid three eggs, resulting in a higher mean clutch size (2.7 ± 0.5 eggs [mean $\pm$ SD]) compared to pairs from other wetlands (de la Peña 2005: 2.4 eggs; Barrionuevo & Montes 2015: 2.4 ± 0.5 , Reynoso *et al.* 2023: 2.0 ± 0.0). Despite this geographical difference in the clutch size, it is clear enough that the clutch size of the Many-colored Rush-Tyrant typically ranges from 2 to 3 eggs, as happens with more than half of all bird species (Jetz *et al.* 2008). The mean clutch size of the Many-colored Rush-Tyrant in our study site was closely like that documented by Yom-Tov *et al.* (1994) for the Tyrannidae family in southern South America (2.69 ± 0.55 eggs). That corroborates that Deutero-Oscines passerines have clutch sizes smaller than Oscines passerines in that region (Yom-Tov *et al.* 1994).

Although multiple environmental factors influence the clutch size within bird populations (Wiebe *et al.* 2006, Ricklefs & Wikelski 2002), prevalent explanations are food limitation (Lack 1947, Ashmole 1963, Drent & Daan 1980) and predation risk (Slagsvold 1982, Martin 1993a, 1995, Eggers *et al.* 2006). Since predation upon tyrant nests in Laguna Santa Elena was minimal, we think a more probable reason for the constant clutch size was equitable food availability for the most pairs in each breeding season. According to Ashmole's hypothesis, there should be substantial uniformity of clutch size within a habitat patch since the seasonal productivity of food affects all birds within that habitat patch (Ashmole 1963). Lazo (1996) demonstrated that differential availability of food caused by differences in habitat characteristics influence the clutch size in some species of Chilean passerines.

Growth and feeding of the nestlings

As far as we know, there is minimal information about the growth of Many-colored Rush-Tyrant nestlings. Reynoso *et al.* (2023) measured nestlings at two days old, and their measurements coincided with ours for that age category. Like many altricial birds (Ricklefs 1968, Case 1978), the Many-colored Rush-Tyrant nestlings in our study site exhibited rapid growth, attaining the adult size within 15-17 days from hatching, just when their bodies were fully feathered. That suggests most nestlings left the nest when they were close to achieving the adult mass (7.6-8.8 g; Salvador 2014). Consistently, total and wing length markedly increased as body mass increased.

The insectivorous diet of nestling Many-colored Rush-Tyrants in our study site agrees with previous occasional observations from other localities where tyrant adults hunted insects and other invertebrates (Olrog 1984, Canevari *et al.* 1991, Rottmann 1995, de la Peña 2005, Favretto *et al.* 2022). The high proportion of flying insects captured by adult Many-colored Rush-Tyrants in Laguna

Santa Elena is striking because they are not specialist aerial hunters. Possibly, adult Many-colored Rush-Tyrants captured those prey insects while posing on the rush stems (e.g., dragonflies) and water surfaces (e.g., dipterans) or moving among vegetation.

The preeminence of dragonflies among the food offered to nestlings could be because these insects are generally plentiful in marshlands, and their large body size and striking coloration make them vulnerable prey. We did not measure the prey availability, but dragonflies were regular, active, and conspicuous insects within the tall-rush patch we studied. Moreover, compared to other insect taxa in our study area, the larger body size of dragonflies would give them a higher nutritional value. The high proportion of dragonflies in the nestling diet of other passerine species inhabiting South American wetlands (e.g., Wren-like Rushbirds, Spectacled Tyrant; Lara *et al.* 2011, Pretelli *et al.* 2014) reinforce such presumptions.

Even though Many-colored Rush-Tyrants and Wren-like Rushbirds co-nested in Laguna Santa Elena, the latter offered fewer dragonflies and dipterans (40% and 11.4% of all individuals prey, respectively) and many more spiders (20%) to chicks compared to the first one. Moreover, adult Wren-like Rushbirds fed their nestlings with earthworms (11%; Lara *et al.* 2011), a prey item we did not register in the case of the tyrants. That suggests that both species used the available prey resources differently. Unlike the Wren-like Rushbirds, adult tyrants seemingly did not look for prey on the ground.

Nest loss and breeding success

The negligible predation rate of Many-colored Rush-Tyrants nests we witnessed in our study site (1.5%) is striking as predation is one of the more determining factors of nest failure in marsh-dweller passerines (e.g., Martin 1993b, Pretelli & Isacch 2013, Chiaradia *et al.* 2017). Perhaps we underestimated the nest predation rate since those nests we considered lost by unknown causes suffered possibly predation. If so, the nest predation becomes relatively high (37.7% of all nests). A high predation of nests in our study site is feasible as there are several potential avian and mammalian predators. Among these are Chimango Caracaras (*Milvago chimango*), Cocoi Herons (*Ardea cocoi*), Great Egrets (*Ardea alba*), long-tailed rice rats (*Oligoryzomys longicaudatus*), domestic cats (*Felis catus*), and dogs (*Canis vulgaris*) (Lara *et al.* 2011).

Commonly, water overflow and the activity of other animal species can cause the loss of a few nests of passerine species that breed in wetlands (Burger 1985, Chiaradia *et al.* 2017). However, the impact of the flood in our study site was far beyond a few lost nests. Although the flooding occurred only at the start of the breeding sea-

son 2007-2008, it was enough to inhibit the Many-colored Rush-Tyrant's breeding activity during the rest of the season. Thus, when they occur, floods can have a negative impact superior to predation on the breeding success of marsh-dwelling passerines. The capacity of Many-colored Rush-Tyrants to successfully resume breeding activity during the following years after flood indicates this species can rapidly overcome catastrophic circumstances.

Considering nests combined, Many-colored Rush-Tyrants in Laguna Santa Elena exhibited a breeding success similar to co-nesting Wren-like Rushbird pairs (hatching success = 60%, fledgling success following laying = 46%; Lara *et al.* 2011). The breeding success of these two species in our study site was as high as that observed in Peruvian wetlands (Barrionuevo & Montes 2015, Reynoso *et al.* 2023). However, the breeding success of Many-colored Rush-Tyrants and Wren-like Rushbirds in Laguna Santa Elena considerably differs from those reported for some marsh-dweller passerine species in Argentinean wetlands. In marshlands of the Pampa region, Argentina, Chiaradia *et al.* (2017) found that fledgling success and nest success of Wren-like Rushbirds was only 29% (69 fledglings/235 eggs laid), and 14% (33 out 245 nests produced fledglings), respectively. In the same region, Pretelli & Isacch (2013) observed that the breeding success of Spectacled Tyrants was only 28% (15 out of 54 nests produced fledglings).

In our study site, the survival probability for one tyrant nest during the entire nesting period was also high compared with those of Wren-like Rushbirds and Spectacled Tyrants in some Argentinean wetlands. Pretelli & Isacch (2013) and Chiaradia *et al.* (2017) found the survival probability for one nest of these two species throughout the entire nesting period varied between 0.21 and 0.25. Thus, the values of nesting success of Many-colored Rush-Tyrants in Laguna Santa Elena are closer to those of several Nearctic passerine species that nest in marshes (Martin 1993b). As already discussed, local-specific factors could explain the variations observed in nesting success among passerine species breeds in wetlands (Chiaradia *et al.* 2017).

Advancing the natural history of the Many-colored Rush-Tyrant

Our study reveals remarkable aspects of the natural history and breeding biology of the Many-colored Rush-Tyrant, which have implications for conservation and management both at the species and habitat levels. First, many pairs nested in well-protected and densest vegetation bands using almost exclusively tall-rush to build their nest and fed nestlings mostly with aquatic insects. Such findings indicate that Many-colored Rush-Tyrants are

strongly habitat-dependent. Second, the clumped nesting of tyrant pairs reflects they are spatially tolerant of conspecific individuals. That fact merits much more attention as this could have social implications (*e.g.*, nest defense, information transfer). Third, the small clutch size of Many-colored Rush-Tyrants indicates that this species tends to be a K-type breeder (Yom-Tov *et al.* 1994). That implies its population will remain small among populations of passerine species with larger clutch sizes. Finally, Many-colored Rush-Tyrants recuperated their breeding success after suffering an almost total nest failure due to a catastrophic climate event. This capacity could be fundamental for an eventual population recovery.

Some limitations of our study (*e.g.*, not identifying adult tyrants by some marking method) prevented us from knowing much more about the breeding biology of the Many-colored Rush-Tyrant. Nevertheless, we hope our findings will allow ornithologists to understand more deeply the natural history and fundamental ecology of an eye-catching little-studied passerine.

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DIVERSIDAD DE PIOJOS MASTICADORES EN SIETE ESPECIES DE PATOS Y TRES ESPECIES DE GANSOS CHILENOS

Diversity of chewing lice in seven duck species and three geese species inhabiting Chile

DIEGO ALONSO¹, KAREN ARDILES VILLEGAS¹, SEBASTIÁN MUÑOZ-LEAL¹, PABLO OYARZÚN-RUIZ² & LUCILA MORENO SALAS³

¹Departamento de Ciencia Animal, Facultad de Ciencias Veterinarias, Universidad de Concepción, Chillán, Chile.

²Departamento de Patología y Medicina Preventiva, Facultad de Ciencias Veterinarias, Universidad de Concepción, Chillán, Chile.

³Departamento de Zoología, Facultad de Ciencias Naturales y Oceanográficas, Universidad de Concepción, Concepción, Chile.

Correspondencia: L. Moreno, lumoreno@udec.cl

ABSTRACT. – Anatids (ducks, geese) host a great lice diversity. However, there is scarce knowledge about the lice diversity in Chilean ducks, geese, and swans. Here, we describe the lice species parasitizing seven species of duck and three species of geese inhabiting Chile. Among all sampled anatid species, we found eight lice species. The Yellow-billed Pintail (*Anas georgica*) and Upland Goose (*Chloephaga picta*) hosted a higher richness of lice species ($n = 4$). The Blue-winged Teal (*Spatula discors*) and Chiloé Wigeon (*Mareca sibilatrix*) hosted only one species of louse each. The lice *Anaticola crassicornis* and *Trinoton querquedulae* parasitized the higher number of anatid species (six and five, respectively). The records of *Acidoproctus rostratus* and *Holomenopon leucoxanthum* are new for Chile. We identified sixteen new lice-anatid associations, eight of which are new worldwide. In addition, our findings allow us to extend the geographic distribution of five species of lice previously recorded in Chile.

INTRODUCCIÓN

Los piojos (Insecta: Phthiraptera) son ectoparásitos permanentes que mantienen una estrecha relación con su hospedador y dependen metabólicamente de éste. Eventualmente, los piojos pueden generar un efecto patógeno o una alteración hemostática e inmunológica en su hospedador (Rodríguez *et al.* 2009). El resultado de este proceso determinará el desarrollo de un rango amplio o reducido de hospedadores, lo que eventualmente puede conducir a diferencias en la especificidad de los piojos hacia sus hospedadores (Kolencik *et al.* 2022).

Los anátidos (*i.e.*, patos, gansos y cisnes) son hospedadores de una amplia diversidad de especies de piojos (Price *et al.* 2003). En general, los piojos de los anátidos se caracterizan por ser poco específicos, a diferencias de las especies de piojos que parasitan a otros grupos de aves (Escalante *et al.* 2016). El 83,3% de las especies de anátidos del mundo (125 de 150 especies) hospedan al menos

a una especie de piojo (Dickinson & Christidis 2014, Price *et al.* 2003). Aunque en Chile existe una riqueza alta de especies anátidas (30 especies; Vilina & Cofre 2018), solo cuatro especies han sido investigadas respecto de su fauna de piojos. Estas incluyen al pato jergón grande (*Anas georgica*), caiquén (*Chloephaga picta*), piuquén (*Chloephaga melanoptera*) y el cisne de cuello negro (*Cygnus melanocoryphus*) (González-Acuña *et al.* 2005, 2010, Hinojoza-Sáez *et al.* 2009). Además, existen descripciones de los piojos que parasitan al ganso doméstico (*Anser anser*; González-Acuña *et al.* 2009). En total, estas especies de anátidos hospedan a 11 especies de piojos (González-Acuña & Palma 2021).

