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ANIMAL SCIENCE

Tracking the little ones: use of fluorescent powder to follow a leaf litter lizard (*Coleodactylus meridionalis*, Squamata: Sphaerodactylidae) in the Atlantic Forest of southern Bahia, Brazil

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Abstract: The ecology of movement is an expanding area, marked by the diversity of analytical methods and protocols, which enables this integrative reading. We investigated movement ecology aspects of *Coleodactylus meridionalis* in southern Bahia, northeastern Brazil, using fluorescent powder with mineral oil to track individuals. We monitored 69 individuals of *C. meridionalis* that walked an average distance of 148 cm in 2h. We identified this movement as foraging due to the orientation of the step sequence and microenvironments used. We find no significant differences between walking distance and weight. However, we found a decrease in activity over the follow-up period. Most of the lizard's movements were directed north, while south, east, and west were followed equally. The individuals stayed predominantly on the ground (leaf litter), but it was possible to observe the use of other surfaces, such as trunks and burrows on the ground. Therefore, we studied the movement in three dimensions (ground height, distance traveled, and orientation of steps). We observed the lizard's foraging, one of the most common and least investigated movements in small lizards like *C. meridionalis*. This involves not only the species' activity schedule but other intrinsic and extrinsic factors that shape the movement decisions of individuals.

Key words: Abiotic factors, biotic factors, foraging, movement ecology, tracking method.

INTRODUCTION

Research on the natural history and ecological processes, such as dispersal ability and species coexistence, use different methodologies to gather essential information concerning individual and population biology. Movement ecology stands out as a promising cross-disciplinary field, offering the potential to incorporate both biotic and abiotic factors to explain the movement patterns of organisms (Jeltsch et al. 2013, Pittman et al. 2014). Despite advancements in theoretical frameworks, hypothesis testing, equipment development, and analysis techniques, certain groups, such as amphibians and reptiles, still lack sufficient attention (Jacoby & Freeman 2016, Abrahms et al. 2021).

The lack of focal papers that measure, describe, and analyze the type of movement exhibited by reptiles is evident, constituting only 2.1% of 768 articles, which is a percentage notably lower compared to other groups, such as plant dispersal (19%), birds (19%), fishes (14%), and insects (11%; Holyoak et al. 2008). Furthermore, most of these studies do not specify the type of movement involved (Holyoak et al. 2008).

In a recent review of non-avian reptile movement, Crocodylia was the most studied group (44.4%), followed by Testudines (28.7%), Serpentes (7.66%) and Sauria (4.96%; Crane et al. 2021). The review highlighted ambiguous terms that could lead to multiple interpretations and highlighted the lack of detail provided for techniques used as well as results found across different studies. These factors make it difficult to compare studies, especially in under researched groups such as reptiles.

Literature brings definitions, paths, and perspectives for the standardization of movement ecology. The movement of an organism can be defined as "a change in the spatial location of the whole individual in time [...]", and depending on internal and external factors, this organism can move in different ways (Nathan et al. 2008). The best-known types of movement are dispersal, migration, and foraging. An animal disperses when it moves from the place of birth to a usually unknown location, and this movement does not precisely involve returning to the place where it started (Russell et al. 2005). Migration consists of a displacement that can extend over thousands of kilometers, for days or months at regular time intervals (Nathan et al. 2008, Jeltsch et al. 2013). Meanwhile, foraging is carried out repeatedly and involves the search for food, potential partners, and escape from predators and intolerable environmental conditions, representing a threshold for their safety within their living habitat (Jeltsch et al. 2013). Within the known techniques for movement ecology (e.g., radio telemetry, use of GPS, spool and line, fluorescent powders), most studies tend to be performed with larger and essentially terrestrial reptiles, decreasing the effort with smaller species that have arboreal, fossorial or semi-fossorial habits (Crane et al. 2021).

The genus *Coleodactylus* comprises five small lizard species that inhabit forest environments in northeastern Brazil, except for *C. septentrionalis*, which is also recorded in northern South America (Hoogmoed 1977, Cole et al. 2013, Ribeiro-Júnior 2015, Uchôa et al. 2022). Individuals of this genus present short limbs and a granular body. Their ocular adaptations denote a specialization for life on the ground, seeking refuge in the leaf litter of shaded forests (Vanzolini 1957, Brandão & Motta 2005).

