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Research Brief

Body Temperature of the Yellow-Headed Amazon Parrot (*Amazona oratrix* sp)

Sebastian Armando Andrade-Sánchez, Ricardo Itzcóatl Maldonado-Reséndiz,
and Gary García-Espinosa

Abstract: The yellow-headed Amazon parrot (*Amazona oratrix* sp) is an endangered species because of habitat loss and illegal trafficking. Currently, there is no data on body temperature available for this species, and this makes a complete clinical examination for determining its health status difficult. The objective of this study was to compare 2 methods for measuring body temperature (digital rectal thermometer, skin infrared thermometer) in 22 yellow-headed Amazon parrots. Over multiple measurements, the mean cloacal and skin temperatures were $41.46 \pm 0.45^{\circ}\text{C}$ ($106.62 \pm 0.81^{\circ}\text{F}$) and $40.69 \pm 0.37^{\circ}\text{C}$ ($105.24 \pm 0.67^{\circ}\text{F}$), respectively, and there was a moderate positive correlation ($r = 0.552$, $P = 0.008$) between the 2 methods. These data can be useful for evaluating the health of these endangered parrots. Future studies evaluating other species of parrots should be conducted to obtain specific information and to avoid the use of nonspecific ranges. It is also suggested that temperatures be measured noninvasively from other anatomical sites to reduce stress and maintain the welfare of these parrots.

Key words: body temperature, animal welfare, clinical examination, infrared thermometer, avian, psittacine, *Amazona oratrix*

INTRODUCTION

The yellow-headed Amazon parrot (*Amazona oratrix* sp) is a species of parrot classified as endangered “(P)” in Mexico,¹ endangered “(EN)” by the International Union for Conservation of Nature,² and listed in the appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora.³ Illegal trafficking and acquisition of the parrots have increased by 47.9% despite the prohibition of removing parrots from the Mexican territory since 2008.⁴ Due to its colorful plumage and being known as “the talking parrot,” its popularity has led it to be the most valued companion bird in Mexico;⁵ therefore, this species is considered a priority for conservation projects.⁶

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In 1887, Robert Ridgway called this species the Pacific yellow-headed parrot (*Amazona oratrix* sp); however, since that time, the taxonomy of the yellow-headed Amazon remains inconclusive because it is grouped with the yellow-naped Amazon parrot (*Amazona auropalliata*) and yellow-crowned Amazon parrot (*Amazona ochrocephala*) in the yellow-headed Amazon complex.^{7,8} There are generally 4 recognized subspecies (*Amazona oratrix oratrix*, *Amazona oratrix belizensis*, *Amazona oratrix hondurensis*, and *Amazona oratrix tresmariae*) and another suggested subspecies (*Amazona oratrix magna*) for this species, and their distribution range is from Mexico to the Amazon basin.^{9–13}

Body temperature is a vital measure that can provide insight into the state of health of an endotherm and be an indicator of disease because fever is an early sign of infection and inflammation.¹⁴ However, in clinically healthy birds, an increase in body temperature can also occur due to hyperthermia associated with stress, differing from fever in that there is no prostaglandin or cytokine involvement as mediators of the process.^{14,15} In these cases, the increase in temperature cannot be reduced with medications such as nonsteroidal anti-inflammatory drugs.^{16,17}

Table 1. Parrot body temperatures reported in the literature.

Species	Temperature, °C/°F	Measurement area	Reference
Not specified	37.9 ± 0.2/100.2 ± 0.3 (resting) 41.3 ± 0.3/106.3 ± 0.5 (active)	Cloaca	Prinzinger et al ²⁵
Blue-fronted Amazon parrot (<i>Amazona aestiva</i>)	41.1/105.9	Cloaca	Greenacre and Lusby ²⁹
Hispaniolan Amazon parrot (<i>Amazona ventralis</i>)	42.1/107.8		
Grey parrot (<i>Psittacus erithacus</i>)	41/105.8	Not specified	Pollock and Carpenter ³⁰
Mulga parrot (<i>Psephotellus varius</i>)	43.4/110.1	Cloaca	McWhorter et al ³¹
Galah cockatoo (<i>Eolophus roseicapilla</i>)	44.1/111.3		
28 clinically healthy birds of different genera and species	40.8 ± 0.8/105.5 ± 1.4 40.3 ± 1.2/104.6 ± 2.2	Cloaca Axillary (infrared)	Anderson et al ³²

Abbreviations: °C, degrees centigrade; °F, degrees Fahrenheit.

