Bird Behavior: Rural vs. Urban *Turdus leucomelas* Prey Interaction

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Abstract. Rural and urban environments differed in various aspects with consequences for characteristics related to the behavior of diverse animal groups. However, little was known about the extent to which this behavioral differentiation between rural and urban populations was acquired or inherited, and how these differences might affect complex behaviors, such as the recognition of conspicuous patterns in potential prey. With this in mind, this study aimed to assess whether there was a difference in the predisposition to interact with conspicuous artificial prey between Thrush Bird (*Turdus leucomelas*) originating from rural and urban environments and raised under controlled captive conditions since the nestling stage. Thirty Thrushes were captured between their 6th and 10th day of life in seven municipalities of São Paulo State and hand-reared as part of another research project, with 18 from the urban areas and 12 from the rural areas. For this study, cryptic and conspicuous artificial prey were produced, thus evaluating whether certain individuals of thrushes would be more prone to attack conspicuous prey than others. The hypotheses tested addressed whether 1) there was a difference in the interaction time and number of pecks of thrushes with cryptic and conspicuous prey, and if they reacted innately, and 2) thrushes from urban areas were more likely to peck at the conspicuous artificial prey. Finally, we found no differences in the behavior of individuals from rural and urban environments and concluded that our study species had no innate avoidance of conspicuous prey.

Keywords. Urbanization. Foraging. Focal observation. Thrush. Caterpillar.

1. Introduction

The predator-prey interaction, in which the predator faces challenges and obstacles for successful predation, has strong ecological and evolutionary implications. However, this relationship may differ among populations, especially for urban and rural animals, as the impacts of urbanization cause various changes in biodiversity and natural habitats [1].

In environments altered by human activity, the abundance and variety of invertebrate species may differ significantly from those in natural environments [2], potentially leading to changes in the foraging patterns of their primary predators, including birds [3]. The result of these and other pressures imposed by urbanization is well studied in birds [4], which, for example, tend to be more audacious in urban environments compared to rural birds, which exhibit a greater fear of the unknown [5].

Given that interaction time with prey may vary at the individual level and according to their place of origin, it is important to investigate how prey color patterns influence their risk of predation,

particularly when they are conspicuous. Conspicuous coloration has evolved to protect prey against visually oriented predator attacks, as they are associated with unpalatable aposematic organisms [6].

Despite the large number of studies demonstrating that conspicuous colorations are effective in reducing prey predation risk [7], the role of ontogeny concerning the recognition of conspicuous patterns of unpalatable prey is rarely studied [8]. In this study, the innate predisposition of Thrushes (*Turdus leucomelas*) to interact with cryptic and conspicuous artificial prey models was addressed, expressed by the latency and intensity (frequency) of attacks.

2. Objectives

The aim of this study is to assess whether Thrushes captured during the nestling stage and raised in captivity instinctively avoid conspicuous artificial caterpillar models, even though they have never had contact with this type of prey. Thus, the question arises as to whether there are significant innate differences between the behaviors of thrushes captured in rural and urban areas, thus highlighting the effect of microevolution of this behavior in this species.

The following hypotheses were tested: 1) there is a difference in the interaction time and number of pecks by thrushes with cryptic and conspicuous prey, indicating that they react instinctively, and 2) thrushes originating from urban areas are more likely to peck at the conspicuous artificial prey.

3. Materials and Methods

3.1. Ethic note

This study has approvals for the procedures to be carried out, with the authorization for the research being CEUA: no. 0652 dated 09/03/2023.

3.2. Species Studied

The genus *Turdus* (Passeriformes, Turdidae) has a wide global distribution and can be classified as cosmopolitan, occurring in the Americas, Africa, Eurasia, and Oceania [9]. The Pale-breasted Thrush (*Turdus leucomelas*) is widely distributed throughout South America but is primarily found in the southern and southeastern regions of Brazil [10]. In the study area, their breeding season occurs between August and January and they are highly adapted to the urban environment, where they exhibit a varied diet, consuming fruits and invertebrates [11].

3.3. Captivity Rearing

For the realization of the present study, 30 Thrushes were used, captured between September and December 2021 as nestlings, still in the nest, between their 6th and 7th day of life, and hand-reared as part of another research project. Of the 30 individuals collected, 12 are from rural areas and 18 from urban areas, originating from the municipalities of Rio Claro, São Carlos, Campinas, Vinhedo, Itatiba, Ibitinga, and Tabatinga, all located in the interior of the State of São Paulo. All birds were raised in controlled conditions since their capture in the nests, housed in individual cages measuring 70 × 30 × 42 cm (length × width × height), visually isolated with white PVC panels.

The Thrushes are fed and provided with water daily, and the cages are periodically cleaned. Before all experiments, the food pots were removed for approximately 30 minutes, and the cage was cleaned to avoid possible distractions during the model test. Thirty thrushes were evaluated and subjected to tests with conspicuous and cryptic artificial prey randomly among individuals from rural and urban areas.

