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COVID-19 pandemic exacerbated food insecurity in South American countries

Carlos Frederico A. Vasconcelos-Neto^{2,46} · Michelle Jacob³ · Daniel Tregidgo² · Denis Valle⁴ · Hani R. El Bizri^{2,5,47} · Sávio Marcelino Gomes⁶ · Julia E. Fa^{7,48} · Thais Q. Morcatty^{2,8} · Frederico Ozanan Barros Monteiro⁹ · Alessandra Scofield¹⁰ · Alessandra Matte¹¹ · Willandia A. Chaves¹² · Luiz Henrique Medeiros Borges¹³ · Antônia I. A. Silva¹⁴ · Didac Santos-Fita¹⁵ · Tiago Lucena Silva¹⁶ · Isaac Ibernón Lopes-Filho¹⁶ · Maria Isabel Afonso Silva¹⁷ · Rebeca Mascarenhas Fonseca Barreto¹⁸ · Marcela A Oliveira¹⁹ · Felipe Silva Ferreira²⁰ · Ricardo Rodrigues Santos²¹ · Jaime Honorato-Júnior²² · Marilene Vasconcelos Silva Brazil²³ · Shirliane Araújo Sousa²⁴ · Deise C. L. Oliveira²⁵ · Valéria R. F. Ferreira²⁶ · Hyago K. L. Soares²⁷ · Marcia F. Pinto²⁸ · Raone Beltrão-Mendes²⁹ · Marcos Paulo Lopes Rodrigues³⁰ · Wáldima Alves Rocha³¹ · Roberto Gutiérrez Poblete³² · Francisco Luigi Schettini³³ · Joe S. S. Rojas³⁴ · Marco A. Aspilcueta³⁵ · Justo D. V. Zevallos³⁶ · Giuseppe Gagliardi-Urrutia³⁷ · Erick Rodolfo Menéndez Delgado³⁸ · Mariela Lissette Polit-Vera³⁹ · Elvira Rodríguez Ríos⁴⁰ · Juan Carlos Carrascal Velásquez⁴¹ · Maria Dalila Forlano Riera⁴² · Lucy Perera Romero⁴³ · Danilo A. Salas Dueñas⁴⁴ · Daniel Garin⁴⁵ · Pedro Mayor¹ 

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Abstract

The COVID-19 pandemic triggered unparalleled political, economic, and social ramifications, exacerbating global food insecurity (FI). To understand the overall impact of the pandemic and how different socio-economic groups were affected, we assessed prevalence and severity of FI in a sample of 18,997 households across seven countries in South America. We employed the Food Insecurity Experience Scale developed by the FAO. Our results showed that pre-pandemic, 4.5% of the sampled population across the entire continent faced Moderate FI, while 0.6% experienced severe FI. During the pandemic, Moderate FI increased to 16.9% (+12.4%), and Severe FI to 2.7% (+2.1%). By country, pre-pandemic households in Venezuela had the highest prevalence of Moderate FI (9.7%), with Peru experiencing the highest Severe FI frequency (1.1%). Peru had the greatest rise in Moderate (+23.9%) and Severe FI (+4.6%) during the pandemic. Low-income households, defined as those earning <2 minimum wages per month, were most susceptible to FI. Uruguayan low-income families exhibited the most significant rise (+40.4%) in Moderate FI, while those in Peru experienced an increase of +9.1% in Severe FI. This study measures the profound and far-reaching impact of the COVID-19 pandemic on FI in South America. Our findings also emphasise the critical importance of implementing effective public policy interventions to improve resilience against future shocks. This would enable policymakers to develop targeted strategies that address the immediate challenges posed by pandemics as well as laying the groundwork for a more resilient and sustainable food security landscape in the region.

Keywords Food security · Nutrition · Covid-19 · Hunger · South America

1 Introduction

Many countries worldwide have been profoundly impacted by the COVID-19 pandemic, caused by the SARS-CoV-2 virus (Hiscott et al., 2020). This global health crisis has had far-reaching effects on the economies, political structures, and social fabric of those countries grappling with its

consequences. The COVID-19 has also exacerbated food insecurity (FI), due to the restrictive measures aimed at controlling the virus' spread (Laborde et al., 2020a, 2020b). This threatened access to food mainly through losses of income and assets that prejudice the ability to buy food. Globally, this was more severe in poorest households, who on average spend around 70% of their incomes on food and have limited access to financial markets, making their food security

Extended author information available on the last page of the article

particularly vulnerable to income shocks (Laborde et al., 2020a, 2020b).

Food insecurity (FI), a pervasive issue globally, affects millions of people, particularly in low- and middle-income countries with high inequality and limited social support. FI arises when individuals or households lack reliable access to enough affordable nutritious food leading to uncertainty about their ability to acquire adequate food for a healthy and active life (World Food Summit, 1996). FI can manifest in various degrees, ranging from occasional uncertainty about obtaining food to more severe and chronic conditions where hunger and malnutrition become prevalent.

Measuring FI is intricate due to its subjective nature, influenced by cultural variations and diverse factors such as economic conditions and climate changes. The dynamic and multidimensional aspects of food security, ranging from availability to access and utilisation, require comprehensive assessment tools. Limited access to accurate data and the interconnected nature of food security with various indicators pose challenges to obtaining a precise understanding. Despite these complexities, ongoing efforts to refine measurement tools and embrace multidimensional approaches contribute to a more nuanced assessment of food insecurity globally (Manikas et al., 2023).

Research on the influence of COVID-19 on food insecurity often neglects to consider variations in food access related to individuals' income levels (Bloem & Farris, 2022), despite income being a recognized central factor influencing FI (IFPRI, 2016). Another notable drawback in the field is the prevalent dependence on cross-sectional studies, which fail to track changes in an individual's food security status over time (Gebeyehu et al., 2023). Despite these limitations, existing research suggests that the impact of COVID-19 on food insecurity varied among countries, primarily mirroring their economic status. However, it may also reflect socioeconomic differences within each nation and the effectiveness of mitigation measures implemented by their respective governments (OECD, 2020). Notably, Indonesia, Mexico, Bangladesh, Lebanon, and the USA witnessed an increase in FI, while a study in Iran indicated improved household food security and dietary diversity linked to government assistance policies (Gebeyehu et al., 2023; Pakravan-Charvadeh et al., 2021). Currently, there are few studies that analyze the impact of the COVID-19 pandemic on FI in several (Benites-Zapata et al., 2021; Hernández-Vásquez et al., 2022, Novoa-Sanzana et al., 2024), or particular countries (Manfrinato et al., 2021; Zila-Velasque et al., 2022) in the entire South America.

It is estimated that Latin America and the Caribbean is the region with the second highest figures for FI globally, with a prevalence of 40.9% in the entire region (Hernández-Vásquez et al., 2022). South America in particular is characterized by income disparities, inequalities in the

opportunities to access goods and public services, as well as high rates of poverty, unemployment, and high inflation. In South America, the wealthiest 10% concentrate 58.6% of the population's average income and over 75% of agricultural lands (Bauluz et al., 2020; Espinosa-Cristia et al., 2019; Otsuka, 2013; World Inequality Lab, 2022). This resource imbalance has historical roots in the colonial origins of South American countries and persists (Frankema, 2010). The current food production model favours large producers and agribusiness corporations while diminishing the capacity of small farmers and local communities to produce their own food (Clapp & Moseley, 2020; Gonzalez, 2004; Mares & Alkon, 2011). As a result, despite the pandemic pushing 33.7 million South Americans into hunger (FAO, 2021), food exports increased by 2%, and the agricultural sector's Gross Domestic Product (GDP) grew by 1.1% during that period. Additionally, a country's dependence on agricultural commodity exports can result in reduced food availability in the domestic market and heightened food prices, disproportionately affecting poorer and more vulnerable families (Nkurunziza et al., 2017; UNCTAD, 2021).

Our study's main objective was to assess the magnitude of changes in FI across seven countries in South American, with a particular focus on comparing conditions before and during the COVID- 19 pandemic. We also assessed FI at the household level and thereby improved the understanding of the impact of the COVID- 19 pandemic on families with various income levels.

2 Material and methods

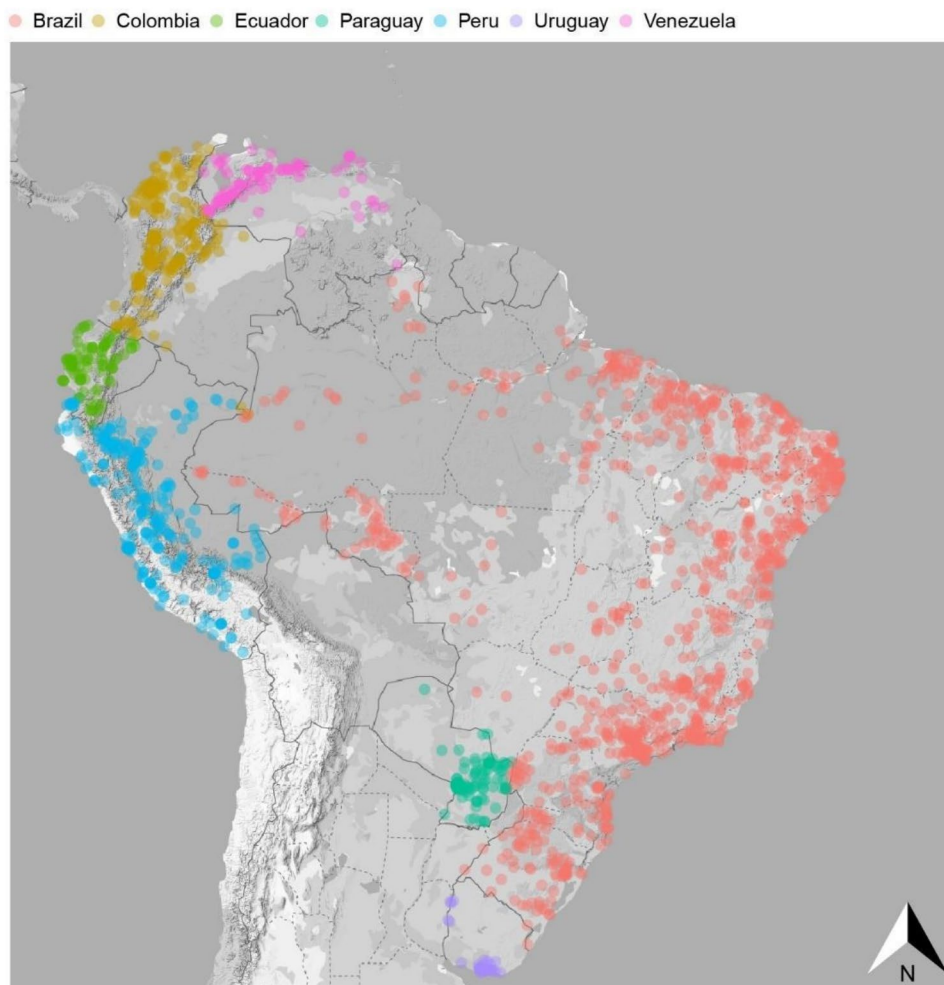
2.1 Sample size

We employed the EpiInfo7 program (Dean et al., 2011), to determine the required sample size. The calculation, based on an expected response frequency of 50% and a 10% margin of error, indicated the need for a total of 16,640 households to be sampled. The study was implemented across seven countries (Brazil, Colombia, Ecuador, Paraguay, Peru, Uruguay, and Venezuela), encompassing a total of 18,997 households (Fig. 1; Suppl. Table 1).