In endothermic animals such as birds, the temperature regulation center is in the preoptic anterior hypothalamus. Body temperature regulation occurs through a set point, involving the input of various thermoreceptors at the level of the central nervous system in the brain, spinal cord, and peripheral nervous system in deep tissues (eg, skin, beak, tongue), followed by a series of efferent endocrine and neural responses that modulate the physiological and behavioral mechanisms of heat gain or loss.¹⁸ Acquisition of sufficient energy in the diet (kcal) provides adequate heat production¹⁹ and, thus, adequately ensures both cellular functions^{20,21} and the correct functioning of metabolic and thermoregulatory mechanisms, which, in turn, maintain a stable body temperature within a constant range regardless of changes in the environment.¹⁸ Body temperature of birds has been reported to be approximately 40°C (104°F),¹⁸ however, the range of temperatures can be quite variable.^{22–28} Published data for the order Psittaciformes are shown in Table 1.^{29–32}

The purpose of this study was to compare cloacal temperatures of adult yellow-headed Amazon parrots obtained using a digital veterinary thermometer with skin temperatures sampled with an infrared thermometer. The hypothesis for this study was that these 2 temperature measurements would be positively correlated.

MATERIALS AND METHODS

Twenty-two adult yellow-headed Amazon parrots that were unsexed and assessed as healthy by physical examination were used in this study. All parrots were rescued from the illegal pet trade and housed in an aviary for breeding and conservation. The study was approved by the Internal Committee for the Care and

Use of Animals of the Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México (protocol number 709).

The birds were housed in outdoor aviaries built of electro-welded mesh with access to sunlight. Areas within the aviary were covered with galvanized sheets of metal to provide shade. Natural wood perches were also provided. The aviaries were surrounded by varied species of nontoxic trees and foliage. The birds' diet consisted of a mixture of vegetables, fruits, various seeds, sprouts, and supplements (vitamins, minerals, and essential fatty acids) offered daily and water ad libitum.

The aviary was in the municipality of Yauatepec de Zaragoza in the state of Morelos, Mexico, at an altitude of 1212 m above sea level. The predominant climate is classified as semiwarm subhumid with a mean temperature of 27°C (80.6°F) with rains between the months of June and September and an annual rainfall of 946 mm. Environmental temperature and humidity were measured with a digital thermohygrometer (TSM HSRfgT-8, TSM S.A de C.V, Monterrey, México) that had a temperature measurement range of 0–50°C (32–122°F), temperature resolution of 0.1°C (0.18°F), relative humidity range of 10–99%, and humidity resolution of 1%. The thermohygrometer was placed in the area where the study subjects' cages were located to record the corresponding data during the sampling times.

The study was carried out over 2 months. Measurements were repeated every 15 days with a total of 3 sample periods with data collected at the same time of day. Birds were divided into 2 groups and sampled over 2 separate days/week/sample period to avoid stress to the birds in nearby cages. Each bird was captured within 1 minute or less with a net and immediately restrained with a hand