3.4. Experimental procedure

Artificial prey were produced from biscuit, an unglazed porcelain clay that hardens when dried. In field studies conducted to determine bird predation rates, indirect signs of predation are monitored through markings [12]. For this purpose, Acrilex® plasticine modeling clay is used, as it is non-toxic to animals and does not harden over time, allowing for the analysis of predation rates through bird beak marks [13]. The aim of this study, on the other hand, is to use biscuits in the production of artificial prey, as focal observation of the birds was conducted, and it allows the same model to be used in all repetitions, thus increasing the reliability of the results. Therefore, only predation attempts by the thrushes were evaluated, rather than the ingestion of the prey itself.

Firstly, artificial caterpillars made of biscuits painted with gouache paint were produced with the aim of reproducing cryptic and artificial colors. For this purpose, the caterpillar of the species *Methona themisto* (Lepidoptera) was used as a base, a possible prey of the Thrushes, as it is found throughout South America. *Methona themisto* caterpillars reach about 4 to 6 cm in length during their 4th and 5th larval instars when the caterpillar exhibits brighter colors and becomes a potential prey for the birds under study [14] (Fig. 1).

With that in mind, two artificial caterpillars were produced, one with cryptic coloration and one with conspicuous coloration, each measuring 5 cm in length with a circumference of approximately 5.5 mm. The cryptic artificial caterpillar, after drying, was painted with light and dark green gouache

paint, in order to blend both shades and make the study object as realistic as possible. Following the same scheme, the conspicuous artificial caterpillar was painted in black and yellow, colors of the larval stage of *M. themisto* (Fig. 1).

Each of the birds was observed according to the focal observation method, in which the researcher positioned himself at a distance of two cages, recording the interaction time until each individual made the first peck against the prey, along with the number of pecks made within 10 minutes after the initial interaction with it. At the end of the experiment, the food pots were properly returned to the cages.
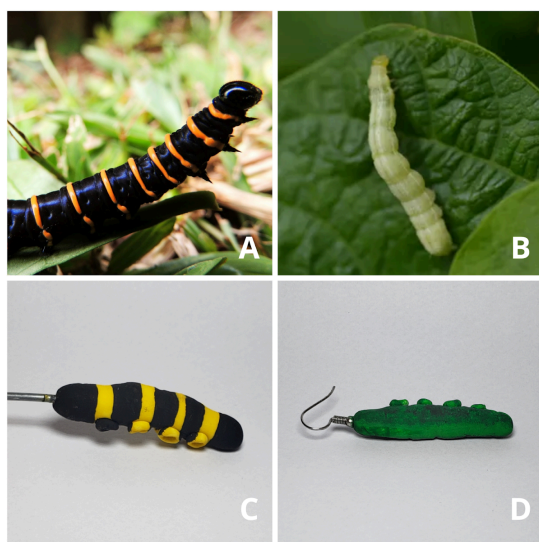

Fig. 1 - Comparison between artificial prey and prey found in nature. In "A," the larval phase of *Methona themisto* found in nature is depicted, compared to photo "C," which represents its biscuit-made model. Meanwhile, in "E," the green caterpillar (*Chrysodeixis includens*), with cryptic coloration, is represented by model "D" made of biscuits. To standardize the artificial prey, both measure 5 centimeters, corresponding to the length they reach during their 4th and 5th larval instars.

A: Image from Getúlio Vargas, Rio Grande do Sul, BR; B: Image from Ernesto de Souza/Ed. Globo; C and D: Own authorship.

3.5. Statistical analysis

Considering that each individual was observed twice, linear mixed models (LMMs) were constructed, which assume different response levels for each of the individuals. Thus, in each of the LMMs, the dependent variable was 1) the interaction time of the thrushes with the artificial prey and 2) the number of pecks delivered by them. In this analysis, the independent factors evaluated were prey color (cryptic or conspicuous) and the origin

location of the study birds (urban or rural environment). The identity of each individual will be included as a random factor in both models

Tests addressing the individual repeatability of the interaction time and the number of pecks of *T. leucomelas* with the artificial prey were also conducted. For this purpose, the above-described mixed models were reconstructed using the rptGaussian function from the "rptR" package [15], thus estimating the significance value (P) of this estimation, which provides a repeatability estimation and its significance value. The analyses were conducted using the R software [16].

4. Results and Discussion

Based on tab. 1, it's possible to assert that the alternative hypothesis is not valid, as the significance value is not less than 0.05. With this in mind, the hypotheses tested throughout the project – whether there is a greater difference in interaction time and number of pecks in conspicuous prey, and whether thrushes from urban environments are more likely to act instinctively against them – are not accepted.

Regarding the interaction time of individuals with cryptic and conspicuous prey, there were no significant differences among prey types, indicating that they do not react instinctively; origins (rural or urban), and sexes (female or male), indicating that they do not tend to react instinctively. In the analysis of the number of pecks throughout the experiment, there were also no significant differences in terms of time, prey types, and origins of the thrushes. However, there was a significant difference between the sexes, indicating that males exhibit a lower tendency to peck at artificial prey compared to females.