Coleodactylus meridionalis occurs mainly in the Brazilian Atlantic Forest from Ceará to Bahia states. It is one of the smallest lizards in America, reaching less than 30 mm in snout-vent length (Vanzolini 1957). The species and its congeners were reported as animals with exclusively diurnal and cryptic habits, moving mainly on top of and within the forest leaf litter. For these reasons, the species and its congeners are among the least studied Sphaerodactylidae (Gamble et al. 2011). The occurrence of *C. meridionalis* in environments with different vegetation cover and annual temperatures in the Atlantic Forest may be related to a high thermal tolerance (Carilo Filho et al. 2021). However, these organisms are mainly seen on leaf litter, near tree roots and shaded environments, and shelters that can mitigate macrohabitat's effects and differences (Ribeiro et al. 2013).

To understand factors related to the animal's life history, such as finding resources, escaping stressful situations, and finally, why, when, where, and how to move, the characteristics and patterns of movements need investigation and analysis (Swingland & Greenwood 1983, Nathan et al. 2008). In this sense, this study aimed to observe and describe the movement patterns of *C. meridionalis* in the southern region of Bahia using fluorescent powders, seeking to answer the following questions involving the individual and its space use: What is the most frequent movement type in *C. meridionalis*? Is there a relationship between body weight, substrate temperature, and movements? What is the distance traveled during their hours of activity? Which microhabitat surfaces are most used in this movement? What are the environmental conditions experienced by *C. meridionalis* during the movement? And finally, do environmental conditions require changes in their movement patterns?

MATERIALS AND METHODS

Study site

We performed our study in the Reserva Ecológica Michelin (REM), established in southern Bahia, northeastern Brazil, between the municipalities of Igrapiúna and Ituberá (13°50'S, 39°10'W). This reserve covers about 3800 hectares, with 65% of forest cover divided into three main remnants: Luís Inácio (140 ha), Pacangê (550 ha), and Vila 5/Pancada Grande (625 ha). The annual precipitation is 2000 mm, and the environmental temperature varies from 18°C to 30°C. All individuals were collected and tracked in the Vila 5 Forest, illustrated in Figure 1, which covers 180 ha and hosts the most preserved forest area of the reserve.

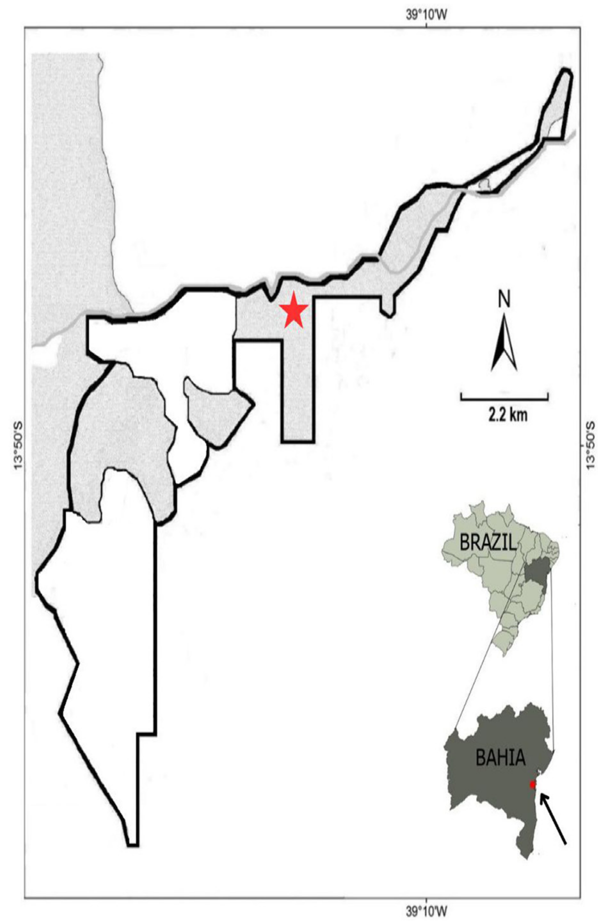

Figure 1. The Reserva Ecológica Michelin located between the cities of Ituberá and Igrapiúna (black arrow), Bahia, Brazil. Short description: Detailed in zoom, the forest of Vila 5 highlighted by the red star, where the tracking activities were carried out.