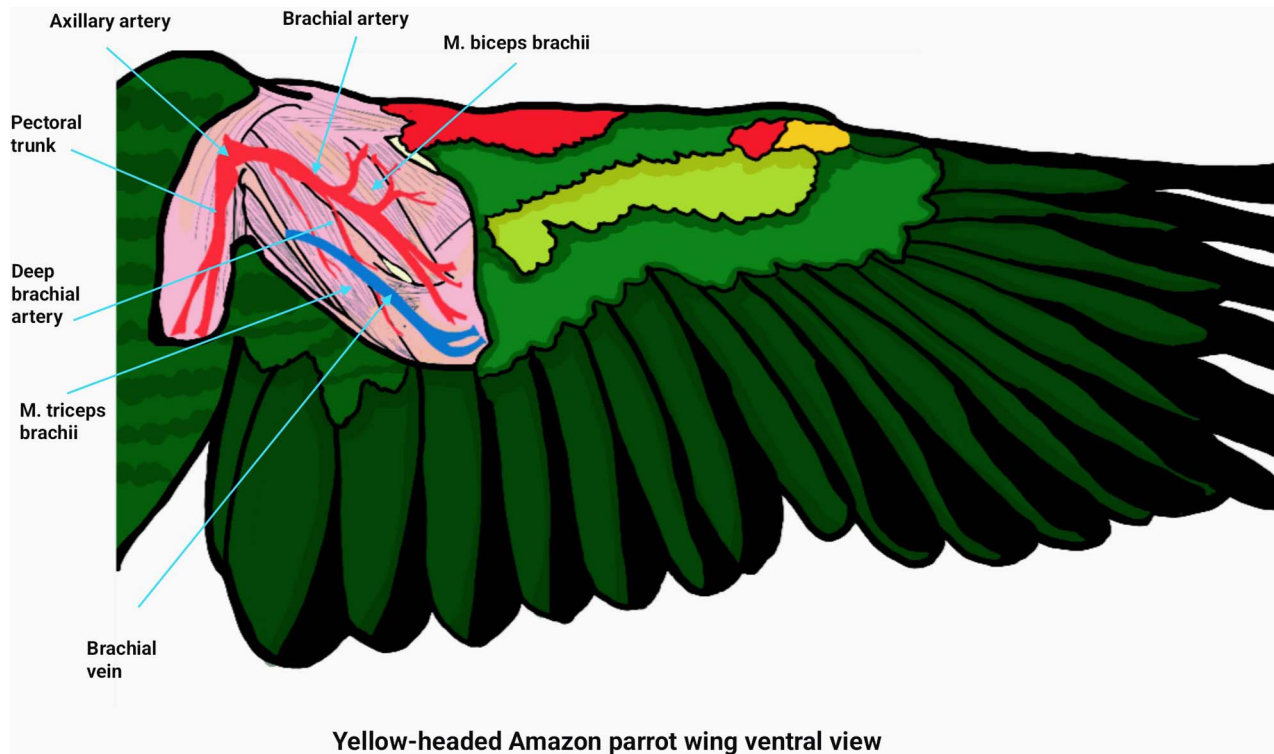


Figure 1. Diagram of the anatomical site used for measuring the surface temperature of the skin on the ventral wing of yellow-headed Amazon parrots (*Amazona oratrix* sp).

towel with ≤ 3 mm thickness to minimize stress.³³ The parrots were held for ≤ 2 minutes,³⁴ and subsequently evaluated to ensure that they had not experienced injuries from the capture.

When the bird was held firmly, a left or right wing was raised to measure the ventral skin temperature on the wing^{22,35} with a direct, contact infrared thermometer (Beuer medical FT 65, Beuer GmbH, Söflinger Str, Ulm, Germany). The thermometer could measure to an accuracy of $\pm 0.07^{\circ}\text{C}$ (0.13°F). The temperature was measured in the region overlying the *triceps brachii* mm, *biceps brachii* mm, and *brachial a* (Fig 1).³⁶ After 5 seconds, a sound played to confirm the reading had been recorded. Immediately after obtaining the temperature using the infrared thermometer, the cloacal temperature was measured using a veterinary digital rectal thermometer (Checkatek TDV01, Hergom International Business Co, Beijing, China). This thermometer could measure to an accuracy of $\pm 0.13^{\circ}\text{C}$ (0.23°F). The digital thermometer was carefully inserted approximately 10 mm into the cloaca using a small amount of lubricant gel maintained at $37\text{--}38^{\circ}\text{C}$ ($98.6\text{--}100.4^{\circ}\text{F}$; K-Y jelly personal lubricant, K-Y, Bangkok, Thailand) and left in place until the measurement was recorded. After 20 seconds, a sound played to confirm the reading had been recorded.