Considerando que solo conocemos a los piojos de una pequeña fracción de las especies anátidas chilenas, es esperable que nuevas especies aparezcan dentro de este grupo de aves. Aquí documentamos la diversidad de piojos de varias especies de patos y gansos chilenos. Nuestro

objetivo fue ampliar el conocimiento de la fauna de piojos de los anátidos chilenos y, de ahí, complementar la información acerca de los ectoparásitos de la avifauna chilena. Nuestros hallazgos son esenciales para comprender mejor las relaciones entre las aves hospedadoras y sus ectoparásitos en condiciones silvestres.

MATERIALES Y MÉTODOS

Entre 2002 y 2020 recolectamos los piojos de 10 especies de anátidos chilenos, incluyendo siete especies de patos y tres especies de gansos. Las muestras de piojos las obtuvimos de especímenes mantenidos en museos, individuos en rehabilitación y de aves muertas durante la temporada de caza legal (Ley 19 473). Los individuos en rehabilita-

ción los obtuvimos del Centro de Rehabilitación de Fauna Silvestre de la Universidad de Concepción (CEREFAS-UdeC). Las aves cazadas provinieron desde distintas localidades dentro de las cuatro zonas biogeográficas del país: norte, centro, sur y austral (Fig. 1). Los especímenes de museo pertenecieron al Museo Nacional de Historia Natural de Santiago, Chile. La ventaja de las pieles almacenadas en museos para muestrear piojos es que estos, a diferencia de otros ectoparásitos, permanecen adheridos al hospedador después que este muere. Así las pieles de museo hacen posible el acceso a especies de piojos que pueden ser difíciles de muestrear en aves silvestres, particularmente si están en alguna categoría de protección (Mey 2003).

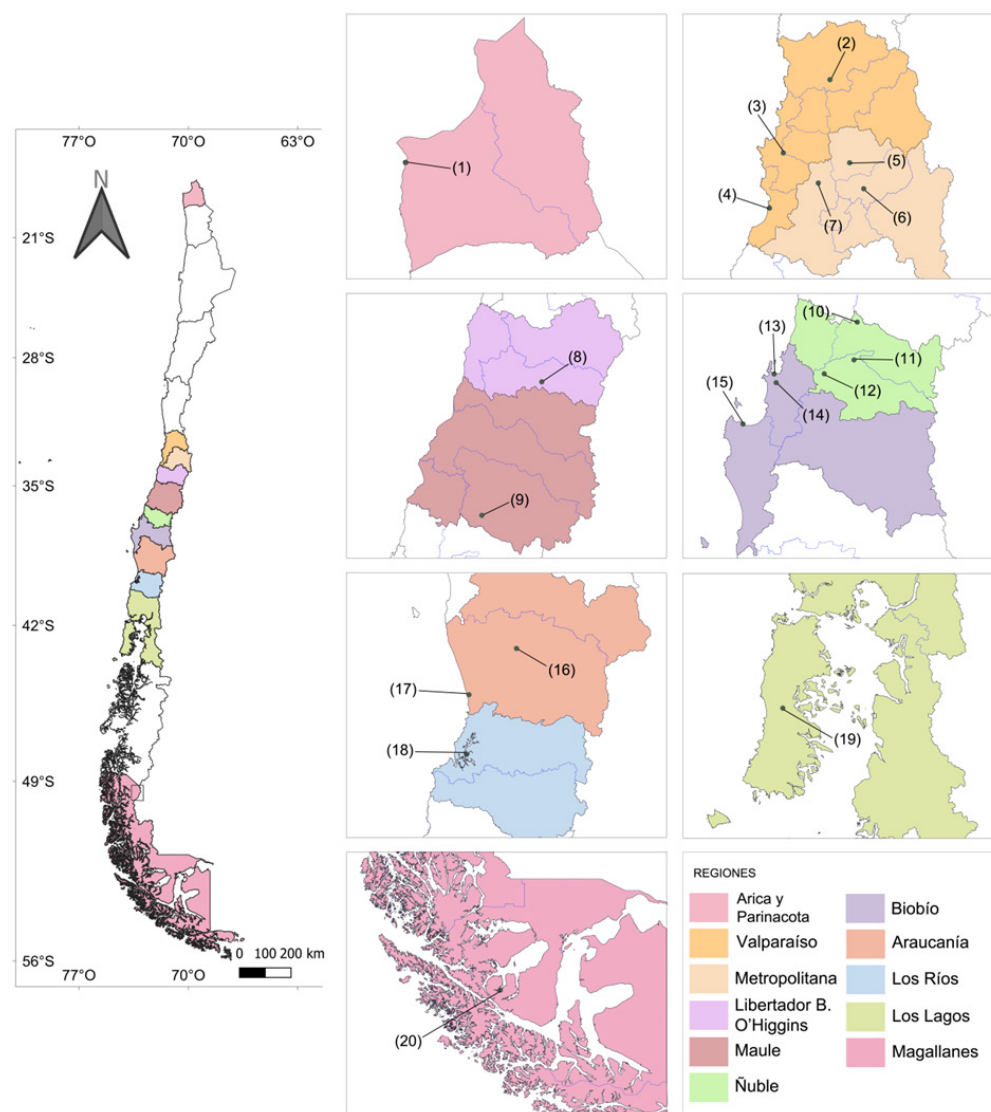


Figura 1. Localidades desde donde provinieron las muestras de patos y gansos nativos chilenos para determinar la diversidad de sus piojos masticadores. La recolección de piojos fue entre 2002 y 2020.. Leyenda: Arica (1), Región de Valparaíso (2), Reserva Nacional Lago Peñuelas (3), Lolleo (4), Batuco (5), Santiago (6), Curacavi (7), Chimbarongo (8), Parral (9), Ñiquén (10), Chillán (11), Quillón (12), Humedal Rocuant-Andalién (13), Concepción (14), Tubul (15), Temuco (16), Toltén (17), Valdivia (18), Chiloé (19), Región de Magallanes y de la Antártica Chilena (20).

Para recolectar piojos, colocamos a las aves sobre una superficie blanca y examinamos el plumaje de acuerdo con el siguiente orden: cabeza, alas, dorso, pecho y cola. Este procedimiento duró ≈ 35 min por cada ave. En el caso de los especímenes de museo, tuvimos mayor cuidado en la manipulación de las aves para no desprender plumas. Cuando encontramos algún piojo, lo extrajimos con pinzas entomológicas blandas para evitar dañar la muestra. Debido a que los piojos en pieles de museo están deshidratados son más frágiles que aquellos que están en aves vivas (Oyarzún-Ruiz & González-Acuña 2020).

Después de finalizar la recolección de piojos, preservamos separadamente la muestra de cada ave en microtubos de plástico que contenían etanol al 70%. Rotulamos cada tubo con la siguiente información del ave examinada: nombre científico, fecha de recolección, procedencia y código de identificación. Para identificar a las especies de piojos fue necesario montar a los especímenes de forma permanente y examinarlos bajo el microscopio. Iniciamos el proceso colocando los piojos en una placa Petri que contenía una solución de hidróxido de potasio (KOH) al 20%. Mantuvimos la muestra en esa solución durante un periodo de 15 a 35 horas dependiendo del tamaño y la esclerotización de cada piojo. Posteriormente, transferimos los piojos a otra placa Petri con agua destilada para detener la acción del KOH.

Concluida la fase anterior, teñimos las muestras utilizando fucsina carbólica, dejándolas en reposo durante 8 a 16 horas. Una vez completado este proceso, deshidratamos las muestras mediante soluciones de alcohol ascendentes (*i.e.*, 70%, 80%, 100%). Para aclarar a los especímenes, los sumergimos durante 24 horas en aceite de clavo dentro de una placa Petri. Finalmente, pusimos a cada espécimen sobre un portaobjeto, añadimos sobre ellos una a dos gotas de bálsamo de Canadá y los cubrimos con un cubreobjeto para su montaje definitivo (Zlotorzyska 1969, Palma 1978, Price *et al.* 2003).

Para la identificación morfológica utilizamos las claves y descripciones propuestas por Clay & Hopkins (1954), Von Kéler (1960), Price (1971), Cicchino & Castro (1998a, 1998b), Arnold (2006) y Naz *et al.* (2010). Los piojos montados fueron depositados en la colección de parásitos del Departamento de Ciencias Animal, Facultad de Ciencias Veterinarias, Universidad de Concepción. Las muestras llevan los siguientes códigos: UdeCPhAcy-1-12, UdeCPhAdi-1, UdeCPhAfl-1-12, UdeCPhAge-1-183, UdeCPhApl-1-10, UdeCPhAsi-1-6, UdeCPhCme-1-7, UdeCPhCpi-1-24, UdeCPhCpo-1-11, UdeCPhDvi-1-10.

RESULTADOS Y DISCUSIÓN

Entre las 10 especies de anátidos estudiadas, identificamos a ocho especies de piojos (Tabla 1). De éstas, cin-

co pertenecieron a la familia Philopteridae (Ischnocera), incluyendo a los géneros *Anaticola*, *Anatoecus* y *Acidoproctus*. Las especies restantes pertenecieron a la familia Menoponidae (Amblycera) y a los géneros *Trinoton* y *Holomenopon*.

El pato jergón grande y el caiquén hospedaron la mayor riqueza de piojos (cuatro especies en cada caso). En cambio, el pato de alas azules (*Spatula discors*) y el pato real (*Mareca sibilatrix*) hospedaron, en cada caso, una especie de piojo. Los piojos *Anaticola crassicornis* y *Trinoton querquedulae* parasitaron a un mayor número de especies de patos (seis y cinco especies, respectivamente; Tabla 1). El piojo *Anaticola marginellus* estuvo presente en el canquén (*Chloephaga poliocephala*), caiquén y piuquén. El piojo *Anatoecus icterodes* fue encontrado en el pato jergón grande, pato cuchara (*Spatula platalea*) y el caiquén. El piojo *Acidoproctus rostratus* fue aislado desde el pato jergón grande y del pato rana de pico delgado (*Dendrocygna viduata*). Los piojos *Anatoecus dentatus* y *Holomenopon leucoxanthum* fueron exclusivos del caiquén y pato rana de pico delgado, respectivamente. Cinco especies de piojos fueron registrados en localidades que no están dentro de su distribución conocida. Dos especies de piojos, *A. rostratus* y *H. leucoxanthum*, constituyen registros nuevos dentro de Chile.

El género *Anaticola* tiene 35 especies, las cuales parasitan cerca de 80 especies de la familia Anatidae y otras cuatro especies que parasitan a la familia Phoenicopteridae (Price *et al.* 2003). En Chile, el género *Anaticola* parasita a varias especies de anátidos silvestres y domésticos y al flamenco chileno (*Phoenicopus chilensis*; González-Acuña *et al.* 2005, 2009, Hinojosa-Sáez *et al.* 2009). Price *et al.* (2003) indican que *A. crassicornis* parasita a 26 especies de anátidos a escala mundial. En Chile, esta especie de piojo fue encontrado previamente por Hinojosa-Sáez *et al.* (2009) en el pato jergón grande en las regiones del Maule, Ñuble y Biobío. Nuestro estudio reveló que el pato real, pato colorado (*Spatula cyanoptera*) y el pato jergón chico (*Anas flavirostris*) también hospedan a *A. crassicornis* dentro de Chile. Nuestros resultados nos permiten añadir dos nuevos hospedadores a escala mundial de *A. crassicornis*: el pato cuchara y el pato rana de pico delgado. Además, aumentamos los registros de *A. crassicornis* a ocho nuevas localidades, de las seis descritas previamente en Chile (ver Fig. 1, Tabla 1).