2.2 Data collection

We developed an online form using Google Forms to gather information on socioeconomic and food security aspects within households. Participants were asked to supply information on number of residents, total monthly income (in national currency) and the status of food and nutritional security (FNS) by using the Food Insecurity Experience Scale (FIES) (Cafiero et al., 2018) developed by FAO (Suppl. Table 1). The FIES method consists of eight

Fig. 1 Human settlements surveyed on food insecurity levels in each South American country during the data collection carried out throughout the year 2020



questions containing a graded FI severity scale (Mild: 1–3; Moderate: 4–6; and Severe FI: 7–8). To capture the effects of the pandemic, respondents were asked about the level of FI in their households during two time periods: A) pre-pandemic (November–December 2019); and B) during the pandemic (May–December 2020). To ensure clarity, questions were translated and adapted to the primary language spoken in each country (Portuguese for Brazil, Spanish for the remaining countries).

Data collection was supervised by a group of 49 regional coordinators, aiming to have at least one representative from each state or region in the countries sampled. These coordinators recruited volunteers and coordinated data collection in their respective areas. A total of 330 volunteers participated in the research, recruited through university websites, social media groups, and announcements offering voluntary internships for research with the issuance of participation certificates. Volunteers were responsible for disseminating the survey link and attracting participants to the research. Weekly reports were shared on the progress of data collection to identify and

prioritize areas with fewer interviews. The survey was distributed by volunteers through messaging apps and social media. Participants were encouraged to become volunteers and share the research link within their networks after completing the questionnaire, thus integrating the snow-ball sampling recruitment method.

Sampling was limited to areas with internet access since health and safety regulations precluded in-person interactions during the data collection period. In 2020, about 74% of the population in South America had internet access (World Bank, 2021). A stratified sampling technique was employed to address potential selection bias, with increased sampling density in urban areas. The average internet connectivity in rural regions is roughly half that in urban locations (Ziegler et al., 2020). Therefore, only 22% ($n = 4,179$) of households were sampled in municipalities with fewer than 50,000 inhabitants, with proximity and influence from rural areas.

The survey was targeted to persons aged 18 years or older. Google Forms was chosen for its free accessibility and its versatility and not requiring high-speed internet

connection. The form could be filled out on both computers and smartphones.

Each country sampled had specific rules regarding the Research Ethics Committee, though in general authorization was not required if participant anonymity was maintained. Research transparency and adherence to medical research ethics protocols as established by the Declaration of Helsinki ('World Medical Association Declaration of Helsinki', 2013) was adhered to and no personal information enabling participant identification was collected. The project description, outlining objectives, expected outcomes, and coordinator contact information, was provided before accessing the questionnaire. Participants were informed of the option to withdraw at any time and invited to sign an informed consent form if choosing to respond to the survey. This study was considered exempt from requiring ethical approval because the nature of the Internet-based questionnaire always protected anonymity and ensured the possibility that the interviewee was free to decide to discontinue the questionnaire.

Households surveyed were classified according to country and income level and information on the person who completed the household survey, including age, gender and educational attainment (Suppl. Table 2).

2.3 Statistical analysis—Rasch Model

Because FIES questions have a gradual severity scale, a positive response to a later question, e.g., question five, is anticipated to be accompanied by positive responses to all preceding questions. However, in practice, not all respondents would follow this, leading to response patterns deemed erroneous. To reduce the impact of this bias on the results, we built a Rasch Model using income as a predictor variable and estimated the probability of each household experiencing Moderate or Severe FI, thereby enhancing the precision and reliability of our analysis:

Let y_{itq} be the binary response of individual i to question q at time t . Our Rasch model assumes that:

$$y_{itq} \sim \text{Bernoulli}\left(\frac{\exp(\theta_{it} - \phi_q)}{1 + \exp(\theta_{it} - \phi_q)}\right)$$

where θ_{it} is the position of individual i at time t in the severity of food insecurity scale. Similarly, ϕ_q is the position for question q . We assume that:

$$\phi_q \sim N(0,1)$$

In relation to the position of each individual at each time, we assume that:

$$\theta_{it} \sim N(\gamma_i + x_{it}^T \beta, 1)$$

where γ_i is an individual-level random effect, x_{it}^T is a vector of covariates, and β is a vector with the corresponding slope parameters. We rely on these individual-level random effects to account for correlation given that respondents replied twice (once referring to the period prior and once referring to the period during the pandemic) to the eight questions that comprise the food insecurity scale. These random effects were modeled as $\gamma_i \sim N(0, \sigma^2)$. The covariates within the vector x_{it}^T included a binary period variable ($t = 0$ for prior to pandemic; $t = 1$ for during pandemic), an income variable, and the interaction between these variables. The income variable was discretized into three categories based on the number of minimum wages per month (MW) in each country (Low: < 2 MW; Medium: $2-4$ MW, and High: > 4 MW). To estimate prevalence for each country and period regardless of income status, we dropped the income variable and the interaction terms before fitting the model.

Since this model is implemented within a Bayesian framework, it is necessary to define our priors. These priors serve as the initial beliefs or assumptions about the parameters of the model before observing the data. These priors are given by:

$$\beta_p \sim N(0,1)$$

$$\sigma \sim \text{Unif}(0,100)$$

2.4 Model fitting

To conduct our analysis, a separate Rasch model was fitted for each country utilising a Gibbs sampler implemented in JAGS (Plummer, 2003) within the R programming environment (R Core Team, 2021). We employed three chains, each consisting of 5,000 iterations. Following a burn-in period, the first 1,000 iterations were discarded, and we retained every 5th sample from the posterior distribution. Convergence of the algorithm was assessed using the Rubin and Gelman *Rhat* statistic (Gelman & Rubin, 1992). Successful convergence was confirmed as all parameters exhibited an *Rhat* statistic below 1.1.

2.5 Estimation of the prevalence of moderate and severe FI for each country and income level

Following the FAO guidelines (Cafiero et al., 2018), we estimated the prevalence of Moderate or Severe FI for country k (M_k) by calculating the mean probability of positively answering the question "Still thinking about the last 12 MONTHS, was there a time when you ate less than you thought you should because of a lack of money or other resources?". This is the question 5 in the FAO questionnaire

(i.e., "ATELESS" question) and therefore this quantity was calculated as:

$$p(x_{itk}) = \frac{\exp(E[\theta_{itk}] - \phi_{5k})}{1 + \exp(E[\theta_{itk}] - \phi_{5k})}$$

where $E[\theta_{itk}] = x_{itk}^T \beta$, thus excluding the individual-level random effects.

Similarly, we estimated the prevalence of Severe FI for country k (S_k) by calculating the mean probability of positively answering the question "During the last 12 MONTHS, was there a time when you went without eating for a whole day because of a lack of money or other resources?". This is the question 8 in the FAO questionnaire (i.e., "WHOLEDAY" question) and therefore this quantity was calculated as:

$$p(x_{itk}) = \frac{\exp(E[\theta_{itk}] - \phi_{8k})}{1 + \exp(E[\theta_{itk}] - \phi_{8k})}$$

Subsequently, we calculated the increase of FI by comparing M_k (and S_k) for 2019 and 2020.

2.6 Estimation of the prevalence of moderate and severe FI for South America

To compute the prevalence of Moderate and Severe FI for South America (M_{LA}), we utilised on the following equation to combine the results from each country:

$$p(M_{LA}|T = t) = \sum_k p(T = t)p(\text{Country} = k)$$

for before and during the pandemic periods. In this expression, $p(\text{Country} = k) = \frac{N_k}{\sum_q N_q}$ where N_k is the population of country k in 2020 (ONU, 2022). Similarly, we calculated the prevalence of Severe FI for South America (S_{LA}) using:

$$p(S_{LA}|T = t) = \sum_k p(T = t)p(\text{Country} = k)$$

3 Results

The median age of surveyed persons was 29 years (Q1 = 22, Q3 = 41), with a sex ratio of 59.2% females, 40.4% males and 0.4% not declared. The average monthly income was 2.5 (\pm 2.1 SD) minimum wages relative to the respective measure in each country. The higher educational level of surveyed people was a university degree (40.5%), followed by secondary education (35.3%). Supplementary Table 2 shows the demographic characteristics of the households surveyed overall and per country.

Our calculations reveal that before the pandemic, 4.5% and 0.6% of our sampled households in the studied South American countries were already experiencing Moderate and Severe FI, respectively (Suppl. Table 3). Severe FI was most prevalent in Paraguay (1.7%), followed by Peru (1.1%), Ecuador (0.8%), Colombia (0.7%), Brazil (0.5%), Venezuela (0.3%), and Uruguay (0.3%); whereas Moderate FI was most prevalent in Venezuela (9.7%), followed by Peru (7.7%), Paraguay (6.6%), Colombia (5.8%), Ecuador (5.7%), Uruguay (5.6%), and Brazil (2.7%) (Fig. 2; Suppl. Table 3).