Statistical analysis

Analysis was carried out using commercial statistical software (SPSS Statistics 25.0, IBM, Armonk, NY USA). The body temperature data were evaluated for normality using the Shapiro-Wilk test. The mean of the biweekly measurements was calculated and considered the mean temperature for each parrot. From these means, the population mean and the standard error of the mean were calculated. The correlation between the measurements obtained with the different methods was assessed with the Pearson correlation coefficient. A Bland-Altman plot was also constructed to measure the level of agreement between the temperature measurements. A $P < 0.05$ was used to determine statistical significance.

RESULTS

The descriptive statistics for the skin and cloacal body temperatures for the 22 parrots are shown in Table 2. The environmental temperature range was $32\text{--}34.3^{\circ}\text{C}$ ($89.6\text{--}93.74^{\circ}\text{F}$), whereas the relative humidity percentage range was 26–37%. A significant moderate positive correlation ($r = 0.552$, $P = 0.008$) was found between the 2 methods (Fig 2). A Bland-Altman plot was constructed to visualize the level of agreement between the temperature

Table 2. Descriptive statistics for body temperatures obtained from the cloaca and skin of 22 yellow-headed Amazon parrots (*Amazona oratrix* sp).

	Mean, °C/°F	SE, °C/°F	Mean difference (°C/°F) ± 1.96 SE
Cloacal	41.5/106.63	±0.45/0.81	0.76/1.37
Skin	40.69/105.24	±0.37/0.67	U (+): 1.55/2.79 L (-): -0.02/-0.04

Abbreviations: °C, degrees Celsius; °F, degrees Fahrenheit; L, lower limit; SE, standard error; U, upper limit.

measurements. The mean difference between the two methods was 0.76 °C, with cloacal temperatures driving the higher measurements (Fig 3).

DISCUSSION

The body temperature ranges measured in the present study are similar to other studies for psittacine birds, including Amazon parrots²⁹ and gray parrots (*Psittacus erithacus*).³⁰ However, the mean cloacal temperature in the present study was higher than the mean cloacal temperature reported in other psittacine birds,³² whereas the mean temperature obtained from the skin using the infrared thermometer was similar to that reported in other species of parrots.³²

In this study, the higher core body temperature and lower skin temperature may have been affected by handling and restraint. This increase has been observed in other Amazon parrots (*A. aestiva*, *A. ventralis*),²⁹ in which the body temperature increased from $41.6 \pm 1.0^\circ\text{C}$ ($106.9 \pm 1.8^\circ\text{F}$) to $43.9 \pm 1.0^\circ\text{C}$ ($111.1 \pm 1.8^\circ\text{F}$) after 15 minutes of restraint, and the rise in temperature was significantly higher starting at 4 minutes of restraint. Similar responses have been observed in other bird species such as free-living pigeons (*Columba livia*),^{16,37} ducks (*Anas platyrhynchos*),¹⁷ and chickens

(*Gallus gallus domesticus*).³⁸ After handling the birds for 3–4 minutes, the body temperatures increased from $41.1 \pm 0.3^\circ\text{C}$ ($105.98 \pm 0.54^\circ\text{F}$) to $41.6 \pm 0.3^\circ\text{C}$ ($106.88 \pm 0.54^\circ\text{F}$) in chickens³⁸ and from 41.5 to 43.5°C (106.9 to 110.3°F) in the common eider (*Somateria mollissima*)³⁹ after 18 and 16 minutes, respectively. In another study measuring skin temperature in chickens using infrared thermography, the comb temperature initially decreased by 2°C (3.6°F) 20 minutes after an approximately 5-second manipulation, whereas the temperature surrounding the periocular region decreased at first but subsequently increased above baseline levels. The temperature associated with the head also increased.⁴⁰ These findings reinforce that the effects of restraint on body temperature must be considered when interpreting readings to limit any potential sampling bias.