Nuestro hallazgo por primera vez de *A. marginellus* en el canquén significa que esta última especie es un nuevo hospedador de esa especie de piojo en Chile. Otros investigadores ya habían registrado a *A. marginellus* en el caiquén en la región de Magallanes (González-Acuña *et al.* 2005), en el cauquén común malvinero (*Chloephaga picta leucoptera*) en las islas Malvinas (citado como Islas

Tabla 1. Especies de piojos recolectadas en 10 especies de anátidos chilenos entre 2002 y 2020. Las aves revisadas provinieron de distintas localidades y correspondieron a especímenes de museo, individuos en rehabilitación y a aves cazadas legalmente.

Hospedador	N° de individuos	Localidades (N° de aves analizadas)	Especie de piojo	N° de aves positivas	N° de piojos recolectados por ave
Pato jergón chico (<i>Anas flavirostris</i>)	6	Chimbarongo (1), Santiago (1), Humedal Rocuant-Andalién (1), Batuco (1), Toltén (1), no especificado (1)	<i>Anaticola crassicornis</i>	2	6
			<i>Trinoton querquedulae</i>	4	5
Pato jergón grande (<i>Anas georgica</i>)	16	RN Lago Peñuelas (1), región de Valparaíso (2), no especificado (1), Batuco (1), Curacaví (1), Parral (3), Quillón (1), Ñiquén (1), Chillán (2), Tubul (1), Valdivia (2)	<i>Acidoproctus rostratus</i>	1	6
			<i>Anaticola crassicornis</i>	7	100
			<i>Anatoecus icterodes</i>	6	27
			<i>Trinoton querquedulae</i>	9	36
Piuquén (<i>Chloephaga melanoptera</i>)	2	Batuco (2)	<i>Anaticola marginellus</i>	2	3
			<i>Holomenopon brevithoracicum</i>	¿?	2
Caiquén (<i>Chloephaga picta picta</i>)	1	Región de Magallanes y de la Antártica Chilena (1)	<i>Anaticola marginellus</i>	1	7
			<i>Anatoecus dentatus</i>	1	2
			<i>Anatoecus icterodes</i>	1	1
			<i>Holomenopon brevithoracicum</i>	1	1
Canquén (<i>Chloephaga poliocephala</i>)	4	No especificada (4)	<i>Anaticola marginellus</i>	2	4
			<i>Holomenopon brevithoracicum</i>	2	4
Pato rana de pico delgado (<i>Dendrocygna viduata</i>)	2	Parral (2)	<i>Acidoproctus rostratus</i>	1	4
			<i>Anaticola crassicornis</i>	1	2
			<i>Holomenopon leucoxanthum</i>	1	4
Pato real (<i>Mareca sibilatrix</i>)	2	Chillán (1), Tubul (1)	<i>Anaticola crassicornis</i>	2	6
Pato colorado (<i>Spatula cyanoptera</i>)	5	Arica (1), Lolleo (1), Tubul (1), Toltén (1), Chiloé (1)	<i>Anaticola crassicornis</i>	3	7
			<i>Trinoton querquedulae</i>	3	4
Pato de alas azules (<i>Spatula discors</i>)	1	Concepción (1)	<i>Trinoton querquedulae</i>	1	1
Pato cuchara (<i>Spatula platalea</i>)	2	Temuco (1), Tubul (1)	<i>Anaticola crassicornis</i>	1	7
			<i>Anatoecus icterodes</i>	2	2
			<i>Trinoton querquedulae</i>	1	1

Falkland por Price *et al.* 2003) y en el piuquén en Perú (Shchedrina *et al.* 2017).

El género *Anatoecus* agrupa a 26 especies, las cuales parasitan a anátidos y flamencos (Price *et al.* 2003). El piojo *Anatoecus icterodes* es común en anátidos y parasita a 69 especies en el mundo (Price *et al.* 2003). En Chile, ya existían registros de esta especie de piojo en el pato jergón grande en las regiones de Valparaíso, Metropolitana, del Maule, del Biobío y del Ñuble (Hinojosa-Sáez *et al.* 2009). *Anatoecus icterodes* también está presente en caiques de la región de Magallanes (González-Acuña *et al.* 2005) y en cisnes de cuello negro (*Cygnus melanocoryphus*) de la región del Biobío y del Ñuble (González-Acuña *et al.* 2010). Nuestros hallazgos amplían la distribución de esta especie de piojo hacia las regiones de los Ríos y Araucanía. Además, especímenes de *A. icterodes* fueron encontrados en el pato cuchara, el cual constituye un nuevo hospedador anátido en Chile y el mundo.

Por otra parte, el piojo *Anatoecus dentatus* fue aislado únicamente de caiques provenientes de la región de Magallanes, la misma región donde González-Acuña *et al.* (2005) ya lo habían encontrado. El piojo *A. dentatus* presenta baja especificidad, parasitando a 66 especies de anátidos a escala mundial (Price *et al.* 2003). Sin embargo, en Chile no hay registros en otras especies.

Hasta ahora, hay descritas 12 especies de piojo del género *Acidoproctus* las cuales parasitan a 18 especies de anátidos a nivel mundial (Price *et al.* 2003, Arnold 2006). Nuestro registro del piojo *A. rostratus* corresponde al primero en Chile. Los hospedadores de esta especie de piojo fueron el pato rana de pico delgado y el pato jergón grande. El primero representa un nuevo hospedador dentro de Chile y segundo un nuevo hospedador a escala mundial.

El género *Trinoton* agrupa a 19 especies de piojos que parasitan a anátidos y flamencos (Cicchino & Castro 1998a). *Trinoton querquedulae* parasita a 68 especies de anátidos alrededor del mundo (Price *et al.* 2003, Palma & Peck 2013, Knee & Galloway 2017). En Chile hay registros de dos especies de este género: *T. querquedulae* en el pato jergón grande (Hinojosa-Sáez *et al.* 2009) y *T. anserinum* en el pato doméstico (González-Acuña *et al.* 2009). Con nuestros registros añadimos al pato colorado, pato de alas azules y pato jergón chico como nuevos hospedadores de *T. querquedulae* dentro de Chile. El hallazgo de *T. querquedulae* en el pato cuchara añade una nueva asociación hospedado-parásito en Chile y el mundo. Respecto de la distribución geográfica de *T. querquedulae*, añadimos nueve localidades dentro de Chile.

Los piojos de género *Holomenopon* parasitan a 18 especies de anátidos (Cicchino & Castro 1998a). En Chile existen registros de dos especies de este género: *Holomenopon brevithoracicum* en el caiquén y el cisne de cuello

negro (González-Acuña *et al.* 2005, González-Acuña *et al.* 2010) y *H. tadornae* en el piuquén (Eichler 1954). Durante nuestro estudio encontramos otras dos especies hospedadoras de *H. brevithoracicum*: el canquén y piuquén. Además, hallamos una tercera especie *Holomenopon* en el pato rana de pico delgado: *H. leucoxanthum*. Con este hallazgo añadimos un nuevo hospedador para esta especie de piojo en Chile.

Resumiendo, durante nuestro estudio identificamos a ocho especies de piojos en anátidos silvestres de Chile. De éstas, dos correspondieron a nuevos registros para Chile: *A. rostratus* y *H. leucoxanthum*. Ocho especies de anátidos ahora son nuevos hospedadores para siete especies de piojos. Encontramos 16 nuevas asociaciones entre piojos y anátidos. De estas, ocho son nuevas a escala mundial. También ampliamos la distribución geográfica de cinco especies de piojos registradas previamente en Chile: *A. crasicornis*, *A. marginelus*, *A. icterodes*, *T. querquedulae* y *H. brevithoracicum*.

Los hallazgos de nuevas especies y asociaciones entre piojos y anátidos en Chile contribuye al conocimiento global de la biología y distribución de estos organismos. Además, ofrece oportunidades para investigaciones más detalladas sobre las relaciones ecológicas y la coevolución entre hospedadores y parásitos. La ampliación de la distribución geográfica de varias especies de piojos sugiere la necesidad de considerar factores ambientales y geográficos en estudios futuros. La información obtenida puede ser valiosa para el monitoreo de la salud de las poblaciones de aves silvestres y la implementación de estrategias de conservación.

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RIQUEZA DE AVES DE LA RESERVA NASAMPULLI, REGIÓN DE LA ARAUCANÍA, SUR DE CHILE

Bird richness of Nasampulli Reserve, Araucanía region, southern Chile

GABRIELA CONTRERAS¹, CARLOS CASTRO-PASTENE², SEBASTIÁN MUÑOZ-LEAL² & OSCAR SKEWES²

¹La Escala 1375, Chillán, Ñuble.

²Departamento de Ciencia Animal, Universidad de Concepción, Chillán, Ñuble.

Correspondencia: Oscar Skewes, oskewes@udec.cl

ABSTRACT. - The Nasampulli Reserve is a private protected wildlife area in the Andean foothills (1000-1700 m a.s.l.) of the Araucanía region, southern Chile. This reserve is covered mainly by *Nothofagus-Araucaria* forests. Between 2011 and 2013, we conducted seasonal surveys within the reserve to evaluate the bird richness. We registered all species sighted or heard along pre-established routes. We detected forty species, with passerine species being the most frequent. Notably, we recorded understory-dependent species such as the Chucao Tapaculo (*Scelorchilus rubecula*), Magellanic Tapaculo (*Scytalopus magellanicus*), Patagonian Sierra-Finch (*Phrygilus patagonicus*), and Black-throated Huet-huet (*Pterotochos tarnii*) even with snow widely covering the vegetation during winter. The presence of endangered bird species such as the Chilean Hawk (*Accipiter chilensis*), Rufous-tailed Hawk (*Buteo ventralis*), Rufous-legged Owl (*Strix rufipes*), and Magellanic Woodpecker (*Campephilus magellanicus*) renders the Nasampulli Reserve a hot spot for conservation purposes.

INTRODUCCIÓN

El aumento y expansión de la población humana en muchos casos, disminuye la disponibilidad y calidad de los entornos naturales para la vida silvestre (Smith & Smith 2001). Además, la expansión de las plantaciones forestales de especies exóticas (e.g., pino insigne [*Pinus radiata*], eucaliptos [*Eucaliptus globulus*]) con fines comerciales, ha reducido significativamente la distribución de la vegetación nativa y la fauna asociada (Donoso & Lara 1996, Simonetti 1999). En el centro y sur de Chile, la pérdida histórica de los bosques nativos y su reemplazo por plantaciones comerciales de pino y eucaliptos condujo a una disminución considerable de la población de varias especies endémicas.

En Chile, el Sistema Nacional de Áreas Silvestres Protegidas del Estado (SNASPE), que incluye parques y reservas, es insuficiente para conservar la biota nativa (Simonetti 1999). Ante esta situación, algunas organizaciones no gubernamentales crearon la red de Áreas Silvestres Protegidas Privadas (ASPP) para complementar el esfuerzo del Estado chileno en la conservación de biodiversidad.

Un ejemplo es el “Santuario de la Naturaleza Los Huemules de Niblinto” creado por el Comité de Defensa de la Flora y la Fauna (CODEFF). Este santuario fue creado específicamente para la conservación del huemul (*Hippocamelus bisulcus*), un ciervo nativo en peligro de extinción. El Santuario los Huemules del Niblinto también alberga una alta riqueza de reptiles, aves y mamíferos (9, 63 y 15 especies, respectivamente; Figueroa *et al.* 2000a, 2000b) incluyendo varias especies con prioridad de conservación. Esto demuestra que ciertas áreas protegidas privadas llegan a ser reservorios relevantes de fauna silvestre. Así, el primer paso para conocer el valor efectivo que posee un área silvestre protegida es determinar el número de especies presente en ella (Mella & Simonetti 1994).