The pandemic had an unprecedented overall impact on FI among our sample population, more than tripling and quadrupling the prevalence of Moderate (from 4.5% to 16.9%) and Severe (from 0.6% to 2.7%) FI, respectively (Suppl. Table 4). This increase in Severe FI represents an additional 53.4 million people experiencing hunger in South America. All countries studied experienced exacerbated increase in FI prevalences; however, Peru experienced the greatest increase in Moderate and Severe FI (Moderate FI 23.9%/Severe FI 4.6%), followed by Ecuador (22.9%/4.2%), Venezuela (21.8%/1.1%), Colombia (20.1%/3.3%), Uruguay (16.1%/0.9%), Paraguay (8.7%/2.5%), and Brazil (6.9%/1.3%) (Fig. 2; Suppl. Table 3).

At the household level, low family income was associated with a higher likelihood of food insecurity (FI), with an increased risk of +28% for moderate and +5% for severe FI, compared to high-income families. Among the countries surveyed, Low-income families in Uruguay were the most vulnerable (Moderate FI 59.2%/Severe FI 5.1%), followed by Peru (49.9%/11.5%), Colombia (44.1%/8.5%), Ecuador (39.9%/8.1%), Venezuela (36.1%/1.7%), Paraguay (17.7%/5.1%) and Brazil (13%/2.4%) (Fig. 3; Suppl. Table 4).

4 Discussion

In this study, we measured the state of food insecurity in seven South American countries before and during the COVID-19 pandemic, carrying out the most extensive collection of FI data in South America during the pandemic. We also undertook novel analytical methods by using Bayesian statistics to improve the FAO's Food Insecurity Experience Scale to allow inferences at the household level. By doing so, we identified a tripling and quadrupling trend in Moderate and Severe FI during the pandemic.

In comparison to previous government data (GAIN, 2023) for the same South American countries, our pre-pandemic data showed lower levels of Moderate and Severe FI. The latter indicated that the combined prevalence of Moderate and Severe FI was 37%, 29%, 25% and 14% for Ecuador, Brazil, Paraguay and Uruguay, respectively. Data for Venezuela, Peru and Colombia were not available. As far as we

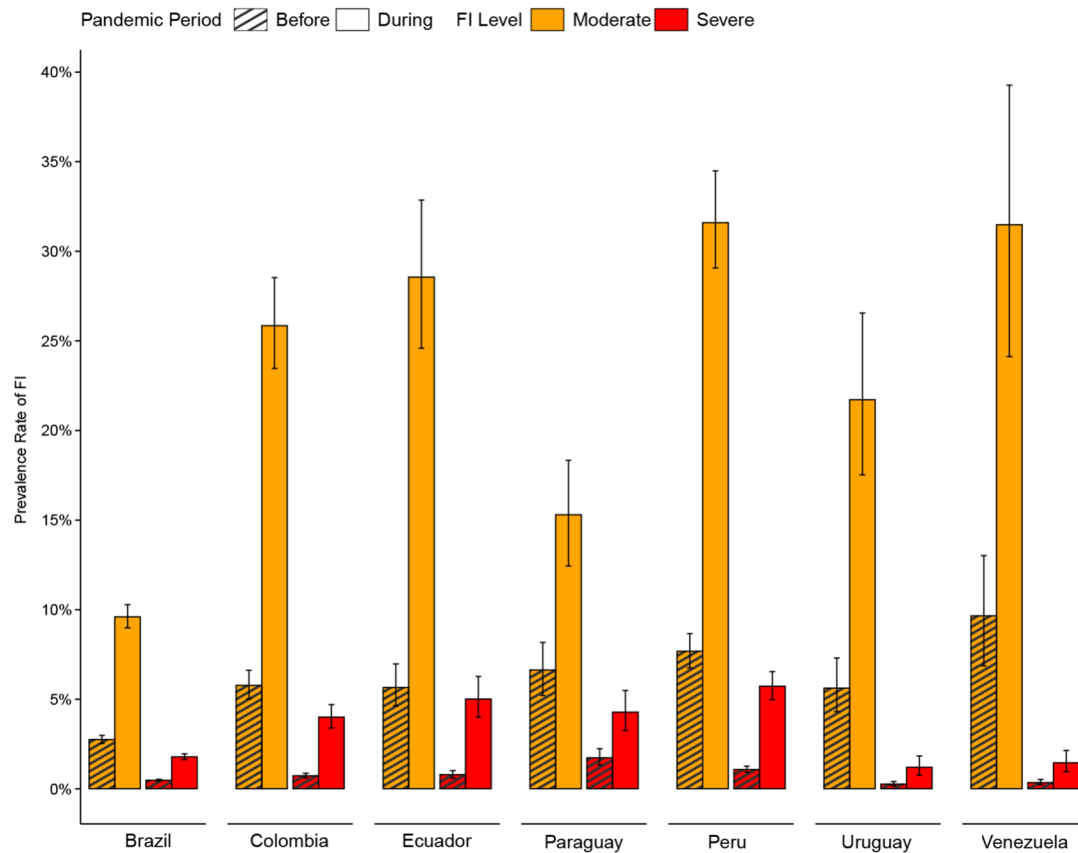


Fig. 2 Prevalence Rate of FI calculated by country, pandemic period, and FI level. The error bars represent the 95% credible Confidence Intervals

know, the available regional information focuses mainly on Latin America. Studies carried out in various Latin American countries during the COVID-19 pandemic reported 40.9%, 41.8% and 75.7% FI, respectively (Benites-Zapata et al., 2021; Hernández-Vásquez et al., 2022; Novoa-Sanzana et al., 2024). Some studies suggest that the combined prevalence of Moderate and Severe FI before the COVID-19 pandemic in particular South American countries was between 23 and 37% in Peru (Curi-Quinto et al., 2021; Zila-Velasque et al., 2022), 40% in Colombia (Sinclair et al., 2022), and 47% in Brazilian favelas (Manfrinato et al., 2021).

Estimates of FI in South America have been influenced by a history of economic crises in the region. From 2000–2008, South American countries enjoyed a period of economic prosperity, characterized by high GDP growth, low inflation, and reduced poverty rates (Moreno-Brid & Garry, 2016). This period experienced significant advancements in food security and nutrition policies and initiatives (Piñeiro et al., 2010). However, the food crisis of 2006–2008 and the subsequent economic crisis of 2008–2009 led to food price inflation, particularly impacting the poorest due to the loss of purchasing power (Piñeiro et al., 2010). The economic crisis that unfolded

in 2014–2017 further exacerbated FI levels (Sousa et al., 2019a, 2019b), potentially contributing to the scenario uncovered by our study in 2019. Therefore, the South American population already had important rates of FI, although unequal based on economic income, before the outbreak of the COVID-19 pandemic.

Our results reveal the vulnerability of food security in South America by showing how the onset of the COVID-19 pandemic exposed a significant portion of the initially food-secure population to rapid and severe FI, without a gradual evolution of the situation. The disparities observed in this study are markedly larger compared to baseline population data for countries in the South American region. For instance, according to the data from the Food System Dashboard (GAIN, 2023), the prevalence of Moderate and Severe FI in Uruguay rose by only 1% due to the pandemic, more than 15 times smaller than in our observations. In general, prevalence studies are not adept at capturing changes in FI within the same sample units, a limitation we attempted to address here. Stability is a crucial dimension of FNS, and the rapid shift in access to food conditions underscores the low resilience of food systems in South America to ensure future food security.

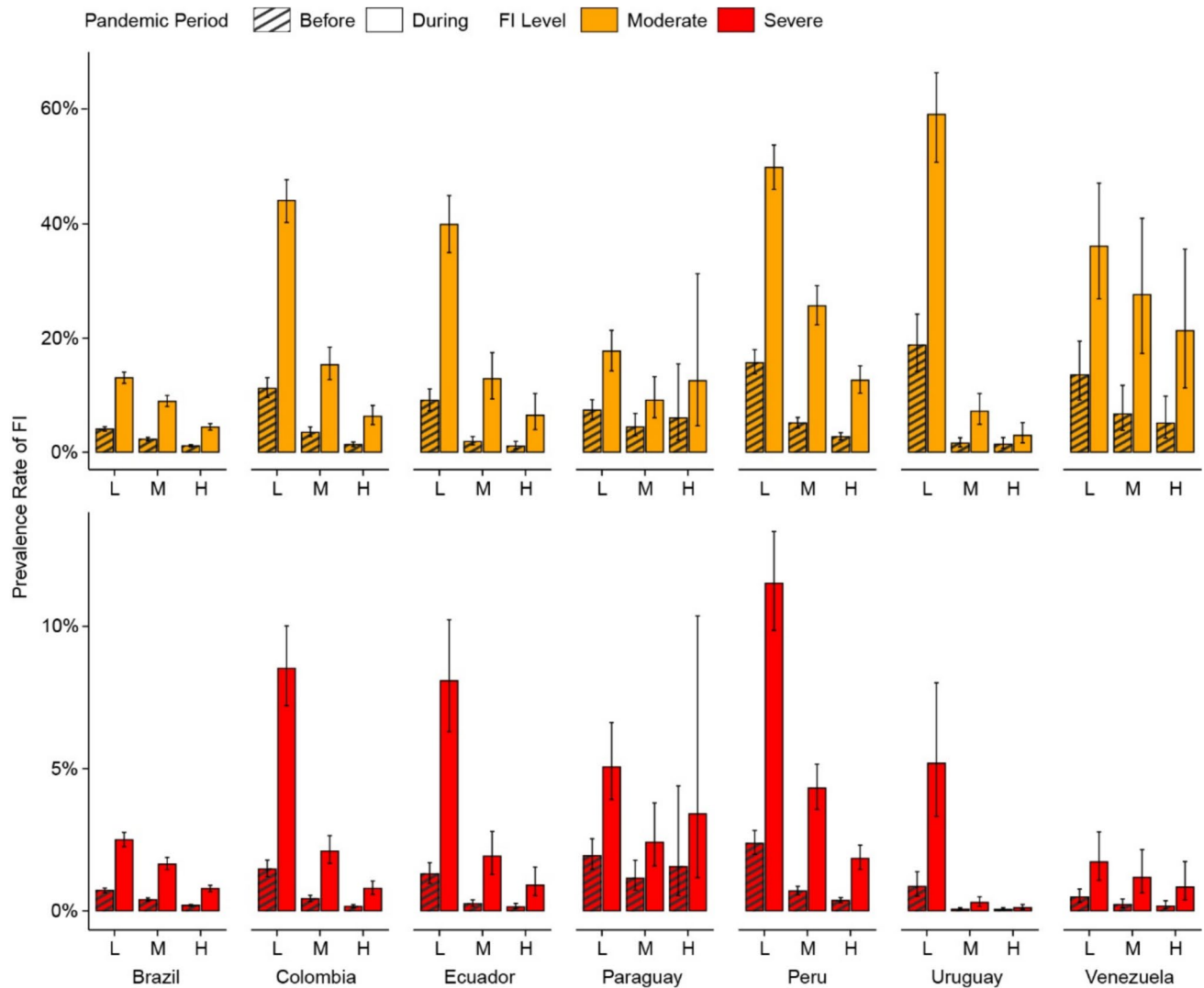


Fig. 3 Prevalence rate of households from different income classes experiencing Moderate and Severe FI based on income and pandemic period in each country. The error bars (vertical lines inside the bars on Y-Axis) represent 95% credible Confidence Intervals