There were limitations for this study that should be acknowledged. One potential limitation was that we did not randomize the order in which we collected the body temperatures. The body temperature was always measured from the skin first, followed by the cloacal temperature. The mean cloacal temperature could have been consistently higher than the skin due to the stress of handling. Whereas we did attempt to keep handling to <2 minutes per bird, previous studies found body

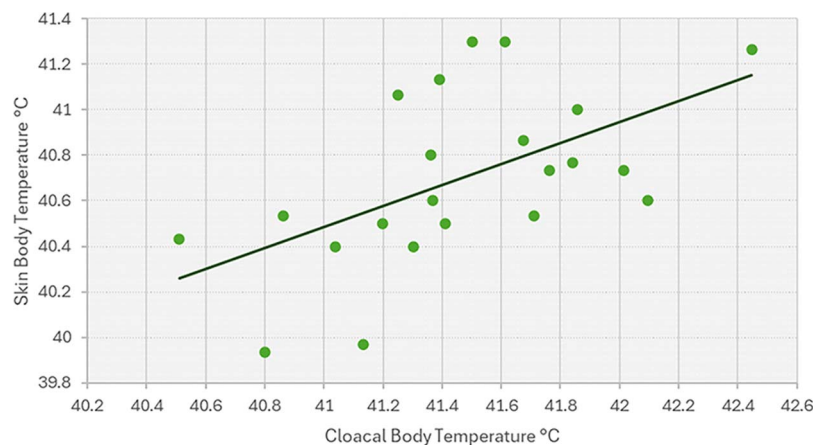


Figure 2. Scatterplot showing the cloacal and skin body temperatures of 22 yellow-headed Amazon parrots (*Amazona oratrix* sp). The best fit line between the 2 temperatures is shown. A significant moderate positive correlation ($r = 0.552$, $P = 0.008$) was found between the 2 methods.