Aquí documentados los resultados de un estudio sobre la diversidad de aves en la Reserva Nasampulli, un área protegida privada creada para preservar el bosque de araucarias (*Araucaria araucana*). Los objetivos de nuestro estudio fueron determinar la riqueza de especies de aves dentro de la reserva y detectar especies con prioridad de conservación de acuerdo con la normativa chilena vi-

gente. Nuestro estudio no solo permite determinar el valor biológico de la reserva Nasampulli, sino también contar con información útil en el establecimiento eventual de un corredor biológico para la avifauna andina.

MATERIALES Y MÉTODOS

Área de estudio

La Reserva Nasampulli es un área protegida privada de 1263 ha que está en la precordillera andina de la región de la Araucanía, a 12 km del cráter del volcán Solipulli (38°58'13,99"S, 71°30'55,99"O; 1000-1700 m s.n.m.) (Fig. 1). La vegetación dentro de la reserva es mayormente boscosa y está conformada por los tipos forestales araucaria, coigüe (*Nothofagus dombeyi*) y lenga (*Nothofagus pumilio*) (Cruz & Lara 2010). El clima en el área es templado lluvioso con una temperatura media anual de

6,8°C, un nivel de precipitación anual de 2500 mm y con un periodo seco de uno o más meses. Actualmente, no hay personas habitando permanentemente en el interior de la reserva. La Reserva Nasampulli es gestionada por la Fundación Centro de los Bosques Nativos FORECOS y Rainforest Concern desde el año 2003.

Métodos de registro de aves

Para determinar la composición y riqueza de aves dentro de la reserva, entre 2011 y 2013 recorrimos siete senderos de uso permanente (Fig. 1). A lo largo de cada sendero, listamos a todas las aves observadas o escuchadas, sin estimar su abundancia. Los hábitats en los senderos prospectados incluyeron bosque y cuerpos de agua (esteros y lagunas).

A lo largo de los tres años de estudio, registramos

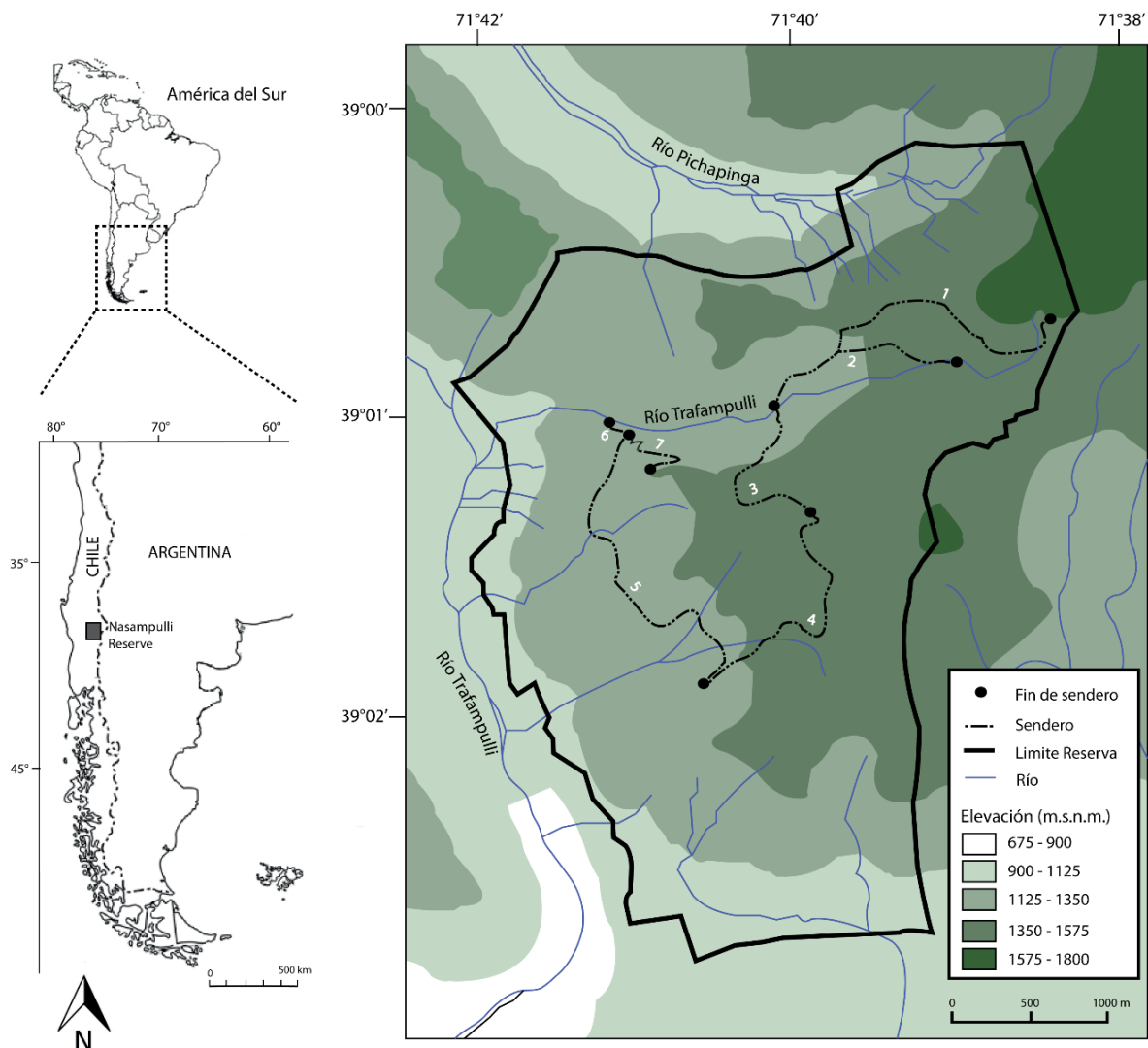


Figura 1. Ubicación geográfica de la Reserva Nasampulli. Los números blancos indican los senderos recorridos para el registro de aves: 1. Laguna Trafampulli; 2. Altos Río; 3. Lagunillas; 4. Los Jabalíes; 5. Los Pudúes; 6. Cascada del Taique; 7. Hogar del Puma.

la riqueza de aves en todas las estaciones climáticas. Sin embargo, los muestreos estacionales variaron entre años. Los dos primeros años solo pudimos visitar la reserva en dos estaciones y el último año solo en tres estaciones, y el número de senderos recorridos varió entre estaciones (Tabla 1). El esfuerzo de muestreo fue de 205 horas de observación, correspondientes a 11 excursiones de 3 a 7 días por estación climática.

Durante nuestras observaciones usamos binoculares con aumento de 8 x 42 x 50 (Bushnell®, Legend 8x42). Para identificar mejor a las aves avistadas nos apoyamos en las láminas disponibles en las guías de campo de Jaramillo (2005), Barros *et al.* (2015), Couvé *et al.* (2016) y Martínez & González (2017).

RESULTADOS Y DISCUSIÓN

Durante nuestro estudio registramos 40 especies de aves (Tabla 2). El orden Passeriformes fue el más representado con 18 especies (43% del total de especies). Esto concuerda con lo observado en otras áreas boscosas protegidas en el centro-sur de Chile. Figueroa *et al.* (2000) encontraron que de las 63 especies registradas en el Santuario Los Huemules de Niblinto, el 47,6% fueron del orden Passeriformes. En el Parque Nacional Conguillío, cercano a la Reserva Nasampulli, el 41% de las especies de aves son aves paserinas (28 de 64 especies; González & Contreras 2005).

La única especie exótica observada en la reserva fue la codorniz californiana (*Callipepla californica*). Un individuo de esta especie apareció entre los registros fotográfico de cámaras autónomas usadas para otros estudios. No incluimos a esta especie en la Tabla 2.

Mientras registrábamos aves en los hábitats boscosos, observamos a cuatro especies propias del sotobosque. Estos fueron el chucao (*Scelorchilus rubecula*), churrín del sur (*Scytalopus magellanicus*),

hued-hued del sur (*Pterotochos tarnii*) y el colilargo (*Sylviothorhynchus desmursii*). Estas especies fueron visibles en todas las estaciones climáticas, incluso durante los periodos con acumulación de nieve. Durante nuestras excursiones invernales, observamos a estos rinocriptidos sobre la nieve que cubrió el sotobosque. El sotobosque fue reconocible porque algunas especies arbustivas tales como la chaura (*Gaultheria mucronata*) y *Berberis* spp., eran visibles entre la nieve que no superaba el metro de profundidad.

Nuestras observaciones contrastan con lo documentado por Ibarra *et al.* (2010), quienes no registraron aves en zonas de sotobosque cuando la nieve sobrepasaba 1 m de profundidad. En los sitios nevados, estos autores solo observaron aves asociadas a árboles grandes del dosel (e.g., pitío [*Colaptes pitius*] y carpintero negro [*Campephilus magellanicus*]), y supusieron que la nieve limita la disponibilidad de alimento para las aves que usan el sotobosque (Becerra & Gricera 2005, Altamirano *et al.* 2012). Es posible que la menor cantidad de nieve acumulada en nuestro sitio de estudio (< 1 m) haya permitido cierta disponibilidad de alimento y refugio para las aves propias del sotobosque.

Entre las especies dependientes del bosque, registramos cuatro especies de aves rapaces: el peuquito (*Accipiter chilensis*), aguilucho chico (*Buteo albigula*), aguilucho de cola rojiza (*Buteo ventralis*) y concón (*Strix rufipes*). Su presencia resalta la relevancia ecológica de la Reserva Nasampulli como un área destinada a la conservación de especies amenazadas. Las cuatro especies registradas son dependientes fuertemente de bosques maduros, requieren de territorios extensos, tienen una baja tasa reproductiva y sus tamaños poblacionales estarían disminuyendo (Figueroa *et al.* 2004a, Trejo *et al.* 2006, Rivas-Fuenzalida *et al.* 2011, Rivas-Fuenzalida 2015, Rivas-Fuenzalida & Figueroa 2019). Además, el nivel de

Tabla 1. Senderos recorridos para determinar la riqueza de aves entre 2011 y 2013 en la Reserva Nasampulli, región de la Araucanía, sur de Chile.

Sendero	Año/Estación climática						
	2011		2012		2013		
	Verano	Invierno	Verano	Otoño	Invierno	Primavera	Verano
Laguna Trafanpulli	x		x	x		x	x
Altos Río	x		x	x		x	x
Lagunillas	x	x	x	x	x	x	x
Los Jabalíes	x	x	x	x	x	x	x
Los Pudúes	x	x	x	x	x	x	x
Hogar del Puma	x		x	x			x
Cascada del Taique	x		x				x

Tabla 2. Especies de aves detectadas entre 2011 y 2013 en la Reserva Nasampulli, región de la Araucanía, sur de Chile.