Data collection

Tracking method

We used the fluorescent powder methodology to track the movement of *C. meridionalis*. This is the most suitable movement ecology method for our study subject due to its small size since it is less invasive and does not cause damage to the lizards during and after tracking (Rittenhouse et al. 2006, Williams et al. 2014, F.G. Fava et al. unpublished data). We added mineral oil to the powders to ensure greater visibility of the individual's tracks in humid places and rainy periods due to the oil hydrophobicity (Williams et al. 2014, F.G. Fava et al. unpublished data). Fluorescent powder (ECO-Series, Dayglo Color Corp, Cleveland, USA DayGlo, without formaldehyde) was used in yellow (ECO17 Saturn Yellow) and orange (ECO15 Blaze Orange) colors, in a 2:1 ratio between powder and oil, following Williams et al. (2014). Using two colors was essential to prevent tracks of different individuals from mixing up.

Night fieldwork

The monitoring of *C. meridionalis* occurred over 13 days, one in November 2021 (pilot field), five in January 2022, and seven in April 2022. During field activities, approximately 91 hours were used for covering active search, collection, and tracking (seven hours a day), and 13 hours for organizing the material and collecting information regarding each individual (one hour per day). The active search method involved visually searching for individuals in their microhabitat, checking for shelters near trunks and rocks, and spotting the lizard in activity (e.g., running or walking in the leaf litter). This method was performed with the aid of a head flashlight, and when individuals were spotted, they were collected by hand and placed in containers for later information gathering and tracking. This information included body weight, using a Mini Electronic Digital Scale High Precision 0.05 g to 2000 g; substrate temperature at the meeting point, using a Portable Digital Thermo-Hygrometer Mod HT-260; geographical coordinates with the aid of a Garmin eTrex 10 Portable GPS; time of encounter and whether the animal was active.

On every field day, the team went to the forest area of Vila 5 and split into two pairs. The first was responsible for marking, releasing, and monitoring the individuals. The second collected information about the individuals and the microhabitat mentioned above. The tracking started at 17:00 and extended until 00:30, when individuals were seen in full activity (foraging on top of or among the leaf litter). To avoid capturing and tracking the same individual, the collecting team prioritized active searches in different patches of Vila 5 during each field period.

We applied the powder and oil mixture to the lizards' ventral region, legs, and tail. Then, the lizards were released at the same spot where they were captured, which was defined as point 1 for the start of tracking. The direction in which the lizards were released was random, with priority given to maintaining the direction in which the individual was moving at the time of capture. These individuals were observed for five minutes to confirm that the mixture did not interfere with their movements and well-being. Following the observation period, the researchers moved ~200 meters away from point 1, turned off their flashlights, and ceased their movements so as not to interfere with the movement of *C. meridionalis*. The individuals were monitored for two hours with observation and data collection of each individual every 30 minutes. We collected the distance (in centimeters) of the sequence of the steps, turning angle, height from the ground, and geographic coordinates of where the individual was found. After collecting the data up to the last point in the sequence of steps (after 2 hours), we checked the lizards' well-being and then left them in the same spot where they were seen for the last time.

Daytime fieldwork

To investigate the absence/presence of *C. meridionalis* activity during the day, we performed the same collecting method (active search) on March 22-24, 2023, between 7:00 am and 5:00 pm, in the same site where we performed the tracking described in this paper. We did not find any active individuals of *C. meridionalis* during the first two days, only recording *Enyalyus catenatus*.

On the second day, we extended our sampling effort until 6:30 pm and found two individuals walking in the leaf litter. These individuals were collected and moved to a room acclimatized to 25° C (the temperature at the time of sampling). The next day we released the two individuals at the same spot where they were collected, using fluorescent powder. Tracking was carried out from 7 am to 5 pm, with 30-minute intervals between each observation.

The tracking has been approved and is supported by the research project "Home range and locomotion patterns of the herpetofauna of the Atlantic Forest of Southern Bahia".