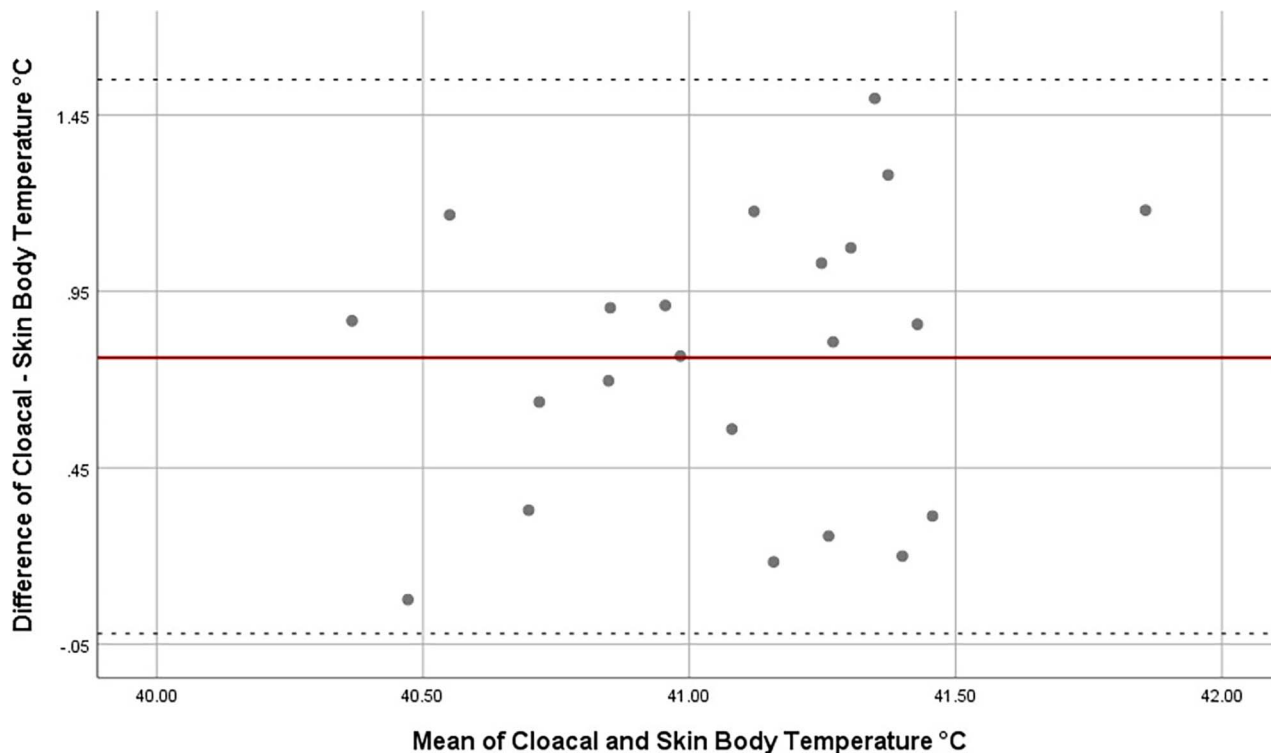


Figure 3. Bland-Altman plot measuring the level of agreement between skin and cloacal body temperatures in yellow-headed Amazon parrots (*Amazona oratrix* sp). The mean difference was 0.76°C (1.37°F) and is represented by the red line. The ± 1.96 standard errors (upper limit 1.55°C [2.79°F], lower limit -0.02°C [-0.04°F]) are represented by the dotted lines.

temperatures to increase with handling in as little as 5 seconds for chickens⁴⁰ and 4 minutes for Amazon parrots.²⁹ Future studies should consider randomizing the order for collecting the skin and cloacal body temperatures or to record the temperature simultaneously. Differences in body temperature might have also been affected by other factors, such as the arrangement of the cages and the organization of the birds in the aviary facilities. The cages were distributed in batteries of 9 individual or paired cages; therefore, the birds in the neighboring cages could observe and hear the other birds being sampled. This could have increased their stress levels and, thus, their body temperatures. Furthermore, parrots in the same cage that were restrained second subjectively appeared more stressed based on flight activity prior to their handling period. These behaviors could have also accounted for increased body temperatures.^{16,26,41} However, whereas these effects may have impacted the overall body temperature, they should not have impacted the difference seen in cloacal and skin body temperatures.

The positive correlation measured between the 2 methods is consistent with body and underwing temperatures recorded in broilers;³⁵ however, the correlation was higher in broilers. This could have been due to

species differences, such as body size, muscle density, or fat content, or due to variability between the sampling sites. In our study, body temperature was specifically measured over the skin covering the *biceps brachii mm* and *triceps brachii mm*, whereas in the broilers the authors did not specify the region beyond “underwing”.³⁶

Another noninfectious factor that can affect the body temperature of birds is exposure to high environmental temperatures in dry climates.¹⁸ The maximum mean body temperature reported in a study on heat tolerance in parrots from Australia was 43–44°C (109.4–111.2°F); these birds were held in a controlled environment with temperatures no higher than 44°C (111.2°F).³¹ In other studies, basal temperatures above 45°C (113°F) have also been reported.^{42,43} In the present study, the environmental temperature only reached 34.3°C (93.7°F) on the warmest day; therefore, it is unlikely that the external temperature influenced these measurements.

In this study, the authors were able to reliably measure body temperature for adult, apparently healthy, yellow-headed Amazon parrots. Additionally, we consistently obtained skin body temperatures from the region overlying the *triceps brachii mm*, *biceps brachii mm*, and *brachial a* using an infrared thermometer, proposing a new option for a minimally invasive method

for measuring body temperature during clinical examination and allowing for a more complete evaluation of yellow-headed Amazon parrots. Future studies measuring body temperatures of other species within the genus *Amazona* and across other genera of parrots should be conducted to expand our understanding of these birds and to determine species specific reference ranges. Moreover, screening additional sites to measure the body temperature on the skin, including the inguinal area, over the pectoral muscles, and the apterium over the jugular vein, should be pursued to further characterize minimally invasive sites for measuring body temperature. This could increase our understanding about the health of our avian patients, reduce stress, and maximize the welfare of the birds.