Especie	Estaciones Climáticas			
	Verano	Otoño	Invierno	Primavera
Anseriformes				
Anátidos				
Pato jergón grande (<i>Anas georgica</i>)	x	-	-	-
Caiquén (<i>Chloephaga picta</i>)	x	-	-	-
Pelecaniformes				
Tresquiornítidos				
Bandurria (<i>Theristicus melanopis</i>)	x	x	-	x
Accipitriformes				
Accipítridos				
Aguilucho chico (<i>Buteo albigula</i>)	x	-	-	-
Aguilucho cola rojiza (<i>Buteo ventralis</i>)	x	-	-	-
Aguilucho común (<i>Geranoaetus polyosoma</i>)	x	x	-	x
Peuco (<i>Parabuteo unicinctus</i>)	x	-	-	-
Peuquito (<i>Accipiter chilensis</i>)	x	-	-	-
Catártidos				
Cóndor (<i>Vultur gryphus</i>)	x	-	-	-
Jote de cabeza negra (<i>Coragyps atratus</i>)	x	x	-	x
Falconiformes				
Falcónidos				
Traro (<i>Caracara plancus</i>)	x	x	-	x
Tiuque (<i>Milvago chimango</i>)	x	-	-	-
Columbiformes				
Colúmbidos				
Torcaza (<i>Patagioenas araucana</i>)	x	x	-	x
Psittaciformes				
Psitácidos				
Cachaña (<i>Enicognathus ferrugineus</i>)	x	x	-	x
Choroy (<i>Enicognathus leptorhynchus</i>)	x	x	-	x
Strigiformes				
Strígidos				
Chuncho (<i>Glaucidium nana</i>)	-	x	-	-
Concón (<i>Strix rufipes</i>)	x	x	-	-
Titónidos				
Lechuza (<i>Tyto alba</i>)	-	x	-	-
Apodiformes				
Troquilidos				
Picaflor (<i>Sephanoides sephaniodes</i>)	x	-	-	-
Piciformes				
Pícidos				
Carpintero (<i>Campephilus magellanicus</i>)	x	x	x	x
Pitio (<i>Colaptes pitius</i>)	x	x	x	x
Carpinterito (<i>Dryobates lignarius</i>)	x	x	x	x
Passeriformes				
Furnáridos				
Rayadito (<i>Aphrastura spinicauda</i>)	x	x	x	x
Churrete acanelado (<i>Cinclodes fuscus</i>)	x	-	-	-
Churrete (<i>Cinclodes patagonicus</i>)	x	-	-	-

Comesebo (<i>Pygarrhichas albogularis</i>)	x	-	-	-
Colilarga (<i>Sylviorthorhynchus desmursii</i>)	x	-	-	-
Rinocriptidos				
Hued hued del sur (<i>Pteroptochos tarnii</i>)	x	x	x	x
Chucazo (<i>Scelorchilus rubecula</i>)	x	x	x	x
Churrín del sur (<i>Scytalopus magellanicus</i>)	x	x	x	x
Tiránidos				
Viudita (<i>Colorhamphus parvirostris</i>)	x	-	-	x
Fio-fio (<i>Elaenia albiceps</i>)	x			
Diucón (<i>Pyrope pyrope</i>)	x	x	-	x
Hirundínidos				
Golondrina Chilena (<i>Tachycineta leucopyga</i>)	x	x	-	x
Troglodítidos				
Chercán (<i>Troglodytes aedon</i>)	x	x	-	x
Túrdidos				
Zorzal (<i>Turdus falcklandii</i>)	x	x	x	x
Traúpidos				
Diuca (<i>Diuca diuca</i>)	x	x	-	x
Emberízidos				
Cometocino patagónico (<i>Phrygilus patagonicus</i>)	x	x	x	x
Ictéridos				
Tordo (<i>Curaeus curaeus</i>)	x	x	-	x
Fringílidos				
Jilguero (<i>Spinus barbatus</i>)	x	x		x

conocimiento sobre la historia natural y ecología de estas cuatro especies es aún precario (Raimilla *et al.* 2012).

Otras especies que registramos en todas las estaciones del año fueron el carpintero negro, carpinterito (*Dryobates lignarius*) y pitío. Mikusinski *et al.* (2001) y Virkkala (2006), señalan que la susceptibilidad que poseen las aves carpinteros a los cambios en sus hábitats las hace indicadoras de la calidad estructural del hábitat y, de ahí, buenos indicadores de la diversidad avifaunística. En particular, el carpintero negro es considerado una especie “paraguas” debido al extenso ámbito de hogar que requiere para mantener su viabilidad poblacional (Saavedra *et al.* 2011). De esta manera, al proteger áreas boscosas con la presencia del carpintero negro también resulta en la protección de comunidades bióticas completas (Arango *et al.* 2007, Espinoza *et al.* 2016).

La alta riqueza de aves en la Reserva Nasampulli indica que ésta contiene una alta disponibilidad de alimento, refugio y de sustratos de nidificación. Lo anterior resultaría de la alta diversidad y calidad estructural del bosque al interior de la reserva. Dados nuestros resultados, la Reserva Nasampulli pasa a ser relevante en la conservación de la avifauna nativa tanto en un contexto local como en un contexto regional. La planificación de los futuros estudios acerca de la avifauna en la reserva, deberán incluir la determinación de la abundancia de cada

especie y su asociación con el hábitat. Tal conocimiento nos permitirá profundizar acerca del valor de conservación de la Reserva Nasampulli.

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EUROPEAN RABBITS AND PETRELS AS THE STAPLE PREY OF THE SHORT-EARED OWL (*ASIO FLAMMEUS*) IN THE JUAN FERNÁNDEZ ARCHIPELAGO OFF THE COAST OF CHILE

Los conejos europeos y petreles como las presas principales del nuco (*Asio flammeus*) en el archipiélago de Juan Fernández, Chile insular

DANIEL GONZÁLEZ-ACUÑA^{1,†}, KAREN ARDILES¹, EMA SORAYA CORALES² & RICARDO A. FIGUEROA³

¹Facultad de Ciencias Veterinarias, Universidad de Concepción, Casilla 537, Chillán, Chile.

²Investigador independiente.

³Unión de Ornitólogos de Chile, Valdivia, Chile.

Correspondencia: Ricardo A. Figueroa, ra_figueroa_rojas@yahoo.com

Resumen. El nuco (*Asio flammeus*) es un depredador tope en el ecosistema terrestre del archipiélago de Juan Fernández, pero su dieta es escasamente conocida allí. Durante marzo de 2005 recolectamos 19 regurgitados de nuco en un pastizal de la isla Robinson Crusoe. El análisis de los regurgitados reveló que los nucus depredaron sobre conejos europeos (*Oryctolagus cuniculus*), petreles (*Pterodroma* spp.), lauchas domésticas (*Mus domesticus*) e insectos. Los conejos europeos y petreles constituyeron casi el 60,9% y 20,7% del total de las ocurrencias de presas en los regurgitados, respectivamente. Nuestros hallazgos coincidieron con los de un estudio realizado 14 años antes, lo cual sugiere que los nucus tienen un fuerte vínculo trófico con conejos y petreles. Es posible que el patrón que detectamos haya resultado de una disponibilidad estable de esos taxones presa combinada con una especialización trófica del nuco sobre ellos. Ya que los petreles son numerosos en el archipiélago de Juan Fernández, estos podrían convertirse en un recurso trófico primario de los nucus ante una erradicación completa de los conejos.

INTRODUCTION

Knowing what top predators feed on is essential to understanding how they adapt to and persist in island ecosystems invaded by allochthonous prey species (e.g., Polis *et al.* 1997). The Short-eared Owl (*Asio flammeus*) is a top predator widely distributed throughout the world. This species mainly occupies terrains with low vegetation (e.g., grassland, tundra, marsh, moorland, and savanna) across large continental regions and on oceanic islands (Holt *et al.* 1999, König & Weick 2008, Wiggins *et al.* 2020). Short-eared Owls prey primarily on small mammals and secondarily on birds and insects (Clark 1975, Holt *et al.* 1999, Wiggins *et al.* 2020). However, the amount in which these owls consume those prey may depend on the local and seasonal prey availability (Clark 1975, Page & Whiteacre 1975, Martínez *et al.* 1998).

In Chile, the Short-eared Owl inhabits a large part of the national territory, including oceanic islands (Araya & Millie 1986, Figueroa *et al.* 2017). As in other regions, in Chile it preys heavily upon small mammals, consuming variable numbers of birds depending on the season (Martínez *et al.* 1998). This diet pattern is even observable in the Juan Fernández Archipelago. Fuentes *et al.* (1993) found that in this archipelago, almost 80% of the prey of the Short-eared Owl were mammals, with the European Rabbit (*Oryctolagus cuniculus*) accounting for 61% of the diet by frequency. Marine birds were the second most consumed prey. Later, Figueroa *et al.* (2017) provided a rough approximation of the prey spectrum of this owl species in that archipelago, including unpublished data.

Here, we provide a further analysis to assess whether there is persistence in the prey composition in

the diet of the Short-eared Owl in the Juan Fernandez Archipelago. If the dietary pattern has remained over time, our results should mirror those previously documented by Fuentes *et al.* (1993).

MATERIALS AND METHODS

Study Area

The Juan Fernández Archipelago is in the Pacific Ocean (33°38'29"S, 78°50'28"W) at almost 590 km off Valparaíso on the coast of Chile. This archipelago is composed of three volcanic islands: Robinson Crusoe (47.11 km²), Santa Clara (2.23 km²), and Alejandro Selkirk (44.64 km²). The climate in these islands is subtropical maritime with high humidity (73-79%). Temperatures and precipitation range from 4.2 to 28.8°C and 24.1 to 180.1 mm, respectively (Dirección Meteorológica de Chile). Rainfall decreases during spring and summer.

The Juan Fernández Archipelago supports a unique biota with high endemism of terrestrial plants and animals resulting from its long-term biogeographical isolation (Schlatter 1987, Stuessy *et al.* 1991, Hahn *et al.* 2006). Because of its ecological uniqueness, the archipelago is in the National System of State Protected Areas (SNASPE) and is part of the World Network of Biosphere Reserves (Campos *et al.* 2009). In addition, Birdlife International declared the archipelago as an Endemic Bird Area (Statfield *et al.* 1998). Despite this, the native biota has suffered successively the predatory impact of several species of invasive allochthonous animals brought by settlers to the archipelago. These species include goats (*Capra hircus*), coatis (*Nassua nassua*), rats (*Rattus* spp.), mice (*Mus domesticus*), domestic cats (*Felis catus*), and European rabbits (Hahn *et al.* 2006, Campos *et al.* 2009).

Methods

In December 2005, we collected 19 pellets of Short-eared Owls within grassland patches between Puerto Francés and Rebaje de la Piña on Robinson Crusoe Island. We were sure the pellets were from Short-eared Owls because we found them scattered on the ground where we observed these owls hunting and perching. In addition, pellet shape, size, and texture matched those previously described for the species (see Holt *et al.* 1987).

We dissected pellets using the dry method as in Holt *et al.* (1987). Before analyzing pellets, these remained at the laboratory's room temperature until they were sufficiently dry to remove the anatomical pieces more cleanly. We identified mammalian prey by skull, mandibles, teeth, and hair features. Avian prey were identifiable only by feathers. In this case, we used two complementary methods: microscopic analysis of feather structures (Reyes 1992, Rau & Martínez 2004), and a comparison of feather

coloration and shape patterns with reference collections. Insect prey were recognizable by elytra, head capsules, or feet.

Because all pellets with avian prey contained only feathers, we could not be sure if they belonged to only one or more individuals. Therefore, we quantified the importance of prey by tallying the frequency of their occurrence in pellets as follows: number of occurrences of each prey taxon divided by the total number of occurrences of all prey taxa, expressed as a percentage. Although Fuentes *et al.* (1993) did not clearly explain how they quantified prey importance, we assumed they used the same method.

RESULTS

The Short-eared Owl pellets collected contained remains from house mice, rabbits, petrels, and beetles. Mammalian prey accounted for almost 70% of the prey occurrences in the pellets, with European rabbits being the most frequent prey (Table 1). Petrels (*Pterodroma* spp.), the only avian prey taxon in the pellets, were secondary in occurrence (Table 1). House mice and beetles occurred in a low frequency (< 10%).