Data analysis

We performed a Generalized Linear Mixed Model (GLMM) to test the relationship between the total distance covered, the individual's weight, and the substrate temperature, considering height from the ground as a random effect. GLMMs combine the properties of mixed linear models, which incorporate random effects to quantify the variation between sample units, and generalized linear models, which use 'link' functions and families of exponential distributions to deal with non-normally distributed data (Bolker et al. 2009). Because we were analyzing a non-negative, integer movement metric (i.e., total distance), we considered a Poisson distribution with an identity link function to generate the models (Da Silva et al. 2022). The Poisson distribution assumes that the events occur independently and that the rate of occurrence is constant over time or space, while the identity link function assumes an additive effect of predictors in the response variable (Da Silva et al. 2022). We fitted the model using the maximum likelihood method with Laplace approximation. We chose the model with the lowest AIC and BIC values (3282.5 and 3290.8, respectively) as the best fit for the data. GLMM calculations were performed through the R package "lme4" version 1.1-33 (Bates et al. 2015).

The Kuiper uniformity test in the kuiper function analyzed the step orientation preference, and it was visualized with a rose diagram using the "CircStats" package version 0.2-6 (Lund & Agostinelli 2001). The figures were constructed through the packages "ggplot2" version 1.0.0 (Wickham 2016) and "plot3D" version 1.4 (Soetaert 2013). All statistical analyses were performed in R environment version 4.2.1 (R Core Team 2022).

Ethical Note

All experiments were performed with the approval of the Instituto Chico Mendes de Conservação da Biodiversidade (ICMBio) and the Sistema de Autorização e Informação em Biodiversidade (Sisbio) by the license number for scientific activities 73371. The Reserva Ecológica da Michelin granted permission for fieldwork. To minimize the stress of the experiments, we used the least invasive protocol for small species (fluorescent powder and mineral oil). In addition, during tracking, we maintained distance to perform the measurements.

RESULTS

Over the 13 days of fieldwork, we monitored 69 individuals of *Coleodactylus meridionalis* for two hours each. Four individuals were preyed upon during the monitoring, and the data was excluded from the analyses. Table I contains the information per individual on weight, total distance traveled, maximum height from the ground, and substrate temperature.

The average total distance covered by individuals was 148.58 cm (SD = 122.42). The lightest individual (CM48, m= 0.04g) walked 103 cm, while the heaviest (CM67, m= 0.51g) walked 61 cm. The longest distance traveled (697 cm) was recorded for individual CM30 (m= 0.23g), and the shortest distance (no predation) (6 cm) for individual CM42 (m= 0.24g). Individuals who weighed less than 0.1 grams reached a maximum of 200 cm in step sequences, while longer distances were covered by individuals weighing over 0.1g (Table I).

While the effect of weight on the total distance covered is not statistically significant as shown in Figure 2, our model displayed in the Table II showed that the substrate temperature, which ranged from 22.9 to 25.1°C, presented a significant negative effect, indicating that as

Table I. **Data per individual (ID) on weight (g), total distance traveled (cm), maximum height (cm), and substrate temperature (°C). *: it was not possible to measure the weight of these individuals; ** individuals who were preyed upon.**

ID	Weight	Total_dist	Max_Height	Sub_Temp
*CM*1	0.27	113	0	24.9
*CM*2	0.17	136	0	24.7
*CM*3	0.14	195	7	24.3
*CM*4**	0.26	148	6	24.3
*CM*5	0.08	52	0	24
*CM*6	0.24	129	0	24.8
*CM*7	*	42	4	24.4
*CM*8	*	188	0	24.3
*CM*9	*	239	0	24.2
*CM*10	0.08	104	8	23.1
*CM*11	0.10	56	0	-
*CM*12	0.32	94	11	23.9
*CM*13	0.13	144	9	-
*CM*14	0.20	432	7	-
*CM*15	0.26	105	0	-
*CM*16	0.09	130	0	24.4
*CM*17	0.08	71	0	24.5
*CM*18	0.13	28	0	24.2
*CM*19	0.26	171	9	23.6
*CM*20**	0.12	55	0	23.7
*CM*21	0.19	54	0	24.3
*CM*22	0.14	215	0	24.4
*CM*23	0.14	324	0	24.8
*CM*24	0.05	27	0	24.7
*CM*25	0.15	115	0	24.5
*CM*26	0.13	27	0	24.5
*CM*27	0.40	278	0	23.5
*CM*28	0.30	84	12	23.1
*CM*29	0.12	212	5	22.9
*CM*30	0.23	697	30	23.2
*CM*31	0.18	58	0	24.2
*CM*32	0.27	65	0	23.9
*CM*33	0.09	42	0	23.9
*CM*34	0.07	131	0	23.1

Table I. Continuation.