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REFERENCES

- DOF. Modificación del Anexo Normativo III: Lista de especies en riesgo de la Norma Oficial Mexicana NOM-059-SEMARNAT-2010, Protección ambiental-Especies nativas de México de flora y fauna silvestres-Categorías de riesgo y especificaciones para su inclusión, exclusión o cambio-Lista de especies en riesgo. Published December 30, 2019. Accessed February 1, 2023. https://www.dof.gob.mx/nota_detalle.php?codigo=5578808&fecha=14/11/2019#:~:text=Que%20el%20art%C3%ADculo%2056%20p%C3%A1rrafo,de%20alguna%20especie%20o%20poblaci%C3%B3n
- IUCN. Red list . Accessed February 1, 2023. <https://www.iucnredlist.org/search?query=Amazona%20oratrix&searchType=species>
- CITES. Appendix. Accessed February 3, 2023. <https://cites.org/esp/app/appendices.php>
- Cantú JC, Saldaña ME, García E, et al. *Disminuye el Tráfico Ilegal de Psitácidos en México*. Defenders of Wildlife, Teyeliz A.C. y UABCS; 2022.
- Cantú JC, Sánchez ME. *La Crianza Comercial de Psitácidos no Detiene el Tráfico Ilegal en México*. Defenders of Wildlife y Teyeliz A.C.; 2020.
- SEMARNAT/CONANP. *Programa de Acción Para la Conservación de especies: Loro Cabeza Amarilla (Amazona oratrix) y Loro Nuca Amarilla (Amazona auropaliata)*. 1st ed. SEMARNAT; 2012.
- Forshaw JM. *Parrots of the World*. Vol 3. Melbourne, Australia: Lansdowne Editions; 1989.
- Juniper T, Parr M. *Parrots: A Guide to Parrots of the World*. New Haven, London: Yale University Press. 1998; p. 584.
- Urantówka AD, Mackiewicz P, Strzała T. Phylogeny of *Amazona barbadensis* and the yellow-headed Amazon complex (Aves: Psittacidae): a new look at South American parrot evolution. *PLoS One*. 2014;13;9:e97228.
- Ruth JM. Yellow-headed parrot (*Amazona oratrix*). Version 1.0 . *Birds of the World*. Schulenberg TS, ed. Cornell Lab of Ornithology; 2020.
- Gómez G. *Loros de México. Historia Natural*. 2nd ed. Porrúa; 2015.
- Nelson EW. Birds of the Tres Marias Islands. In: Merriam H, ed. *North America Fauna*. U.S. Department of Agriculture; 1899.
- Howell SNG, Webb S. *A Guide to the Birds of Mexico and Northern Central America*. Oxford: Oxford University Press; 1995.
- Gray DA, Marais M, Maloney SK. A review of the physiology of fever in birds. *J Comp Physiol B*. 2013; 183:297–312.
- Vinkers CH, Groenink L, Van Bogaert MJV, et al. Stress-induced hyperthermia and infection-induced fever: two of a kind? *Physiol Behav*. 2009;98:37–43.
- Nomoto S. Role of prostaglandin E2 and indomethacin in the febrile response of pigeons. *Jpn J Physiol*. 2003; 53:253–258.
- Gray DA, Maloney SK, Kamerman PR. Restraint increases afebrile body temperature but attenuates fever in Pekin ducks (*Anas platyrhynchos*). *Am J Physiol Regu Integrative Comparative Physiol*. 2008;294:1666–1671.
- McKechnie A. Regulation of body temperature: patterns and processes. In: Colin GS, Dridi S, eds. *Sturkie's Avian Physiology*. Vol 7. Cambridge, MA: Academic Press; 2022.
- McNab BK. An analysis of the body temperature of birds. *The Condor*. 1966;68:47–55.
- Knapp BD, Huang KC. The effects of temperature in cellular physiology. *Annu Rev Biophys*. 2022;51:499–526.
- Kuht J, Farmery AD. Body temperature and its regulation. *Anaesth Intensive Care Med*. 2021;22:657–662.
- Wetmore A. A study of the body temperature of birds. *Smithsonian Miscellaneous Collections*. 1921;72:1–51.
- Benedict FG, Fox EL. The gaseous metabolism of large wild birds under aviary. *Proc Am Phil Soc*. 1927;66: 511–534.
- King RJ, Farner SD. Energy metabolism, thermoregulation and body temperature. In: *Biology and Comparative Physiology of Birds*. London: Academic Press; 1961.
- Prinzinger R, Pressmar A, Schleucher E. Body temperature in birds. *Comp Biochem Physiol Physiol*. 1991; 99:499–506.
- Harrison GJ, Ritchie BW. Making distinctions in the physical exam. In: Harrison GJ, ed. *Avian Medicine: Principles and Application*. Lake Worth, FL: Wingers Publishing, Inc; 1994.
- Martel A. Infectious disease: aspergillosis. In: Speer BL, ed. *Current Therapy in Avian Medicine and Surgery*. Vol 1. St. Louis, MO: Elsevier; 2016.
- Cornell Lab of Ornithology. Birds of the world. Accessed June 20, 2024. <https://birdsoftheworld.org/bow/>