DISCUSSION

Our analysis revealed that Short-eared Owls in the Juan Fernández Archipelago feed primarily on European rabbits and secondarily on petrels. The incidence level of these prey was similar to that reported by Fuentes *et al.* (1993). However, we found two extra prey taxa: house mice and beetles. In terms of prey classes consumed, the diet in the Juan Fernandez Archipelago is similar to those in continental areas of southern South America (Rau *et al.* 1992, Martínez *et al.* 1998, Cirignoli *et al.* 2001, Baladrón *et al.* 2014, Torres *et al.* 2014). Our analysis also confirmed the Short-eared Owl in Chile is a predator specialized on vertebrates, birds and mammals being the basis of its diet (Figuerola *et al.* 2017, Cadena-Ortiz *et al.* 2019).

Although there are similarities between the diets from the archipelago and continental Chile, there is also an evident difference. In the archipelago, native rodents are absent, and Short-eared Owls have become dependent on the introduced European rabbit. Even though allochthonous rodents (*Mus*, *Rattus*) are also present in the archipelago, the owls consume them in low or nil proportions (Fuentes *et al.* 1993, this study). A higher abundance and biomass possibly make European rabbits a more profitable prey for Short-eared Owls. Conversely, up to date, there is no evidence that these owls consume lagomorphs in continental Chile (Rau *et al.* 1992, Martínez *et al.* 1998, Escobar *et al.* 2005), even though the European rabbit and European hare (*Lepus europaeus*) are abundant. Perhaps because native rodents are relatively more abundant in

Table 1. Diet of Short-eared Owl (*Asio flammeus*) determined by analysis of pellets collected in the Juan Fernández Archipelago off the coast of Chile. Collection dates: this study, in March 2005, Fuentes *et al.* (1993), from November 1988 to April 1991. FO (frequency of occurrence) = number of occurrences of each prey taxon divided by the total number of occurrences of all prey taxa, expressed as a percentage.

Prey taxa	This study FO% (N)	Fuentes <i>et al.</i> (1993) FO% (N)	Overall FO% (N)
Mammals			
House Mouse (<i>Mus domesticus</i>)	8.7 (2)	0.0	3.9 (2)
European Rabbit (<i>Oryctolagus cuniculus</i>)	60.9 (14) ^a	60.7 (17)	60.8 (31)
Unidentified mammals	0.0	21.4 (6)	11.8 (6)
Birds			
Petrels (<i>Pterodroma</i> spp.)	21.7 (5)	17.9 (5)	19.6 (10)
Insects			
Beetles (Scarabaeidae)	8.7 (2)	0.0	3.9 (2)
Total occurrences	23	28	51
Total pellets	19	20	39

^aAll mandibles and molars retrieved were from juvenile individuals.

the continental areas (Martínez *et al.* 1998, Cirignoli *et al.* 2001, Torres *et al.* 2014), Short-eared Owls may not be as trophically dependent on lagomorphs, as on the island.

Both the study by Fuentes *et al.* (1993) and ours show that the occurrence of avian prey in the Short-eared Owl diet in the Juan Fernández Archipelago is about 20%. This proportion is higher than in the diet of continental conspecifics. A seasonal study based on large numbers of pellets revealed that the numerical proportion of birds in the Short-eared Owl's diet ranged from 2% to 12% throughout the year (Martínez *et al.* 1998). Other more time-limited studies or studies based on small samples also showed a low proportion, or even absence, of birds in the diet of Short-eared Owls (Rau *et al.* 1992, Cirignoli *et al.* 2001, Baladrón *et al.* 2014, Torres *et al.* 2014, Formoso & Esmoris 2023).

The high similarity between our results and those of Fuentes *et al.* (1992) suggests that dietary patterns of the Short-eared Owls in the Juan Fernandez archipelago have remained constant over time. This could result from a stable availability of European rabbits and petrels combined with a local specialization of the Short-eared Owl on both prey taxa. The importance of rabbits as a primary prey of Short-eared Owls in the archipelago is consistent with the hypothesis that introduced medium-sized prey (e.g., lagomorphs) can substantially modify the original structure of local food webs (Barbar *et al.* 2016). Before humans introduced rabbits and rodents to the Juan Fernández Archipelago, Short-eared Owls may have been trophically dependent on colonial marine birds, particularly petrels. If rabbits were eliminated from the archipelago, perhaps then Short-eared Owls would return to prey heavily on

that avian prey, reestablishing an ancestral predator-prey relationship. Alternatively, they could increase predation on introduced mice and rats.

Fuentes *et al.* (1992) raised the possibility that rabbit eradication from the island could lead to a paradoxical situation. They argued that as the petrels already suffered attacks from introduced predators (coatis, cats), higher predation by Short-eared Owls could further reduce the petrel population. In turn, the owls could suffer a population decline as one of their staple prey becomes scarcer. Similarly, Barbar *et al.* (2016) warned that when lagomorphs become a staple prey for native predators, the extirpation of the former could have disastrous consequences in local food webs. Notwithstanding, after the eradication of rabbits from Santa Clara Island and Robinson Crusoe Island (Camus *et al.* 2008), there is no evidence of a substantial decrease in the local petrel populations (Carboneras *et al.* 2020, Medrano *et al.* 2023). Indeed, the Juan Fernández Petrel (*Pterodroma externa*) population reaches almost 3 million individuals (Carboneras *et al.* 2020). In addition, the Short-eared Owl population appears to be naturally small in the archipelago. Hahn *et al.* (2006) estimated only < 50 individuals spread across Robinson Crusoe Island and Santa Clara Island. Therefore, petrels could still be an abundant food resource to sustain the Short-eared Owl population in the Juan Fernández Archipelago.

Even though our evidence came from a small sample, it has allowed us to hypothesize the eventual ecological changes discussed above. In this regard, we propose that the success of current rabbit and rat eradication programs in Robinson Crusoe Island should gauge the effect

on the diet of native top predators. That would also help to understand how broad is the “marine-food flank” of the Short-eared Owl in the Juan Fernández Archipelago.

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Motmotnirmus danielalfonsoi* n. sp., A NEW SPECIES OF CHEWING LOUSE FROM A TURQUOISE-BROWED MOTMOT (*Eumomota superciliosa*), WITH NOTES ON *Motmotnirmus guatemalensis

Motmotnirmus danielalfonsoi* n. sp., una nueva especie de piojo masticador encontrado en el momoto de ceja azul (*Eumomota superciliosa*), con notas sobre *Motmotnirmus guatemalensis

DANIEL R. GUSTAFSSON¹ & SARAH E. BUSH²

¹Guangdong Key Laboratory of Animal Conservation and Resource Utilization, Guangdong Public Laboratory of Wild Animal Conservation and Utilization, Institute of Zoology, Guangdong Academy of Sciences, 105 Xingang West Road, Haizhu District, Guangzhou, 510260, Guangdong Province, China.

²School of Biological Sciences, University of Utah, 257 S. 1400 E., Salt Lake City, Utah 84112, U.S.A.

Correspondence: Daniel Roland Gustafsson, kotatsu@fripost.org

RESUMEN. - We describe a new species of chewing louse, *Motmotnirmus danielalfonsoi* n. sp., from the Turquoise-Browed Motmot (*Eumomota superciliosa*). It differs from congeneric species in several characters, including the head shape, the abdominal chaetotaxy of the male, and in the characters of the male genitalia. Females differ from congeneric species primarily in the head shape and the shape and size of abdominal plates. Additionally, we suggest that the true host of *Motmotnirmus guatemalensis* is the Lesson's Momot (*Momotus lessonii*), which is also a new host record. Such suggestion is based on examinations of museum specimens of lice from various motmot species. We also provide a key to the species of *Motmotnirmus* and an updated checklist of the genus *Motmotnirmus*.

INTRODUCTION

The motmot group comprises thirteen species in six genera, of which all are endemic to the Neotropics (Clements *et al.* 2019). Only two genera of chewing lice are known to parasitize motmots: *Clayiella* Eichler 1940 and *Motmotnirmus* Mey & Barker 2014. Mey & Barker (2014) erected *Motmotnirmus* and placed four species in this genus. Both these genera are part of the suborder Ischnocera, and within that suborder, *Motmotnirmus* is one of over 30 genera in the *Brueelia* complex (Gustafsson & Bush 2017). Genetic and morphological evidence support that relationship (Bush *et al.* 2016, Gustafsson & Bush 2017). Within this complex, *Motmotnirmus* is distinguishable by having marginal temporal setae 2-3 (*mts*2-3) as macrosetae, and both sexes lack sternal plates II-VI. Here, we describe a fifth species within this genus, *Motmotnirmus danielalfonsoi* n. sp. In addition, we clarify the status of *Motmotnirmus guatemalensis* (Dalglish 1971) by suggesting that the natural host is Lesson's Motmot (*Momotus lessonii*).

MATERIAL AND METHODS

All lice specimens examined for this study were slide-mounted and deposited in the 80s by an unknown donor at the Natural History Museum, London (NHML). We measured specimens by using a Nikon Eclipse E600 microscope fitted with an Olympus DP25 camera and digital measuring software (ImageJ 1.48v, Wayne Rasband). To illustrate specimens, we drew them by hand, using a drawing tube fitted to the same microscope. Line drawings were scanned, collated, and edited in GIMP (www.gimp.org).

Terminology for abdominal chaetotaxy follows Gustafsson & Bush (2017). All measurements are in millimeters (mm) and include total length (along midline including hyaline margin), head length (along midline including hyaline margin), head width (at temples), prothoracic width, pterothoracic width, and abdominal width (at segment V). Host taxonomy follows Clements *et al.* (2019). To avoid confusion, we abbreviated *Motmotnirmus* as *Mot.* and *Momotus* as *Mom.*

We officially registered the nomenclatural acts for *Mot. danielalfonsoi* in ZooBank, the online registration system for the International Code of Zoological Nomenclature (ICZN). The ZooBank LSID (Life Science Identifier) is: urn:lsid:zoobank.org:pub:0A46A47B-4AB7-4199-88B9-89F63C368DCC.

RESULTS

Description

Motmotnirmus Mey & Barker 2014

Motmotnirmus Mey & Barker 2014: 94.

Type species. *Nirmus marginellus* Nitzsch (in Giebel), 1866: 368, by original designation.

Motmotnirmus danielalfonsoi n. sp.

(Fig. 1 and 2).

Type host. *Eumomota superciliosa australis* Bangs, 1906 – Turquoise-browed Motmot (English) or momoto cejiazul (Spanish).

Type locality. Copal, Guanacaste, Costa Rica.

ZooBank LSID: urn:lsid:zoobank.org:act:E6C0E1E2-BBC6-4919-A9B7-17BA8C94A555

Type material. Holotype ♂, Copal, Guanacaste, Costa Rica, 9 Mar. 1986, M.A. Marin, 433, 23553 on reverse (Natural History Museum, London, NHML). Paratypes: 4♂, 6♀, same data as holotype, 23552, 23554–6, 23989–94 on reverse (NHML).

Etymology. The species epithet is in honor of our late colleague Daniel Alfonso González-Acuña (Universidad de Concepción, Chillán, Chile) (1963–2020), in recognition of his long and detailed work with the chewing louse fauna of Chile and nearby regions, culminating in the posthumously published checklist of chewing lice of Chile (González-Acuña & Palma 2021). His death was a significant loss for chewing louse research throughout South America.

Diagnosis. *Motmotnirmus danielalfonsoi* n. sp. is quite different from other species in the genus. It differs from all other described species of *Motmotnirmus* in the following characters (cf. Dalgleish 1971, Oniki & Emerson 1982, Valim & Cicchino 2015, Mey & Barker 2014, Gustafsson & Bush 2017): pre-antennal head more slender, lateral margins straighter, and frons slenderer (Fig. 2A); ventral section of tergopleurites slender in *Mot. danielalfonsoi* (Fig. 1A–B) but wide in all other species; pre-spir-

acular ridges absent in *Mot. danielalfonsoi*, but present on at least some tergopleurites in all other species.