Historical trends (Sousa et al., 2019a, 2019b) and specific Food Security and Nutrition (FSN) policies and actions developed by each country (Espinosa-Cristia et al., 2019; Farrow et al., 2005; Gómez Perazzoli, 2022; Vargas & Penny, 2010; Vasconcelos et al., 2019) suggest pre-existing problems and vulnerabilities in South America (Clapp & Moseley, 2020). Countries with less social support and higher inequality rates, as in South America, tend to be more impacted (Myers, 2006; Ohnsorge & Yu, 2022; Rosen & Shapouri, 2009), mainly because the fiscal adjustments implemented to contain the crisis usually prioritize cutting resources for strategic social programs that fight hunger and poverty (Sousa et al., 2019a, 2019b). While these austerity measures proved incapable of containing the negative effects of previous crises, fiscal incentives and investment in social policies not only mitigated

the harmful effects on the population but also accelerated the recovery of the economy (Farnsworth & Irving, 2015; Starke, 2013).

Existing studies on the impact of the COVID-19 pandemic lack clear narratives regarding how changes in FI may vary among socioeconomic groups (Bloem & Farris, 2022). In this study, we demonstrate that in South America the lower-income families experienced a greater impact of FI after the onset of the pandemic. It may seem plausible that poorer families have been more vulnerable due to limited access to financial safety nets and a lower capacity to protect themselves from disruptions caused by the pandemic. Contrary, wealthier families more integrated into the national or global economic system, could be less directly affected by disturbances related to the pandemic (Aggarwal et al., 2020; Mahmud & Riley, 2021).

South America is among the most unequal regions in the world in terms of wealth concentration, where the richest 10% of the population hold around 58.4% of income (World Inequality Lab, 2022). A positive, albeit nonlinear, correlation exists between economic development and the enhancement of resilience capacities within the food system. On average, countries with a higher per capita GDP exhibit higher scores in terms of food system sustainability. The increase in per capita GDP is associated with induced improvements in FNS (Béné et al., 2022).

The COVID-19 pandemic in 2020 resulted in a global 30.7% rise, from 88 to 115 million, in the population living in extreme poverty (defined as individuals earning less than US\$1.90 per day) (World Bank, 2020), paralleled by the emergence of 5.2 million new millionaires (Credit Suisse, 2021). The increase in unemployment during the pandemic boosted informality and precariousness, and restriction and flexibility of laws and labour rights (Acevedo et al., 2021; Huang, 2022; Lima & Durán, 2021; Llop-Gironés et al., 2021; McNamara et al., 2021; Parwez, 2022). In this context, conditional cash transfer programs should play a pivotal role in mitigating the negative effects of inequality (Kabeer & Waddington, 2015; Molina-Millan et al., 2016).

Simultaneously with these shifts in population income levels, food prices experienced an upward trajectory. Despite the pandemic having negatively affected GDP growth worldwide, the economic contribution of the agricultural sector in South American countries increased and food exports grew by an average of +5% (World Bank, 2022b). The region is among the largest food producers in the world, contributing 8.9% of GDP (World Bank, 2022a) and employing 14% of the population (International Labour Organization, 2022). Thus, South American countries have production chains that are strongly connected to the global market, with a focus on exports, strongly hindering food self-sufficiency and leaving the population exposed to fluctuating financial market prices and inflation, thereby reducing access to food (Baer-Nawrocka & Sadowski, 2019; Khoury et al., 2016). This dramatic scenario questions whether food systems, at least in South America, have as their primary objective to provide enough food for their population, or simply to trading food.

In addition, the devaluation of South American currencies against the US dollar (OECD, 2022) further boosted food exports and accentuated inflation in the price of the basic food basket, which reached 21.9% in 2020 (FAO, 2021). Among the countries studied, Uruguay (13.8%) and Brazil (9.1%) showed the largest price increases, while Paraguay (1.2%) and Ecuador (0.8%), the smallest (FAO, 2021). Any increase in the price of food should affect the poorest population more intensely by committing a greater percentage of income to food alone (Smith et al., 2017; Sousa et al., 2019a, 2019b). For example, in Peru, the country with the greatest increase in FI according to our results, the cost of

a basic food basket corresponds to 34.8% of the minimum wage (INEI, 2020), while in Paraguay (lower increase in FI) the cost is 12.0% (INE, 2020).

Macroeconomic indicators appear to be linked to the low resilience of food systems and the sudden increase in FI during the COVID-19 pandemic. Countries with the worst FI prevalence had a greater proportion of informal workers, and lower GDP growth and GNI PPP (Gross National Income per Purchasing Power Parity). Peru and Ecuador were also the countries with the highest percentage of informal labour (70.1% and 68.6%, respectively) and agricultural labour force (27.4% and 29.7%). In 2020, the countries that in our study had the highest levels of Moderate and Severe FI, Peru and Ecuador, had the biggest declines in GDP (− 10.9% and − 7.8%, respectively); while Paraguay and Brazil, with the smallest declines in GDP (− 1.2% and − 2.1%), showed the least dramatic FI levels, reinforcing the relationship between economic indicators and loss of FNS. In addition, Peru and Ecuador had the lowest social protection coverage (29.3% and 31.7%) and recorded the greatest increase in the Gini Index between 2019–20 (+ 2.2 and + 1.6, respectively) (World Bank, 2022c; Suppl. Table 5).

There is no way to fully assess the effectiveness of measures aimed at reducing the impacts of future pandemics or other major food security shocks based solely on economic indicators, without considering the numerous variables associated with the environmental, cultural, geographic, historical, political, and social complexity of each country. Specifically, it is necessary to take into account how each country has developed and implemented its policies to combat hunger, poverty, and inequality over the years (Espinosa-Cristia et al., 2019; Piñeiro et al., 2010). Several authors have emphasised the need for FSN programs to be integrated with policies across multiple government sectors (Mavridis & De Walque, 2022; Piperata et al., 2011, 2016). Brazil was one of the most organized countries in this regard, having established a food and nutritional security management council (CONSEA) composed of members from different political and social spheres. This council has implemented interconnected actions in the agrarian, educational, economic, and health sectors (Vasconcelos et al., 2019). For example, the School Feeding Program (PNAE) is based on sourcing 30% of food from local small farmers, ensuring access to high quality food for children (Campos, 2013). This policy not only contributes to reducing FI, but also to providing a stable income to ~400 thousand small-family farmers. Additionally, it increases the diversity of the food supply and may, potentially, reduce the carbon footprint by lowering the costs of food distribution. In Brazil alone, the closure of schools meant that around 40 million children were left without food due to the interruption of meals (WFP, 2020). This has particularly affected poorer families by putting pressure on an already tight monthly budget.

Our study faces some limitations that are important to discuss as they may result in bias in our results. Firstly, the sampling strategy through virtual platforms likely conditioned homogeneous access of the population and representativeness, not only by economic class strata but also by region and age. FI scales should be administered by trained professionals, but due to the preventive health safety regulation during the pandemic, we opted for an online approach, limiting our sample to those areas with reliable internet access, and restricting the participation of people living in rural and isolated localities due to lower internet coverage. It is estimated that 74% of the population of South America has access to the Internet, and that this access is double in urban areas (World Bank, 2020). To address this limitation, we established a wide collaborative network tasked with disseminating our research, since Internet access is more common among young people, as an intermediate access route to the heads of households responsible for food. Since these rural communities, and even in urban settlements, have higher extreme monetary poverty levels, lower coverage of these areas may have led to an underestimation of FI in our study. Secondly, the network of participating researchers influenced the countries included in the study, so the results cannot be extended to the entire continent. The results of our study should be interpreted with caution within particular social, economic, and geographic contexts. Thirdly, another limitation of the study is the recall period. The data reported by respondents may be subject to recall or social desirability biases because a single-point questionnaire was conducted to refer to specific events that occurred in a past health and economic crisis. Therefore, we face a possible recall bias and a telescoping effect that can affect the quality of the data, and generally tends to overestimate food consumption estimates in the recall (Abate et al., 2022; Beegle et al., 2012). This limitation may have implications that must be considered since households could exaggerate food consumption, then they could indicate lower FI levels than they really are. Fourthly, we acknowledge the inherent trade-off in using individual FIES items as proxies for overall food insecurity. While the full FIES scale offers a more nuanced perspective, cross-cultural comparability using the full scale presents significant challenges. Therefore, we adopted these specific indicators, recommended by the FAO for global comparisons (Cafiero et al., 2018), to ensure internationally comparable measures of food insecurity prevalence. Although these indicators do not capture the full spectrum of food insecurity, they provide reliable insights into critical aspects of food deprivation across diverse contexts. Diagnostic analyses supporting the assessment of our findings are available in the Supplementary Table 6. Finally, the cross-sectional design does not allow establishing causal relationships between the emergence of the COVID-19 pandemic and FI. Our study uses a before and after approach to compare the

prevalence and severity of FI. Furthermore, although the main global change between both periods is the appearance of the COVID pandemic, we cannot establish an exclusive causal relationship, since other variables or trends unrelated to the pandemic could be affecting the results. However, despite the abovementioned restrictions and the need to be cautious when generalizing and interpreting the results, our extensive sample size allowed for robust statistical analyses, yielding essential insights into the impact of the COVID-19 pandemic on FNS in South America. This information is highly useful in addressing current FNS challenges in South America, and even during future crises, including potential pandemics.