29. Greenacre C, Lusby A. Physiologic responses of Amazon parrots (*Amazona* species) to manual restraint. *J Avian Med Surg.* 2004;18:19–22.
30. Pollock C, Carpenter JW. Normal biological data. In: Speer BL, ed. *Current Therapy in Avian Medicine and Surgery.* Vol 1. St. Louis, MO: Elsevier; 2016.
31. McWhorter T, Gerson A, Talbot W, et al. Avian thermoregulation in the heat: evaporative cooling capacity and thermal tolerance in two Australian parrots. *J Exp Biol.* 2018;221.
32. Anderson J, Kaplan-Stein S, Adolph S, et al. Assessment of non-contact infrared thermometer measurement sites in birds. *J Appl Anim Welf Sci.* 2020;23:131–139.
33. Bailey T. Capture and handling. In: j. Samour J, ed. *Avian Medicine.* Vol 3. St. Louis, MO: Elsevier; 2016.
34. Korbel R, Reese S, Liebich HG. Handling, restraint, and anesthesia. In: Koning H, Korbel R, Liebich H, eds. *Avian Anatomy Textbook and Color Atlas.* Stuttgart, Germany: 5m Publishing; 2009.
35. Iyasere O, Edwards M, Bateson M, et al. Validation of an intramuscular-implanted microchip and a surface infrared thermometer to estimate core body temperature in broiler chickens exposed to head stress. *Comput Electron Agri.* 2017;133:1–8.
36. Maier J, Koning HE, Liebich HG, et al. Thoracic limb (membrum thoracicum). In: Koning H, Korbel R, Liebich HG, eds. *Avian Anatomy Textbook and Color Atlas.* Stuttgart, Germany: 5mm Publishing; 2009.
37. Bittencourt MA, Falkenburger FM, Marino-Neto J. Stress-induced core temperature changes in pigeons (*Columba livia*). *Physiol Behav.* 2015;139:449–458.
38. Cabanac M, Aizawa S. Fever and tachycardia in a bird (*Gallus domesticus*) after simple handling. *Physiol Behav.* 2000;69:541–545.
39. Cabanac M, Guillemette M. Temperature and heart rate as stress indicators of handled common eider. *Physiol Behav.* 2001;74:475–479.
40. Edgar JL, Nicol CJ, Pugh C, et al. Surface temperature changes in response to handling in domestic chickens. *Physiol Behav.* 2013;119:195–200.
41. Morrison P. Modification of body temperature by activity in Brazilian hummingbirds. *The Condor.* 1962;64:315–323.
42. Thompson ML, Cunningham SJ, McKechnie AE. Inter-specific variation in avian thermoregulatory patterns and heat dissipation behaviors in a subtropical desert. *Physiol Behav.* 2018;188:311–323.
43. Nilsson JÅ, Nord A. Testing the heat dissipation limit theory in a breeding passerine. *Proc Biol Sci.* 2018;285.