Motmotnirmus danielalfonsoi is most like *Mot. marginellus*, with which it shares the following characters: proximal mesosome rounded not indented (Fig. 2C), and tergal posterior setae absent from male tergopleurite VI and female tergopleurite VII (Fig. 1A–B). These two species can be distinguished by the characters listed above. In addition, *Mot. danielalfonsoi* and *Mot. marginellus* can be distinguished by the following characters: mesosome slender and oblong in *Mot. marginellus*, but rounded trapezoidal in *Mot. danielalfonsoi* (Fig. 2C); female sub-genital plates differ in shape (Fig. 2E); pre-antennal nodi slenderer in *Mot. danielalfonsoi* (Fig. 2A) than in *Mot. marginellus*; no macrosetae present in setal rows of male tergopleurites VIII–XI+X in *Mot. danielalfonsoi* (Fig. 1A), but two macrosetae present on each tergopleurite in *Mot. marginellus*; posterolateral corner of tergopleurites II–III of both sexes overlapping next segment in *Mot. danielalfonsoi* (Fig. 1A–B), but not in *Mot. marginellus*.

Description. Both sexes. Head triangular, with rounded temples and slightly indented frons (Fig. 2A); lateral margins of pre-antennal head straight. Marginal carina with irregular median margin interrupted submedianly and displaced posteriorly at frons. Hyaline margin long, connected laterally to narrow dorsal pre-antennal suture that reaches aperture of the *dorsal submarginal setae*. The pre-antennal nodi is slender. Head chaetotaxy is as in Figure 2A. Posterolateral corners of tergopleurites II–III extended posteriorly into small triangles overlapping the next tergopleurite.

Male. Thoracic and abdominal structure and chaetotaxy as in Figure 1A; no *tergal posterior setae* on tergopleurite VI. The subgenital plate is roughly oval. Basal apodeme roughly rectangular, slightly constricted at mid-length, distal margin much indented (Fig. 2B). Mesosome as in Figure 2C; proximal end broad, rounded trapezoidal; gonopore wide, posterodistal margins slightly serrated; 1 seta on each side distal to gonopore; distal margin of mesosome highly rugose. Parameres, as in Figure 2D. Measurements (n = 5): total length = 1.69–1.87 mm; head length = 0.47–0.51 mm; head width = 0.47–0.51 mm; prothoracic width = 0.27–0.36 mm; pterothoracic width = 0.41–0.46 mm; abdominal width = 0.57–0.62 mm.

Female. Thoracic and abdominal structure and chaetotaxy as in Figure 2; no *tergal posterior setae* on tergopleurite VII. The subgenital plate is short and broad (Fig. 2E). Vulval margin gently rounded (Fig. 2E), *vulval marginal setae* not visible, maybe sensilla, 2–4 short, thorn-like *vulval submarginal setae* on each side; 6–9

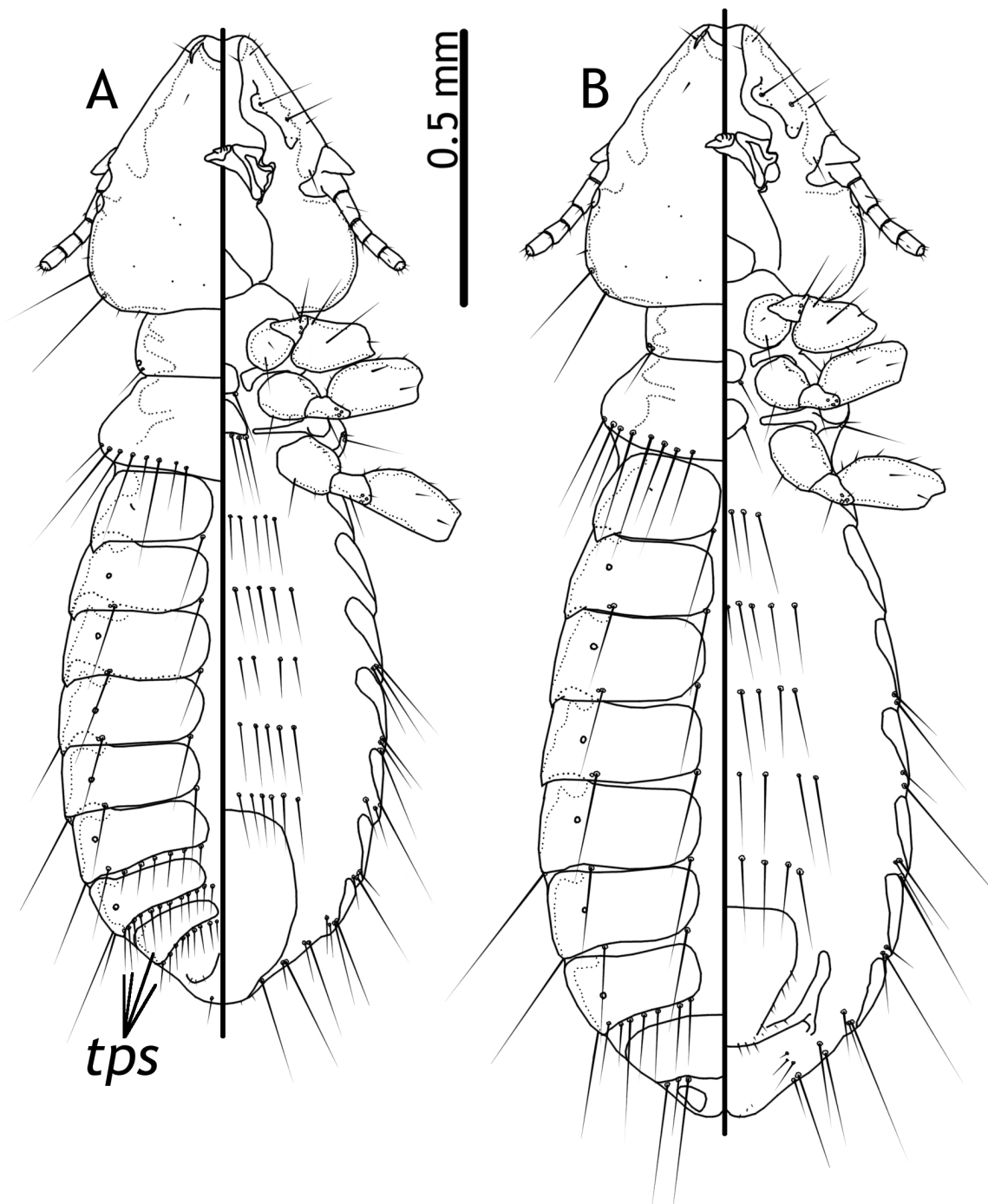


Figure 1. *Motmotnirmus danielalfonsoi* n. sp. ex Turquoise-browed Motmot (*Eumomota superciliosa*). A. Male habitus, dorsal and ventral views. B. Female habitus, dorsal and ventral views. Anatomical structure: tps = tergal posterior setae.

long, slender *vulval oblique setae* follow lateral margins of the subgenital plate on each side, with distal 1-3 *vulval oblique setae* located median to *vulval submarginal setae*. Measurements (n = 6): total length = 1.96-2.16 mm; head length = 0.50-0.55 mm; head width = 0.49-0.53 mm; prothoracic width = 0.30-0.38 mm; pterothoracic width = 0.43-0.50 mm; abdominal width = 0.61-0.68 mm.

***Motmotnirmus guatemalensis* (Dalglish 1971)**

Brueelia guatemalensis Dalglish 1971: 140.

Motmotnirmus guatemalensis (Dalglish 1971); Mey & Barker 2014: 98.

Type host. *Campephilus guatemalensis* (Hartlaub, 1844)
 – Pale-billed Woodpecker (English) or carpintero pico

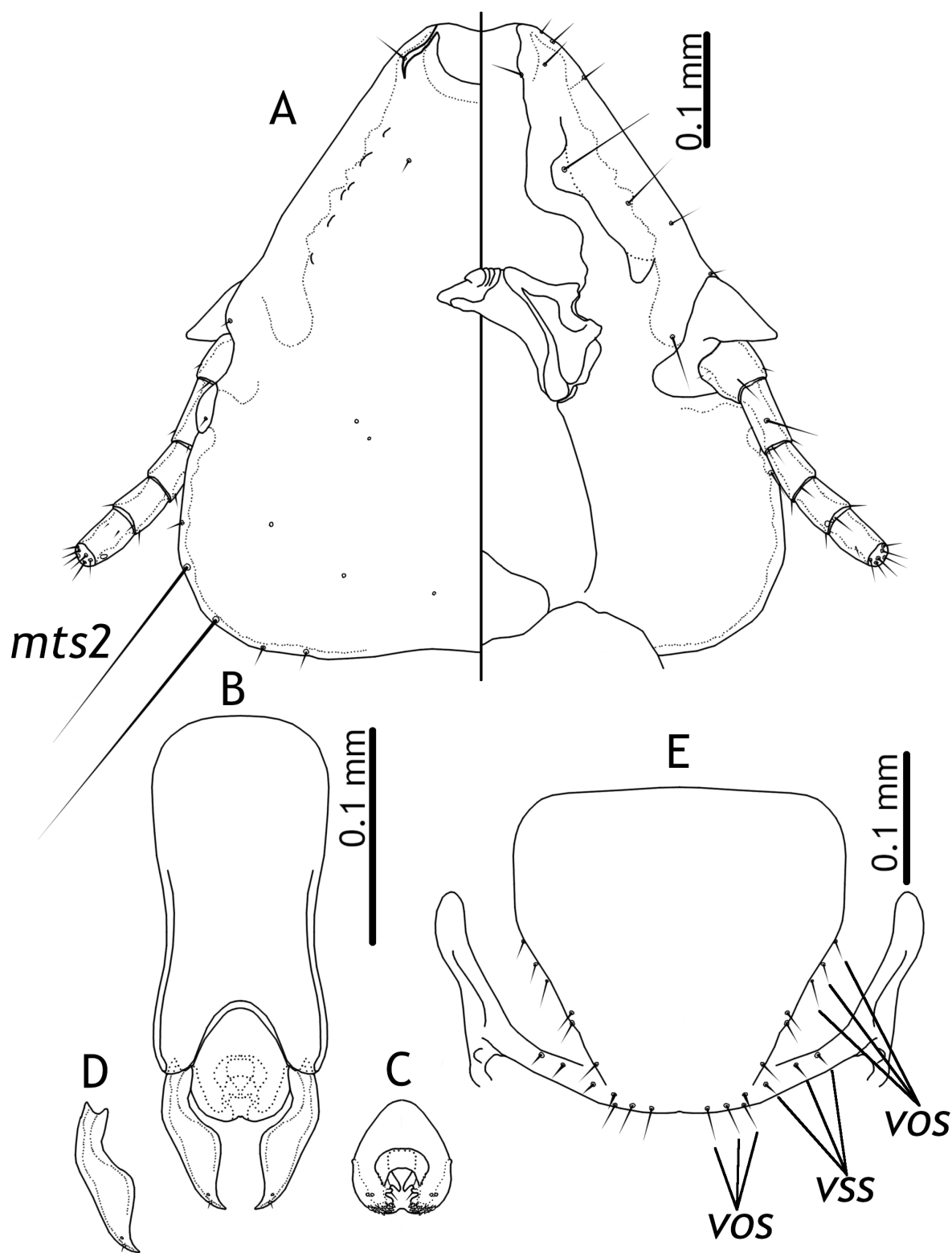


Figure 2. *Motmotnirmus danielalfonsoi* n. sp., ex Turquoise-browed Motmot (*Eumomota superciliosa*). A. Male head, dorsal and ventral views. B. Male genitalia, dorsal view. C. Male mesosome, ventral view. D. Male paramere, dorsal view. E. Female subgenital plate and vulval margin, ventral view. Anatomical structures: *mts2* = *marginal temporal seta 2*; *vos* = *vulval oblique setae*; *vss* = *vulval submarginal setae*. Note that the *vulval oblique setae* form two separate sets in this species.

plateado (Spanish).