We shed light on the complex challenge of tackling FNS. In this regard, the imperative lies in policymakers crafting anti-hunger initiatives underpinned by multifaceted strategies, bolstering agrarian reform policies, alleviating poverty, and labour precariousness, and above all, executing effective measures for curbing food price inflation and socioeconomic inequalities. The post-pandemic phase should result in key changes within the food systems with emphasis on strengthening resilience to address the inequality of accessing healthy food (Mardones et al., 2020), and adopt risk-based approaches to target interventions and policies to mitigate future shocks. We need to develop further studies that allow for the implementation of a multilevel, person-centered framework to understand how people living in food-insecure households cope with inadequate access to food themselves and within their households, communities, and the broader food system. Many of these coping strategies can have an adverse impact on health, particularly mental health conditions when maintained over time (Fang et al., 2021; Kolovos et al., 2020). The improvement of opportunities to improve access to programs and policies that support food security is essential to support better health outcomes, both in terms of quantity and quality of diet. Additionally, existing food assistance programs themselves could be used as a platform to monitor FI. We need to accelerate progress towards the Sustainable Development Goals and by strengthening local and global food systems. Locally produced food may be an opportunity for a new low-cost for better production agri-food system that would reduce long-distance transportation and distribution by third parties with significant carbon footprints (Weber & Matthews, 2008). Finally, food security requires a “One Health” and “Planetary Health” approach, to cut across traditional domains to address the challenge posed by COVID-19 (Mardones et al., 2020). The pandemic demonstrated our increasingly global, interdependent, and environmentally constrained societies. Crises in food systems, such as COVID-19, go beyond a single-sector approach and require the mobilization and integration of knowledge and skills across geographic, institutional and disciplinary boundaries. These findings underscore the

urgency of implementing comprehensive and coordinated approaches to address the multifarious aspects of the food security challenge.

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Authors contribution Conceptualization; CFAVN, PM; Data curation; CFAVN; Formal analysis; CFAVN, HREB, DV; Methodology; CFAVN, MJ, DT, DV, HREB, SMG, JEF, TQM, FOBM, AS, AM, WAC, LHMB, AIAS, DSF, TLS, IILF, MIAS, RMFB, MAO, FSF, RRS, JHJ, MVSb, SAS, DGR, DCLO, VRFF, HKLS, MFP, RBM, MPLR, WAR, RGP, FLS, JSSR, MAA, JDVZ, GGU, ERMD, MLPV, ERR, JCCV, MDRF, LPR, DASD, DG, PM; Original draft. CFAVN; Writing—review & editing. CFAVN, MJ, DT, DV, HREB, SMG, JEF, PM; All authors read and agreed with the draft.

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Data Availability Data will be made available on request.

Declarations

Conflict of interest The authors declared that they have no conflict of interest.

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Carlos Frederico A Vasconcelos-Neto Graduated in Biological Sciences from the Federal University of Paraíba (2013). Master's degree in Ecology from the University of São Paulo (2014-2016). PCI-D fellow at the Mamirauá Institute for Sustainable Development (2017-2022). He has 9 years of experience in the field of Ecology, with an emphasis on Ethnozoology, Ethnecology, and Human Ecology, focusing on the impacts of hunting on wildlife in the Caatinga and Amazon biomes. Since

2020, he has been conducting research in the area of Food and Nutritional Security. Additionally, he has 7 years of experience in data analysis, statistics, and programming in R language, and one year in SQL, Python, and Power BI.



Michelle Cristine Medeiros Jacob professor in the Nutrition Department at the Federal University of Rio Grande do Norte, contributes to the Graduate Program in Social Sciences and leads LabNutrir. LabNutrir is a research hub focusing on the vital connection between biodiversity and nutrition, with a goal to foster more sustainable and equitable food systems. Michelle's research explores the role of wild foods and their biocultural significance within these systems, as well as the socio-

psychological factors that influence dietary choices.



Daniel Tregidgo holds a degree in Biological Sciences from Lancaster University (2009), a master's degree in Ecology and Environmental Management from the University of York (2011), and a doctorate in Ecology with a joint degree from the Federal University of Lavras and Lancaster University (2017). He is a researcher at the Mamirauá Institute for Sustainable Development. His work primarily focuses on the role of Amazonian biodiversity in the food and nutritional security of rural populations, and he is active in research, dissemination, and outreach projects.



Denis Valle has a PhD in Ecology (from Duke University) and MS degrees in Statistics (from Duke University) and Forest Resources and Conservations (from University of Florida). He is currently an associate professor at the School of Forest, Fisheries, and Geomatics Sciences at the University of Florida. His research is at the interface of global environmental change and data science. Many of his projects have focused on developing novel statistical models and quantitative methodologies for applied

problems in the Amazon region.



Hani Rocha El Bizri is a Lecturer in Conservation Biology at the University of Salford, UK, and a Scientist at the Center for International Forestry Research (CIFOR), Indonesia. He earned his PhD in Natural Sciences from Manchester Metropolitan University, UK, and has been recognized as a Green Talent by the German Federal Ministry of Education and Research. He has extensive experience coordinating large-scale projects on wildlife use and biodiversity monitoring in the Global South,

particularly in South America. He dedicates to advancing sustainable wildlife use practices through community-based research and management, and by using innovative methods, such as citizen science and ecological modelling.



Sávio Marcelino Gomes. Nutritionist with a master's and PhD in public health. Currently, he works as a Professor in the Nutrition program at the Federal University of Paraíba and as a Researcher at the Laboratory of Biodiversity and Nutrition (Lab-nutrir), where he studies social inequalities in food systems in the Global South.



Julia E. Fa holds a doctorate in Animal Ecology from the University of Oxford and has over 30 years of experience in academic research and teaching conservation science across Africa, Latin America, and Europe. As a Professor of Biodiversity and Human Development at Manchester Metropolitan University, UK, she combines her extensive knowledge of ecology with a keen interest in the interplay between human activities and wildlife. Her research primarily explores the dynamics of

hunting and wildlife use in tropical and subtropical regions, as well as the underlying factors contributing to zoonotic disease transmission. Julia is also a Senior Research Associate at the Center for International Forestry Research (CIFOR), where she leads the Bushmeat Research Initiative. Through her work, she aims to bridge the gap between biodiversity conservation and sustainable human development, providing valuable insights into the ecological and socio-economic challenges faced by communities reliant on wildlife resources.



Thais Q. Morcatty is a Lecturer in Environmental Futures at the Department of Geography, University College London. She earned her PhD in Anthropology and Geography from Oxford Brookes University, UK, and her MSc in Ecology from the National Institute of Amazonian Research, Brazil. Dr. Morcatty has worked at institutions such as the Wildlife Conservation Society and the Mamirauá Sustainable Development Institute. With over 10 years of hands-on experience researching socioecologi-

cal systems, she particularly focuses on the role of wild meat for Amazonian communities and the wildlife trade supply chain. She is dedicated to conducting research in partnership with local communities and is engaged in advanced data analysis to support strategies for sustainable wildlife use and enhance food sovereignty. Dr. Morcatty is a member of REDEFAUNA - Research Network on Diversity, Conservation and Use of Wildlife in Amazonia and ComFauna - Community on Management of Wildlife in Latin America and Amazonia.



Frederico Ozanan Barros Monteiro. Professor Monteiro's career has been characterized by dedication to teaching, research, and leadership in animal health and production. He currently holds a research fellowship from the National Council of Technological and Scientific Development (CNPq - PQ 1D) and is a Full Professor at the Federal Rural University of the Amazon (UFRA). His research is primarily focused on wild animals, primates, and the application of ultrasound technology in animal reproduction. Beyond his academic roles, Dr. Monteiro has a wealth of practical experience. He

worked as a veterinarian in a private clinic, gained experience in the reproduction of domestic carnivores, and served as a visiting professor at the University of Texas MD Anderson Cancer Center (2014-2015). This multifaceted experience provides a rich context for his current research, which combines cutting-edge technology with practical applications in animal health and production.



Alessandra Scofield is graduated in Veterinary Medicine, Master's degree and PhD in Veterinary Sciences from the Rural Federal University of Rio de Janeiro and professor at the Faculty of Veterinary Medicine, Postgraduate Program in Animal Health in the Amazon and Residency Programs in Small Animal Medical and Surgical Clinic, Wild Animal Medical and Surgical Clinic and Medical and Reproduction Clinic of Ruminants and Equidae at the Institute of Veterinary Medicine, Federal University of

Pará. Alessandra has a 19-year experience working in the Brazilian Amazon and her research is focused in the parasitic and infectious diseases of domestic and wild animals, with an emphasis on parasitic zoonoses, parasitic and infectious agents transmitted by arthropods, arthropod vectors, immunodiagnosis and molecular biology.



Alessandra Matte is researcher in the Postgraduate Program in Agroecosystems at the Federal Technological University of Paraná. Animal Scientist, Master's and Ph.D. in Rural Development. Coordinator of the Research, Innovation, and Extension Network in Rural Development (Rede Campo). Her research primarily focuses on family farming and livestock, with an emphasis on agri-food systems, vulnerabilities, and social reproduction.



Willandia A. Chaves is a conservation social scientist working with the human dimensions of fish and wildlife conservation, using tools and methods from different fields, including Conservation Psychology, Economics, Human Geography, Wildlife Management, and Education. She is an Assistant Professor in the Department of Fish and Wildlife Conservation at Virginia Tech. Her research aims to understand how people make decisions about their use of natural resources and, in turn, use this understanding to foster more

sustainable behaviors and influence policy. She is interested in wildlife trade, how urbanization affects people and biodiversity, broadening participation in STEM education, and cutting-edge approaches to collecting sensitive information on natural resource use (e.g. illegal wildlife trade).



Luiz Henrique Medeiros Borges has a doctorate in Ecology, extensive experience in consulting, teaching and research, currently coordinates projects at SOS Amazônia focused on conservation and education.



Tiago Lucena da Silva is Professor at the Federal University of Acre (UFAC) Campus Floresta, Cruzeiro do Sul. Master's and Doctorate in Animal Biology from the Postgraduate Program in Animal Biology, concentration area in Structural Biology, UNESP/IBILCE. Coordinator of the Animal Biology Laboratory, where he develops projects with Biology, Management and Conservation of Amazonian Chelonians.