ID	Weight	Total_dist	Max_Height	Sub_Temp
*CM*35	0.14	321	0	23.9
*CM*36	0.17	320	8	23.7
*CM*37	0.25	261	0	24.3
*CM*38	0.16	278	27	24
*CM*39	0.24	131	0	23.8
*CM*40	0.20	26	0	24.1
*CM*41	0.24	165	0	24.8
*CM*42	0.24	6	0	22.9
*CM*43	0.40	227	0	22.9
*CM*44	0.45	213	18	22.9
*CM*45	0.08	337	0	23.8
*CM*46	0.31	114	0	23.2
*CM*47	0.43	61	0	23.6
*CM*48	0.04	103	0	23.2
*CM*49	0.31	7	0	23.2
*CM*50**	0.19	0	0	23.7
*CM*51	0.12	10	0	24.1
*CM*52	0.06	36	0	23.8
*CM*53	0.23	87	0	23.5
*CM*54	0.20	59	0	23.9
*CM*55**	0.24	38	0	23.6
*CM*56	0.13	69	0	25
*CM*57	0.09	394	3	24.4
*CM*58	0.19	176	0	24.7
*CM*59	0.33	148	11	25.1
*CM*60	0.08	62	0	24.8
*CM*61	0.10	296	8	24.9
*CM*62	0.08	79	4	24.6
*CM*63	0.44	133	0	23.2
*CM*64	0.37	197	0	22.9
*CM*65	0.25	242	0	22.9
*CM*66	0.15	143	0	23.5
*CM*67	0.51	61	0	23.8
*CM*68	0.47	35	0	23.8
*CM*69	0.09	103	0	22.9

Tsub rises, the total distance decreases. We also found substantial variation in the distance covered by the animals at different heights after accounting for the effects of the fixed predictors (variance = 23226, SD = 152.4), indicating that this variable significantly impacts the distance covered by the individuals and, therefore, should be considered an important factor in any future analyses or models.

We observed a decrease in the distances covered over time considering the partial time-point measurements (30, 60, 90, 120 minutes). As illustrated in Figure 3, during the first 30 minutes the individuals walked a average of 57.8 cm, followed by 30.2 cm by 60 minutes, 27 cm by 90 minutes, and 26 cm by 120 minutes.

Most movements of *Coleodactylus meridionalis* were directed towards the north (V= 2.8902, p-value < 0.01). This is shown in Figure 4, where the south, east and west directions obtained a balance of orientation between the individuals' steps. Most individuals remained on the ground throughout the two hours of tracking. Still, some were recorded at levels above the leaf litter, allowing their movement to be visualized in Figures 5a, b, in three dimensions: height, distance traveled, and number of steps.

We noticed peaks of encounters with active individuals in the leaf litter throughout the search period, mostly between 7:00 pm and 8:00 pm as can be seen in Figure 6. Most of the movement occurred in the first hour of monitoring, between 5:00 and 6:00 pm and 7:00 and 8:00 pm (Fig. 3). The movements gradually decreased soon after this period, but did not reach a total halt, because specific individuals were still moving into the forest even after the end of the monitoring period.

Regarding daytime monitoring, during the 10 hours of tracking, 1 individual walked 116 cm and another 91 cm. Even though the intensity of the UV flashlight faded in the sunlight, we were able to see the trails clearly and only reapplied the powder and oil mixture once. A distinct observation was that throughout the day *C. meridionalis* moved slowly and only in shady places, with the substrate temperature ranging between 26.4° and 27.5° C.