	Estimate	SE	t
Time to peck the prey			
Interception	4,87	1,23	3,96*
Test time	-0,00	0,00	-1,29
Type of prey (control)	-0,24	0,40	-0,61
Origin (urban)	-0,07	0,46	-0,15
Sex (male)	0,24	0,39	0,63
Type X Origin	-0,11	0,52	-0,21
Number of pecks			
Interception	4,57	2,21	2,06*
Test time	0,00	0,00	0,40
Type of prey (control)	0,09	0,76	0,12
Origin (urban)	-0,08	0,82	-0,10
Sex (male)	-1,48	0,65	-2.25*
Type X Origin	-0,84	0,98	-0,85

Tab. 1 - Results of the linear mixed-effects models assessing the reaction of Pale-breasted Thrushes (*Turdus leucomelas*) to artificial caterpillars, expressed by the time elapsed to peck at the artificial prey and the number of pecks given; the time at which the tests were conducted; the type of prey introduced (cryptic or conspicuous); the origin of the individual (rural or urban); their gender (male or female); and the interaction between the type of prey and the animal's origin. Only values marked with * have a significance value (P) less than 0.005.
SE: Standard Error.
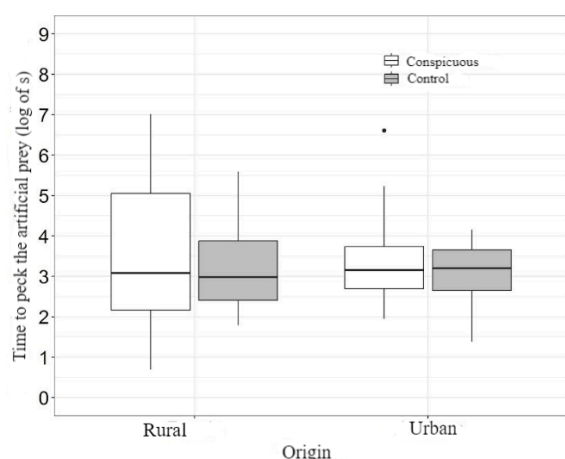
Graph 1 - Variation between the origin of the thrushes and the elapsed time until pecking at the artificial prey, with white indicating the conspicuous prey and gray indicating the control prey (cryptic).
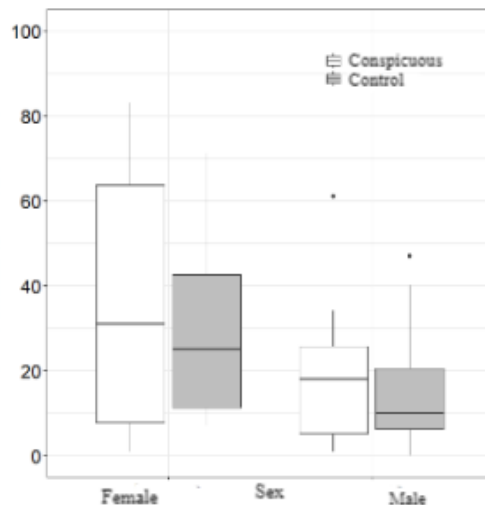
Graph 2 - differences between the sex of the analyzed individuals and the number of pecks delivered by them on the artificial prey, with white boxplots representing the conspicuous prey and gray boxplots representing the control prey (cryptic).

In Graph 1, we found that there were no significant differences in the interaction time with conspicuous and control artificial caterpillars between rural and urban individuals, suggesting a lack of innate behavior. Conversely, in Graph 2, there was a notable difference in the number of pecks originating from male and female individuals, indicating distinct behavior among conspecifics of differing sexes.

Although the main hypotheses were refuted, it is important to note that there was a difference in the significance level between sexes, with females showing a higher frequency and intensity of pecks at the prey compared to males. Thus, while the obtained result was not as expected, it indicates that behavioral differences tend not to have a genetic relationship, but rather are influenced by parental care and the environmental conditions in which the individual is situated.

In this context, it is imperative to discuss the behavioral disparities among conspecifics of opposite sexes in the feeding context. Specifically, female birds may exhibit a propensity for more vigorous predation compared to males, irrespective of their place of origin. For a more nuanced discussion, further investigation into this topic is warranted, thereby facilitating new avenues of research in the realm of animal feeding behavior.

5. Conclusion

In conclusion, this study investigated the impact of urbanization on predator-prey interactions, focusing on the innate responses of Thrushes to cryptic and conspicuous artificial prey. Through analysis of interaction time and peck frequency, the research elucidated the influence of urban environments on predator behavior. The findings emphasize the

necessity for further research on the ecological implications of human activity on wildlife.

Upon statistical analysis, we concluded that Pale-breasted Thrush (*Turdus leucomelas*) do not exhibit innate behavior when distinguished between their original environments. However, in another analysis, it was found that females of this species tend to display a distinct foraging behavior compared to males, with a higher frequency of pecks delivered to the artificial prey.

For a more comprehensive understanding of the obtained results, further research in this field is warranted to determine whether there is indeed a significant difference in feeding behavior between males and females of the same bird species, along with its intensity and relevance in the ecology of these animals.

6. References

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