Antônia Ivalnice Castro da Silva obtained the degree in Agronomy, MSc and PhD in Environmental Sciences and Sustainability in the Federal University of Amazonas (2006). Researcher at the Research Centers: Ethnoecology in the Brazilian Amazon (NETNO/UFAM); Laboratory of Rural Education and Agroecology (LEduCA/UEA) and Center for Socio-environmental Studies of the Amazon (NESAM/UEA). Adjunct Professor IV at the Nature and Culture Institute/Federal University of Amazonas, in the area of agroecology and conservation of natural resources. She has experience in the area of Agronomy, with an emphasis on Family Farming, working mainly on the following topics: food security, agrobiodiversity, agricultural production and marketing and local supply on the triple border (Brazil/Peru/Colombia).

of Amazonas, in the area of agroecology and conservation of natural resources. She has experience in the area of Agronomy, with an emphasis on Family Farming, working mainly on the following topics: food security, agrobiodiversity, agricultural production and marketing and local supply on the triple border (Brazil/Peru/Colombia).



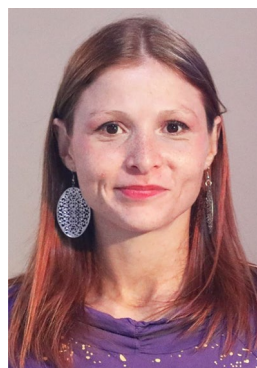
Dídac Santos-Fita currently professor and postdoctoral researcher in the Department of Social and Cultural Anthropology at the Autonomous University of Barcelona. His research focuses on the field of human-nature relations, ethnozoology, use and management of fauna, within the specialties of hunting, cosmovision, food security and sovereignty, impact of human activities, sustainable use and conservation of natural resources and productive strategies. Dídac has been working for 17 years

among indigenous peoples (Yucatec Maya and Purhépecha) and mestizos in Mexico and Afro-descendant and rural communities in the Brazilian Amazon.



Isaac Ibernson Lopes Filho graduated in Agricultural Engineering from the Federal University of Acre (UFAC) in 2001, with a Master's degree in Animal Science from the PPGESPA/UFAC Program. He is a career civil servant for the Government of the State of Acre in the State Department of Agriculture and currently responsible of Planning and Budget Director for the municipality of the city Cruzeiro do Sul in the State of Acre. Previously, he assumed the positions of Head of the Acre environmental Institute (IMAC) in the Juruá region and State Secretary of the Environment (SEMA).

environmental Institute (IMAC) in the Juruá region and State Secretary of the Environment (SEMA).



Maria Isabel Afonso da Silva is a biologist and holds a PhD from the Postgraduate Program in Animal Biology at the Universidade Estadual Paulista "Júlio de Mesquita Filho", UNESP/IBILCE. Currently, Maria is a researcher and professor at the Federal University of Acre (BR). Responsible for the Animal Biology Laboratory at UFAC- Campus Floresta, where she develops projects aimed at the study and conservation of animal biodiversity in the far western Amazon. Maria Isabel is particularly interested in the areas of herpetology and wild animal management,

animal physiology, cell biology, hematology and ecotoxicology.



Rebeca Mascarenhas Fonseca Barreto is a Researcher and Associate Professor at the Federal University of Vale do São Francisco, where she has worked since 2010. She has a Bachelor's degree in Biological Sciences from the State University of Santa Cruz and a PhD in Ecology and Evolution from the State University of Rio de Janeiro, with an internship sandwich in Quantitative Ecology from North Carolina State University. Currently, her interests focus on the use of statistical tools and qualitative

and/or quantitative models, aiming to identify and explain patterns found in her research.



Marcela Oliveira holds a bachelor's degree in Biological Sciences from the Federal University of Rondônia (2006), a master's degree in Ecology and Natural Resources Management from the Federal University of Acre (2012) and a doctorate in Biodiversity and Biotechnology from Rede Bionorte from the Federal University of Rondônia (2022). She is currently a lecturer on various courses at the Metropolitan College of Rondônia (UNNESA) and the Aparício Carvalho University Centre

(FIMCA), and a permanent lecturer and advisor on the Postgraduate Program in Conservation and Use of Natural Resources (PPGReN) at the Federal University of Rondônia (UNIR). She is a researcher with the Research Network on Diversity, Conservation and Use of Amazonian Fauna and a volunteer with the Association for Ethno-Environmental Defense. She is a post-doctoral fellow linked to the Saúde Única project in the areas of urban and peri-urban streams in Porto Velho (SUIg). She has experience in the areas of human ecology, ethnoecology and mammal ecology, working mainly on the following topics: game fauna, subsistence hunting, sport hunting, linear transects, mastofauna, road ecology and exotic species. Above all, she is Pietra's mother.



Felipe S Ferreira has a degree in Biological Sciences and master's degree in Molecular Bioprospection from the Universidade Regional do Cariri and a PhD in Biological Sciences (Zoology) from the Universidade Federal da Paraíba. He is currently a professor at the Universidade Federal do Vale do São Francisco, working at the Ecology Course. He works in the Postgraduate Program in Ciências da Saúde e Biotecnológicas (UNIVASF). He has experience in the area of Zoology, with an

emphasis on Ethnozooology. He works on the following topics: Ethnozooology, zooterapy, socio-ecological systems and systematic review.



Ricardo Rodrigues dos Santos has been a zoology professor at the Federal University of Maranhão, Brazil, since 2006. He is affiliated with the Department of Oceanography and Limnology and held a visiting position at the University of Georgia during 2013-2014. He holds a bachelor's degree in biology, a master's degree in zoology, and completed his PhD in animal behavior at the Federal University of Rio Grande do Norte in 2010, specializing in the feeding behavior of neotropical primates.

His extensive experience includes research in the Amazon, Cerrado, and mangrove forests.



Jaime Honorato Júnior is Professor of Pest Management: Phytopathology in EARTH University and participates in the Work Experience course. He has research works published in scientific journals of Phytopathology, which deal with: etiology, diagnosis, epidemiology and integrated management of diseases of tropical crops. Jaime is Brazilian, Agricultural Engineer graduated from EARTH, his Alma Mater, with Ph.D. in Phytopathology by the Universidade Federal de Viçosa, Brazil. He

also worked as Professor of Microbiology of Soils at the Universidade Federal do Oeste da Bahia, Brazil. The main objective of the course given by Jaime, who is also his professional motivation, is to stimulate critical thinking about the phytopathological information available that allows the student to manage plant diseases in an ethical and sustainable manner.



Marilene Vasconcelos Silva Brazil. Responsible for the Biodiversity Department of the State Secretariat for the Environment of Acre - SEMA/AC. Graduated in Full Degree in Biological Sciences from the Federal University of Acre (2002), master's degree in Ecology and Natural Resource Management from the Federal University of Acre (2006) and PhD in Biodiversity and Biotechnology PPG-BIONORTE from the Federal University of Acre (2020). He

has experience in the areas of zoology, ecology and paleontology, working mainly on the following topics: public policies, the Amazon, herpetology (especially snakes and chelonians), chelonians, hunting and fauna more broadly.



Shirliane de Araújo Sousa Adjunct Professor at the State University of Ceará (UECE/FAEC). She has a PhD in Animal Science (UFPI); Masters in Zoology (UFPA/MPEG); Degree in Biological Sciences (UFPI); Coordinator of the Education and Zoology Laboratory (LEDZOO), of the Interdisciplinary Educator Training Laboratory (LIFE); and Education, Research and Extension Projects; Coordinator of the Crateús Com Ciências Extension Program. Her research topics

include: zoology and education; ethnobiology; education in museums; inclusive education; gender bias and female protagonism in academia. Co-founder of networks: Mulheres em Zoologia and OrnitoMulheres.



Deise C L Oliveira. Graduated in Rural Development from the Federal University of Pará. Master's student in the Postgraduate Program in Family Farming and Sustainable Development (MAFDS) at the Amazon Institute of Family Farming (Ineaf) at the Federal University of Pará (UFPA). Rural Development Agent, interested in studies on agrarian conflicts in the Amazon, peasantry and rural settlements. I work on research on the following topics: Social conflicts, Traditional Knowledge, Management of Wild Fauna and

Flora, Management of natural resources in the Amazon, Relationship to Society and Nature, Ethnobiology and Ethnoecology, Extractive reserves and Traditional peoples and communities.



Valéria Raiana Fonseca Ferreira is a veterinarian, a graduate from the State University of Maranhão (2017). She holds a master's degree in Animal Health and Production in the Amazon, from the Federal Rural University of the Amazon (2022), where she researched food security during the COVID-19 pandemic. She has been working for 7 years in the field of small animal medicine.



Hyago K de Lucena Soares is a biologist with a keen interest in the connections between humans and animals. His research interest are ethnozoology, ethno-ornithology, wildlife uses, wildlife trade and conservation. His research focus particularly on global patterns of wildlife use and ecological and environmental drivers of wildlife trade and uses.



Marcia Freire Pinto. Biologist, Specialist in Alternatives for a New Education, Master in Development and Environment and PhD in Ethnobiology and Nature Conservation. I work in the areas of Ethnobiology, Socio-environmental Analysis, Fisheries Management, Environmental Management, Conservation of fishing resources and Teaching Practices in Science and Biology. I have nine years of experience in higher education and more than ten years in ethno-biological research.



Raone Beltrão-Mendes undergraduate in Biological Science, Master in Ecology and PhD in Biological Science (Zoology). He concentrates his research on medium- and large-mammal ecology, with an emphasis on the ecology and behavior of Neotropical primates. Raone has over 20-year of experience working with medium and large mammals and primates in the Brazilian Caatinga, Atlantic Forest, and Amazon. Throughout this period, he developed activities on the distribution, density, habitat

factors driving mammal and primate abundance, and hunting pressure. In the meantime, he has contributed to local and regional conservation strategies, being a permanent consultant member of the National Action Plans for the conservation of Northeastern Brazilian primates, as well as a senior coordinator of risk assessments and analysis. He has executed and coordinated such activities in association with local and regional institutions, and also being part of post-graduate programs as supervisor and post-doc fellow.



Marcos Paulo Lopes Rodrigues is Master's student in Zoology at the National Museum/UFRJ. Graduated in Biological Sciences from the Faculty of Education of Crateos/ State University of Ceará. Collaborating researcher at the Education and Zoology Laboratory, working with zoological collections. Member of the research and extension group, Crateús Com-Ciencia. Collaborates in teaching and extension research in the area of Education and in the area of Zoology and Conservation.

Collaborating researcher at the Ceará Natural History Museum Prof. Dias da Rocha in the Herpetology laboratory.