DISCUSSION

Our findings revealed that understanding the dynamics of living species in conjunction with their environment involves individuals' intrinsic

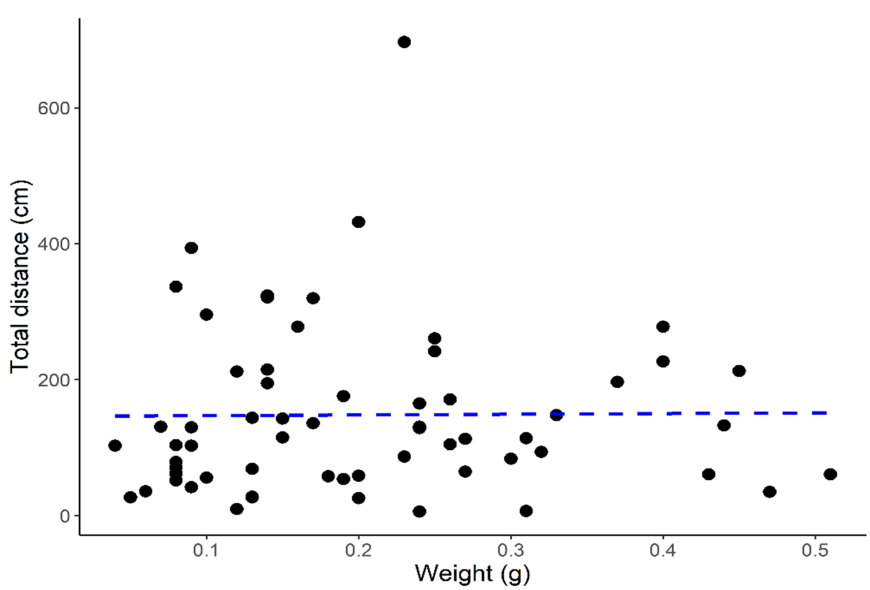

Figure 2. Relationship between total distance traveled and weight of individuals. Short description: With the aim of identifying any relationship between the total distance traveled and the weight of the individuals, we plotted a linear regression with the data. Each black circle represents an individual of *Coleodactylus meridionalis*. The dashed blue line shows that there is no relationship between the variables.

Table II. Results of the Generalized Linear Mixed Model. The intercept represents the expected value of the response variable (distance) when all predictor variables are equal to zero. The z-value indicate the extent to which the predictor variable is related to the response variable.

Variable	Estimate	Standard Error	z-Value	p-Value
Intercept	439.64	59.70	7.37	<0.001
Weight	-24.46	14.42	-1.70	0.09
Substrate Temperature	-8.74	2.20	-3.98	<0.001

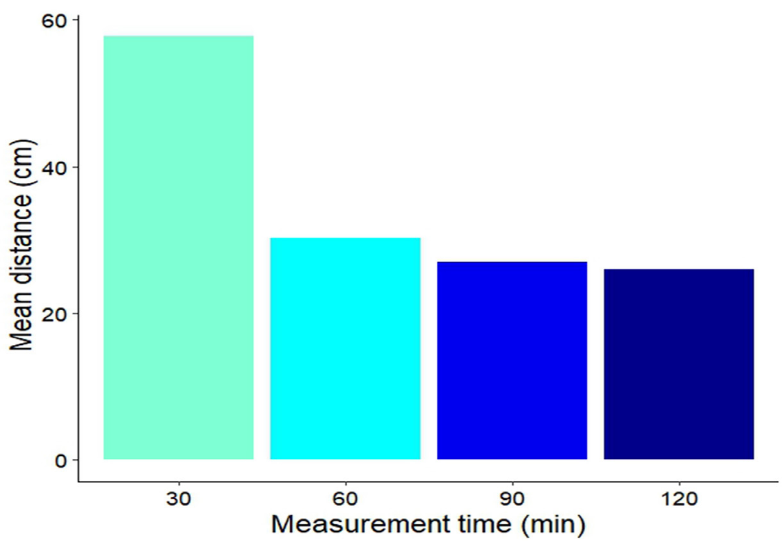

Figure 3. Mean distance covered by individuals of *Coleodactylus meridionalis*, with evidence of differences between partial measurements. Short description: In this plot we intended to show the decrease in the movements of *C. meridionalis* throughout the 120 minutes. Each column refers to a certain period of time (i.e., 30, 60, 90 and 120 min).