New host. *Momotus lessonii* Lesson, 1842 – Lesson's Motmot (English) or momoto diademado (Spanish).

Type material. *Holotype* ♂, Santa Clara, Chiriquí Province, Panama, 15 Feb. 1956, G. Hartman, Brit. Mus. 1956-449 (NHML). *Allotype* ♀, same data as holotype (NHML). Additional material examined (non-types). Ex *Momotus coeruliceps lessonii*: 23♂, 34♀, Panama, R. Meinertzhagen, 13468 (NHML) [one slide also contains an unidentified *Picicola* female].

Remarks. *Motmotnirmus guatemalensis* is the only species in the genus known from a woodpecker. Mey & Barker (2014) suspected that the host record of *Mot. guatemalensis* is likely the result of straggling, and they questioned the validity this species. These authors suggested that it may be a synonym of *Motmotnirmus marginellus* (Nitzsch [in Giebel] 1874). They based this synonymization on the female genitalia of *Mot. guatemalensis*, which are like those of *Mot. marginellus*. However, several non-genital characters contradict this synonymization. Males of *Mot. marginellus* do not have *tergal posterior setae* on tergopleurite VI, and female *Mot. marginellus* do not have *tergal posterior setae* on tergopleurite VII. Conversely, *Mot. guatemalensis* have *tergal posterior setae* on both these segments. In the specimens we have examined, there are no other significant differences between the type series of *Mot. guatemalensis* and the series from *Mom. c. lessonii*, indicating that the two sets of specimens are conspecific.

Supposing that the type locality of *Mot. guatemalensis* is correct, the natural host of this species is most likely a species that occurs in western Panama. Three motmot species occur in or near Chiriquí Province: Broad-billed Motmot (*Electron platyrhynchum minus*), Tody

Motmot (*Hylomanes momotula obscurus*) and Lesson's Motmot (Vallely & Dyer 2018, Clements *et al.* 2019). Up to now, no louse specimens have been reported from the first two host species. However, as specimens of *Motmotnirmus* from *Mom. lessonii* are indistinguishable from the type specimens of *Mot. guatemalensis*, we suggest that this may be a natural host of *Mot. guatemalensis*. More collections of lice from Central American motmots and woodpeckers are necessary to establish whether this louse species occurs naturally on other hosts.

Key to the species of *Motmotnirmus*

Based on current knowledge, females of *Motmotnirmus humphreyi* (Oniki & Emerson 1982) and *Mot. marginellus* cannot be reliably separated. The status of *Motmotnirmus xilitla* is not clear (see Oniki & Emerson 1982, Gustafsson & Bush 2017).

1. Lateral margins of pre-antennal head straight, pre-antennal nodi slender (Fig. 2A) ... *Motmotnirmus danielalfonsoi* new species.
- Lateral margins of pre-antennal head convex, pre-antennal nodi wide ... 2.
2. Row of *tergal posterior setae* on tergopleurite VI (male) or tergopleurite VII (female) ... *Motmotnirmus guatemalensis* (Dalglish 1971).
- No *tergal posterior setae* on tergopleurite VI (male) or tergopleurite VII (female) ... 3.
3. Pre-antennal nodi with distinctly narrowed anterior "neck" ... *Motmotnirmus xilitla* (Carriker 1954).
- Pre-antennal nodi with broad anterior section ... 4.
4. Male proximal mesosome with bilobed anterior margin

Table 1. Checklist of the louse species of the genus *Motmotnirmus* Mey & Barker 2014 and their avian hosts.

Louse	Host
<i>Motmotnirmus danielalfonsoi</i> Gustafsson & Bush, new species	Turquoise-browed Motmot, momoto cejazul (<i>Eumomota superciliosa</i>)
<i>Motmotnirmus guatemalensis</i> (Dalglish 1971)	Pale-billed Woodpecker, carpintero pico plateado (<i>Campephilus guatemalensis</i>) ^a Lesson's Motmot, momoto diademado (<i>Momotus lessonii</i>)
<i>Motmotnirmus humphreyi</i> (Oniki & Emerson 1982)	Rufous-capped Motmot, momoto yeruvá oriental (<i>Baryphthengus ruficapillus</i>)
<i>Motmotnirmus marginellus</i> (Nitzsch [in Giebel] 1866)	Andean Motmot, momoto serrano (<i>Momotus aequatorialis chlorolaemus</i>) Amazonian Motmot, momoto común (<i>Momotus momota momota</i> , <i>Momotus momota natteri</i>) Amazonia Motmot (<i>Momotus momota natteri</i>) Whooping Motmot, momoto rojizo (<i>Momotus subrufescens subrufescens</i> , <i>Momotus subrufescens spatula</i>)
<i>Motmotnirmus xilitla</i> (Carriker 1954) ^b	Blue-capped Motmot, momoto capiazul (<i>Momotus coeruliceps</i>)

^a The records from *C. guatemalensis* are presumably based on stragglers, contaminations, or misattributions, but that needs verification.

^b It is unclear whether *Mot. xilitla* can be reliably separated from *Mot. marginellus*.

.... *Motmotnirmus humphreyi* (Oniki & Emerson 1982).
 - Mesosome with rounded anterior margin ... *Motmotnirmus marginellus* (Nitzsch [in Giebel] 1866).

DISCUSSION

With the description of *Motmotnirmus danielalfonsoi*, we now know lice in this genus are present on three of the six genera of motmots (Table 1). To date, there are no descriptions of any species of *Motmotnirmus* from the host of the genera *Hylomanes*, *Electron*, or *Aspatha*. Species of *Motmotnirmus* from different host genera are remarkably homogeneous morphologically, suggesting that the genus has radiated recently. However, three of the five known species of *Motmotnirmus* occur on host species of the *Momotus* genus, which are also morphologically homogeneous (Stiles 2009). The morphological similarity and close relationship between these motmot host species may indicate that selective pressures do not differ significantly between host species, which may restrain morphological variation in the lice. Alternatively, the perceived lack of morphological diversity within the genus *Motmotnirmus* may be an artifact of sampling bias. As more species and individuals of motmots are available for lice sampling, a clearer picture of the morphological variation within *Motmotnirmus* may emerge.

Several morphological characters separate *Motmotnirmus* from all other lice in the *Brueelia*-complex. Among these characters are the lack of sternal plates, the shape of the dorsal pre-antennal suture, the structure and chaetotaxy of the female subgenital plate, the abdominal chaetotaxy of both sexes, and that *marginal temporal seta* 2 is a macroseta (Gustafsson & Bush 2017). There are no other genera of lice that are morphologically similar. Valim & Cicchino (2015) once considered *Bobdalgleishia* from jacamars a close relative of these lice, but this hypothesis was later rejected in a morphological revision by Gustafsson & Bush (2017). Genetic data suggest that the closest relatives of *Motmotnirmus* are present in Old World bee-eaters and some Madagascan endemic cuckoos (Bush *et al.* 2016).

In a curious parallel, the only other ischnoceran lice genus known from motmots is *Clayiella*. This genus is limited to motmots and the distantly related Madagascan endemic Cuckoo-roller (*Leptosomus discolor*; Mey 2004). *Clayiella* is morphologically closest to *Vinceopteris* from Asian trogons (Gustafsson *et al.* 2019). These relationships are peculiar. While bee-eaters are widely distributed across the Old World, Neotropical motmots, Madagascan endemics, and Asian trogons do not have overlapping ranges. Moreover, these host groups are not closely related (*e.g.*, Prum *et al.* 2015). Neither strict co-evolution between hosts and lice nor extensive switch-

ing of lice between distantly related but geographically overlapping hosts are sufficient to explain the host associations of *Motmotnirmus*, *Clayiella* and their relatives.

Motmots, cuckoo rollers, and trogons are all known from fossil deposits well outside their current ranges, suggesting that the prehistoric distribution of these taxa may have been radically different (*e.g.*, Olson 1976, Becker 1986, Kristoffersen 2002, Mayr 2005, 2009, Mourer-Chauviré 2006, Weidig 2006). Moreover, the ischnoceran louse fauna of many Neotropical bird groups is poorly known. For instance, few or no lice are known from jacamars, todies, puffbirds, barbets, and many groups of cuckoos and suboscine passerines. Conceivably, undiscovered close relatives of *Motmotnirmus* and *Clayiella* may occur in these host groups. Large-scale surveys of lice from Neotropical birds are rare (*e.g.*, Clayton *et al.* 1992, Soto-Patiño *et al.* 2018), and checklists are published for only a few Latin American countries (Sánchez-Montes *et al.* 2018, González-Acuña & Palma 2021, Guzmán-Torres & Cano-Santana 2021, Minaya *et al.* 2021). Clearly, much research on Neotropical chewing lice remains to be done before we can get an overview of the diversity and relationships of lice in this part of the world.

IN HONOR OF DANIEL

The kind of large-scale, long-term devotion to the chewing louse fauna of a region shown by Daniel González-Acuña, whose publications on lice of Chile span 20 years, is rare in South America, surpassed only by M.A. Carriker, Jr. (active 1903-1966), Lindolpho R. Guimarães (active 1935-1985), and Armando C. Cicchino (active 1977-present). Therefore, it was with great sadness we received the news of the untimely death of Dr. González-Acuña, and we hope to honor his contributions to our knowledge of Neotropical lice with the dedication of a new species to his memory.

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Appendix 1. Definition of some technical terms used in this description.

Abdomen (abdominal): the last, and largest, part of the body, inside which both the stomach and the genitalia are found.

Allotype: traditionally used term for specimen considered typical of the species, but of a different sex than the holotype.

Basal apodeme: the largest part of the male genitalia, positioned anterior to the other parts and, in *Motmotnirmus*, articulating with them distally.

Carina: internal thickenings of the exoskeleton that run along the margins of the body, most prominently along the circumference of the head.

Chaetotaxy: a description of the general length and size, placement, and number of setae on the louse's head or body.

Endophallus: the often-tube-like organ that delivers the sperm during copulation.

Frons: the most anterior part of the head.

Gonopore: the opening in the male genitalia from which the endophallus emerges.

Holotype: the specimen designated to be the link between the theoretical world of humans and the natural world in taxonomy. Essentially, the holotype establishes that at the time of description, at least one specimen existed that possessed the combination of characters described. Holotypes are also important when establishing whether two species (or other taxa) are conspecific.

Macrosetae: very long setae.

Mesosome: part of the male genitalia, typically formed by the fusion of many genitalic plates and associated with the gonopore.

Nodus (nodi): internal thickening of the exoskeleton that is wider, more rounded, and more limited in extent than a carina.

Paratype(s): specimen(s) considered conspecific with the holotype at the time of description. If the holotype is lost or destroyed, these specimens should be used to replace it by designating a "lectotype".

Pre-spiracular ridges: internal thickenings of the tergopleurites just in front of the spiracle openings.

Prothorax (prothoracic): the first body part behind the head, where the first leg pair is situated.

Pterothorax (pterothoracic): the second body part behind the head, where the second and third leg pairs are situated.

Seta (plural: **setae**): hair- or spike-like bristles on the head and body of the louse, often useful for species identification. Some may be modified to sense organs (*e.g.*, on the antennae).

Setal rows: A row of setae.

Spiracle openings: small openings on the surface of the louse's body (most prominently on the abdomen) which are connected to the spiracle system, which distributes oxygen to all parts of the louse's body.

Subgenital plate: hardened plate on the lower (ventral) side of the abdomen just below the male genitalia, or just in front of the female genital opening.

Tergopleurites: hardened plates on the upper (dorsal) side of the abdomen.

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