Wáldima Alves da Rocha PhD in Zoology from the University of Brasília (UNB). Master's degree in Zoology from the Museu Paraense Emílio Goeldi (2007). Graduated in Biological Sciences from the Federal University of Piauí (2002) and a bachelor's degree in Biological Sciences from the Federal University of Piauí (2004). She has experience in Zoology, with an emphasis on Ecology, Evolution and Biogeography of Reptiles, working mainly on the following topics: reptiles, snakes, biological

inventories and zoological collections. Since 2013, she has been an Adjunct Professor of the Biological Sciences course at the Senador Helvécio Nunes de Barros Campus of the Federal University of Piauí (UFPI).



Roberto Gutierrez Poblete is a Peruvian biologist, Curator and Principal Researcher of the Herpetology Area of the Natural History Museum of the Universidad Nacional de San Agustín de Arequipa, Peru, and specialist in monitoring of the biodiversity in the Areas Protected Natural service of the Ministry of the Environment Peru. He works in wildlife management, management and conservation of protected areas, use of wildlife, one health, interested in the systematics of amphibians and reptiles

of the tropical Andes and the coastal desert, with a special focus on lizards of the genus *Liolaemus*. Roberto has carried out several studies on biodiversity, inventories, biological evaluations and monitoring programs in the country. He has published more than fifty scientific articles, books and book chapters.



Francisco Luigi Schettini. Graduated in Veterinary Medicine from the National University of San Marcos of Lima (2005). Diploma in biodiversity management from the postgraduate unit of the Faculty of Veterinary Medicine from the National University of San Marcos of Lima (2008). Master's degree in marketing from the ESAN University of Lima (2017). He has more than ten years' experience in projects financed by international and private sources. Professional with high sensitivity

and concern for the care of the environment, the well-being of local communities and the sustainable management of their biodiversity. He currently works at the NGO DRIS (Sustainable Rural Development), responsible for project management (design, execution, monitoring and evaluation) in communal reserves in the Peruvian Amazon.



Joe S S Rojas. Forestry Engineer from the National University of the Peruvian Amazon (2005). Magister Scientiae in Management and Conservation of Tropical Forests and Biodiversity of the Tropical Agricultural Center of Research and Teaching – CATIE -Costa Rica (2015). Professional with 5 years of research experience in management and conservation of flora and fauna of the Peruvian Amazon. He has 3 years of work with native and peasant communities of Loreto and Ucayali on forest tenure of

the territory. Additionally, he worked supervising forest concessions in Madre de Dios region. Currently, since 2020, he is a specialist in Administration Contracts, a mechanism that supports the co-management of the Natural Protected Areas of SINANPE.



Marco Antonio Arenas Aspilcueta. Agricultural Engineer with a Master in Biodiversity Management and a Master in Public Management; with specialty and experience in conservation and management of biodiversity (protected natural areas), strategic planning and articulation of the territory, project management, financial sustainability, governance and participation in the territory with Indigenous Organizations and/or Local Population; works in adaptive management, territory management;

ecosystem management in the Andes and the Amazon In recent years in terms of participation and governance, with emphasis on populations, on issues associated with forms of conservation and management, legal security, territorial management, food security, health, and Indigenous Population in Isolation and Initial Contact.



Justo D V Zevallos Veterinarian with extensive experience in Agricultural Health, agri-food safety, public health, animal health surveillance (epidemiological investigation, outbreak control), public management, quality management systems; University Teaching and Manager; graduated from the Universidad la Católica of Santa María de Arequipa, Peru, with a Master's degree in International Trade from the Rey Juan Carlos University in Spain, a Doctorate degree awarded by the Las Palmas University of Gran Canaria, Spain, and a Master's degree in Public Health from the Universidad de San Juan Bautista, Lima.

mas University of Gran Canaria, Spain, and a Master's degree in Public Health from the Universidad de San Juan Bautista, Lima.



Giuseppe Gagliardi-Urrutia. Biologist graduated from the National University of the Peruvian Amazon, passionate about the study of Amazonian amphibians and reptiles. Doctor in ecology and evolution of biodiversity from the Pontifical Catholic University of Rio Grande do Sul, Brazil. Founding member of the Herpetological Association of Peru, member of the Peru-IUCN amphibian specialist group and Co-Chair. He has worked for more than 20 years in the ecology and taxonomy of Amazonian

amphibians and reptiles; He has also carried out various research on issues of conservation of Amazonian natural resources. As a researcher at the Peruvian Amazon Research Institute (IIAP), he has participated in more than 20 Amazonian biological diversity expeditions, making him a great expert on the diversity of Amazonian ecosystems and species. He has more than 40 scientific publications. He has been a visiting professor at the National University of the Peruvian Amazon based in Iquitos.



Erick Rodolfo Menéndez Delgado is Principal Professor of the Business, Accounting and Commerce Science Faculty in the Universidad Laica Eloy Alfaro de Manabí and Doctor in Sea Management and Conservation for the University of Cadiz in 2022. Erick has 10 years of experience in the field of sustainability focusing in productive context. His research interests include sustainable management resources, marine resources, sustainable development, applied economy, and competitiveness in

productive contexts.



Mariela Lissette Polit-Vera was born in Portoviejo, Ecuador. She completed primary and secondary studies at the Santa Mariana de Jesús Educational Unit and higher studies at the Technical University of Manabí (UTM). She obtained my master's degree from the Polytechnic Institute of Leiria - Portugal as a Master in Intercultural Mediation and Social Intervention. She have worked as a university professor for four years and have held positions as Director of Organizational Development, Financial

Coordinator and Institutional Management Coordinator of different public companies. She enjoys reading and generating knowledge through research into social and economic reality.



Elvira Rodriguez-Rios holds a PhD in Economics from the National Autonomous University of Mexico (UNAM) and a Master of Science in Economics from the Peoples' Friendship University of Russia, and she has been a visiting researcher at the Postgraduate Department of Economics, UNAM. She is a former director of the Central Department for Research of the Laica Eloy Alfaro University at Manta, Ecuador. She teaches applied Microeconomics at Laica Eloy Alfaro University

(ULEAM) and the Manabí Technical University (UTM) and has leader of several research Projects. Her research works have been developed in Natural Resources Economics and Sustainable Development. She published research articles in international Journals.



Juan Carlos Carrascal Velásquez is a Veterinarian and Zootechnician (University of Córdoba, Colombia), specialized in Animal Welfare & Ethology and University Teaching, Master and Doctor in Veterinary Medicine from the Federal University of Viçosa in Brazil. His international leadership includes the World Veterinary Association WVA/CEVÁ SANTE ANIMAL World Award in Animal Welfare (2022). He is a full professor at the Faculty of Veterinary Medicine and Zootecnics of the University of Córdoba,

department of Animal Welfare, Ethology and Wildlife. He is an active researcher and co-founder of the One Health Colombia Network (OHCol), One Health Latin American, Iberian and Caribbean Network (OHLAIC), committed to research and education in animal welfare and public health. Currently, he directs the Technical Committee on Animal Welfare of the Department of Córdoba and is Advisor/Co-author of the One Health Bill for Colombia in the Congress of the Republic.



Maria Dalila Forlano professor and researcher at the “Lisandro Alvarado” Universidad Centrooccidental dedicated to teaching, diagnosis and research of parasitic diseases of domestic animals. She has extensive experience of 29 years of dedication in an academic environment, with great capabilities and experience in service, teaching and research, research coordinator, laboratories and postgraduate professor at various universities in the Venezuela. She graduated in Master's and Doctorate studies

in Veterinary Sciences, Veterinary Parasitology at the Universidade Federal Rural do Rio de Janeiro-Brazil. She is currently technical advisor for a veterinary products laboratory in Venezuela.



Lucy Perera-Romero graduated in Biological Sciences from Simon Bolivar University, Venezuela, and has a Master's in Conservation Biology from the University of Kent, UK. Her research focuses on the quantitative and spatial aspects of wildlife monitoring to manage subsistence hunting in Neotropical forests. She has worked on these themes with local communities in the Guiana Shield forest of Venezuela and the Maya Forest of Guatemala. She is currently conducting her Ph.D. in the

Mammal Spatial Ecology and Conservation Lab at Washington State University, USA.



Danilo A. Salas Dueñas is a Biologist with a master's degree in social project management. Research and conservation manager of the Moisés Bertoni Foundation in Paraguay. Focal point of the Mbaracayú forest biosphere reserve.



Daniel Garin Doctor from the Autonomous University of Barcelona (2002). Professor and researcher from the University of the Republic in Uruguay, from 1990 to 2015. Since 2020, President of the largest wholesale fruit and vegetable market in Uruguay. His teaching and research have been focused on the field of management of agricultural systems and sustainable use of natural resources, within the specializations of animal feeding in extensive systems, food security, and impact of


human activities in the grasslands and rural population. Garin's most relevant papers were in: i) increasing the safety of beef through technological development to improve traceability in beef chain; and ii) feeding domestic ruminates (sheep and cattle). Recently, there has been an interest in improving aspects of nutrition and health for vulnerable populations, with emphasis on overcoming a deficit in animal protein intake.



Pedro Mayor lecturer and researcher from the Autonomous University of Barcelona. His research is focused in the field of biology, ecology, health, conservation and management of wildlife, within the specializations of public health, zoonoses, one health, food security and sovereignty, morphology, reproduction, alimentary ecology of wild species, impact of human activities, sustainable models of subsistence hunting, sustainable use of natural resources and productive strategies for the rural Amazon.

Pedro has a 19-year experience working in the Peruvian Amazon. In this period, he has developed a broad and deep activity on the holistic conception of Amazon rural communities. On the framework of the concept *One Health*, Pedro has conducted health studies directed to the improve of the well-being of local communities. These activities have been always coordinated with local institutions, were based on prevention measures of low-cost, and the improvement of training programs.

Authors and Affiliations

Carlos Frederico A. Vasconcelos-Neto^{2,46} · Michelle Jacob³ · Daniel Tregidgo² · Denis Valle⁴ · Hani R. El Bizri^{2,5,47} · Sávio Marcelino Gomes⁶ · Julia E. Fa^{7,48} · Thais Q. Morcatty^{2,8} · Frederico Ozanan Barros Monteiro⁹ · Alessandra Scofield¹⁰ · Alessandra Matte¹¹ · Willandia A. Chaves¹² · Luiz Henrique Medeiros Borges¹³ · Antônia I. A. Silva¹⁴ · Dídac Santos-Fita¹⁵ · Tiago Lucena Silva¹⁶ · Isaac Ibernón Lopes-Filho¹⁶ · Maria Isabel Afonso Silva¹⁷ · Rebeca Mascarenhas Fonseca Barreto¹⁸ · Marcela A Oliveira¹⁹ · Felipe Silva Ferreira²⁰ · Ricardo Rodrigues Santos²¹ · Jaime Honorato-Júnior²² · Marilene Vasconcelos Silva Brazil²³ · Shirliane Araújo Sousa²⁴ · Deise C. L. Oliveira²⁵ · Valéria R. F. Ferreira²⁶ · Hyago K. L. Soares²⁷ · Marcia F. Pinto²⁸ · Raone Beltrão-Mendes²⁹ · Marcos Paulo Lopes Rodrigues³⁰ · Wáldima Alves Rocha³¹ · Roberto Gutiérrez Poblete³² · Francisco Luigi Schettini³³ · Joe S. S. Rojas³⁴ · Marco A. Aspilueta³⁵ · Justo D. V. Zevallos³⁶ · Giuseppe Gagliardi-Urrutia³⁷ · Erick Rodolfo Menéndez Delgado³⁸ · Mariela Lissette Polit-Vera³⁹ · Elvira Rodríguez Ríos⁴⁰ · Juan Carlos Carrascal Velásquez⁴¹ · Maria Dalila Forlano Riera⁴² · Lucy Perera Romero⁴³ · Danilo A. Salas Dueñas⁴⁴ · Daniel Garin⁴⁵ · Pedro Mayor¹ 

✉ Carlos Frederico A. Vasconcelos-Neto
fredvasconcelosnt@gmail.com

✉ Pedro Mayor
pedrogines.mayor@uab.cat

¹ Sanitat i Anatomia Animals, Facultat Veterinària, Universitat Autònoma de Barcelona, Campus UAB S/N, Bellaterra, 08640 Barcelona, Spain

² Instituto de Desenvolvimento Sustentável Mamirauá, GP Ecologia de Vertebrados Terrestres, Estrada do Bexiga, Tefé, Amazonas 258469553 - 225, Brazil

³ Departamento de Saúde Coletiva e Nutrição, Centro de Ciências da Saúde, Universidade Federal do Rio Grande do Norte, Lagoa Nova, Natal, Rio Grande do Norte 59075000, Brazil

⁴ University of Florida, Gainesville, FL 32611, USA

⁵ School of Science, Engineering and Environment, University of Salford, 43 Crescent, Salford M5 4 WT, UK

⁶ Department of Nutrition, Centre of Health Sciences, Universidade Federal da Paraíba, R. Tabelião Estanislau Eloy, S/N, João Pessoa, Paraíba 58050585, Brazil

⁷ Natural Sciences, Faculty of Science and Engineering, Manchester Metropolitan University, Chester Street, Manchester M15 6BH, UK

⁸ Department of Geography, University College London, North West Wing, Gower Street, London WC1E 6BT, UK

⁹ Institute of Health and Animal Production, Federal Rural University of the Amazon, Av. Presidente Tancredo Neves, 2501, Belém, Pará 66077 - 830, Brazil

¹⁰ Laboratory of Animal Health, Postgraduate Program in Animal Health in the Amazon, Institute of Veterinary Medicine, Federal University of Pará, Universidade Federal do Pará (UFPA), BR 316, Km 61 s/n, bairro Saudade II, Castanhal, Pará 68746360, Brazil

¹¹ Programa de Pós-Graduação Em Agroecossistemas (PPGSI), Universidade Tecnológica Federal Do Paraná (UTFPR), Prolongamento da Rua Cerejeiras, S/N, Santa Helena, Paraná 85892000, Brazil

¹² Department of Fish and Wildlife Conservation, Virginia Polytechnic Institute and State University, 310 West Campus Drive, Blacksburg, VA 24061, USA

¹³ Associação SOS Amazônia, Rua Pará, 61, Rio Branco, Acre 69905082, Brazil

¹⁴ Universidade Federal do Amazonas, Instituto Natureza e Cultura, Rua 1º de Maio, 5, bairro Colônia, Benjamin Constant, Amazonas 69630000, Brazil

¹⁵ Antropología Social y Cultural, Universidad Autónoma de Barcelona, Campus de Bellaterra, 08193 Cerdanyola del Vallès (Barcelona), Spain

¹⁶ Multidisciplinary Center, Animal Biology Lab, Biodiversity Institute, Estrada Do Canela Fina Km 12, Glebo Formoso, Cruzeiro Do Sul, Acre 69980000, Brazil

¹⁷ Education and Letters Center - CEL, Animal Biology Laboratory, Universidade Federal Do Acre - UFAC, Estrada Do Canela Fina, Km 12, Gleba Formoso, Lote 245, Colônia São Francisco, Cruzeiro Do Sul, Acre 69980000, Brazil

¹⁸ Universidade Federal do Vale do São Francisco, Colegiado de Ciências Biológicas, Rod. BR 407, Km 12, Lote 54, S/N, Petrolina, Pernambuco 56.300 - 990, Brazil

¹⁹ Programa de Pós-Graduação em Conservação e Uso de Recursos Naturais, Universidade Federal de Rondônia, Br 364, Porto Velho, Rondônia 76801 - 059, Brazil

²⁰ Colegiado de Ecologia, Universidade Federal do Vale do São Francisco, Not Applicable, Tomaz Guimarães, S/N, Senhor do Bonfim, Bahia 48970000, Brazil

²¹ Oceanografia e Limnologia, Centro de Ciências da Saúde, Universidade Federal do Maranhão, Avenida dos Portugueses, 1966, São Luís, Maranhão 65080 - 805, Brazil

²² EARTH University, Campus Guácimo, Guácimo, Limón 4442 - 1000, Costa Rica

²³ Secretary of State for the Environment of Acre, Biodiversity Department, Benjamin Constant, 856, Rio Branco, Acre 69900 - 160, Brazil

²⁴ Faculdade de Educação e Ciências Integradas de Crateús, Universidade Estadual do Ceará, Av. Gov. Beni Veras, 6217 - Veremos, Crateús, Ceará 63704 - 155, Brazil

²⁵ Instituto Amazônico de Agriculturas Familiares, Augusto Corrêa, Belém, Pará 66055 - 240, Brazil

²⁶ Programa de Pós Graduação em Saúde e Produção Animal na Amazônia, Universidade Federal Rural da Amazônia, Saúde

- E Meio Ambiente, Avenida Presidente Tancredo Neves, Nº 2501, Belém, Pará 66.077 - 830, Brazil
- ²⁷ Universidade Federal da Paraíba, Sistemática e Ecologia, João Pessoa, Paraíba 58109 - 753, Brazil
- ²⁸ Biologia, Universidade Estadual do Ceará, Av. Dom Aureliano Matos, 2058 - Centro, Limoeiro Do Norte, Ceara 62930 - 000, Brazil
- ²⁹ Post-Graduate Program in Ecology and Conservation, Universidade Federal de Sergipe, Av. Marcelo Deda Chagas, São Cristóvão, Sergipe 49107 - 230, Brazil
- ³⁰ Universidade Federal do Rio de Janeiro/Museu Nacional, Vertebrados, Herpetologia, Quinta da Boa Vista, São Cristovão, Rio de Janeiro, Rio de Janeiro 20940 - 040, Brazil
- ³¹ Núcleo de Pesquisa em Ciências Naturais do Semiárido Do Piauí - NUPECINAS, Universidade Federal do Piauí, Avenida Cícero Eduardo, Picos, Piauí 64607675, Brazil
- ³² Servicio Nacional de Áreas Naturales Protegidas, Unidad de Monitoreo de Biodiversidad, Dirección de Gestión de Áreas Naturales Protegidas, Lima 15036, Perú
- ³³ Asociación Civil Oikos, Research, Animal Health, Manuel A. Fuentes 440 San Isidro, Lima 15046, Perú
- ³⁴ Servicio Nacional de Áreas Naturales Protegidas Por El Estado -SERNANP, Dirección de Gestión de Las Áreas Naturales Protegidas -DGANP, Unidad Operativa Funcional de Gestión Participativa -UOF GP, Sede Central: Calle Diecisiete 355, Urb. El Palomar - San Isidro - Perú, Lima 51, Perú
- ³⁵ Desarrollo Ambiental y Social Perú, Gerencia de Ecosistemas, Ecosistemas y Cambio Climático, Calle Julián Sandoval 165. Dep. 102, Surquillo, Lima/Surquillo, Lima/Peru 15048, Perú
- ³⁶ Animal and Public Health, San Juan Bautista University, Veterinary Medicine School, I- 02, Ica 0051, Perú
- ³⁷ Dirección de Investigación en Diversidad Biológica Terrestre Amazónica, Instituto de Investigaciones de la Amazonía Peruana, Av. Quiñones Km 2.5, San Juan, Loreto 16007, Peru
- ³⁸ Division Carrera Comercio Exterior, Facultad de Ciencias Administrativas, Contables y Comercio, Universidad Laica Eloy Alfaro de Manabí, Circunvalación – Vía a San Mateo, Manta, Manabí 130213, Ecuador
- ³⁹ Economía, Facultad de Ciencias Administrativas y Económicas, Universidad Técnica de Manabí, Calle Chalet del Norte, Portoviejo, Manabí 130103, Ecuador
- ⁴⁰ Economics Career, Department of Economics, Universidad Laica Eloy Alfaro de Manabí (ULEAM), Circunvalación y Av. San Mateo, Manta, Manabí 130201130213, Ecuador
- ⁴¹ Ciencias Pecuarias, Facultad de Medicina Veterinaria y Zootecnia, Universidad de Córdoba/One Health Colombia, Calle 15 A número 14B- 43 Barrio Urbina, 230003 Montería, Córdoba, Colombia
- ⁴² Universidad Centroccidental “Lisandro Alvarado”, Baquisimeto, Lara, Venezuela
- ⁴³ Washington State University, Pullmann, Washington, USA
- ⁴⁴ Fundación Moisés Bertoni, Investigación y Conservación, Procer Arguello 208, Asunción, N.a., Paraguay
- ⁴⁵ Unidad Agroalimentaria Metropolitana (UAM), Montevideo, Uruguay
- ⁴⁶ Calle Enrique Granados, 30, Boadilla del Monte, 28660 Madrid, Spain
- ⁴⁷ Center for International Forestry Research - CIFOR, Bogor, Indonesia
- ⁴⁸ Natural Sciences and Environment Research Hub, University of Gibraltar, Gibraltar, Gibraltar