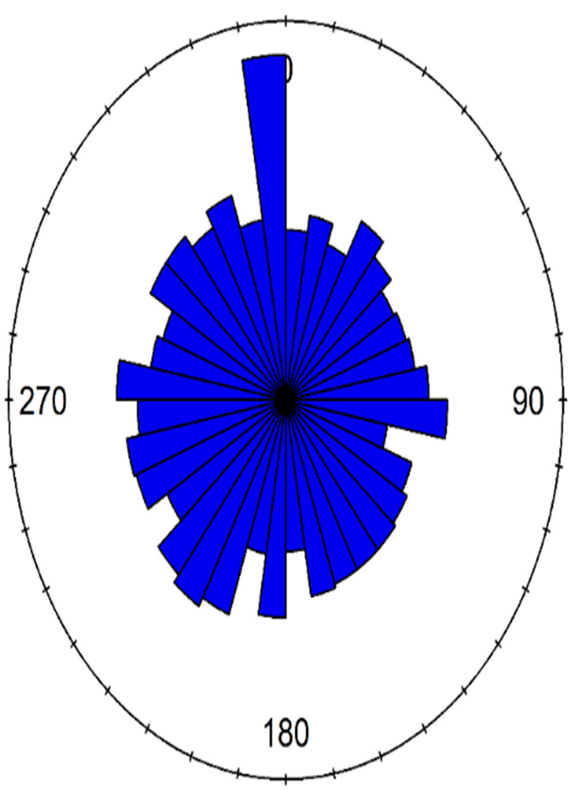

Figure 4. Total distance covered by individuals of *Coleodactylus meridionalis*¸ with evidence in the angulation of turning of the steps. Short description: The wind rose graph shows that individuals are heading north, alternating between east, west and south when foraging, with the south being the least explored.

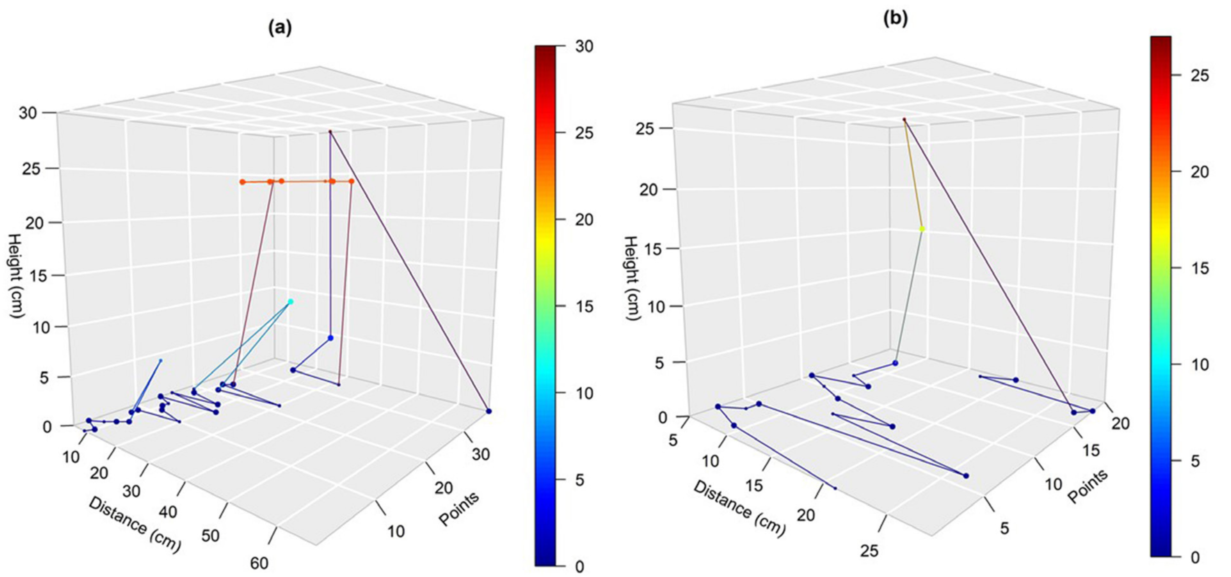

Figure 5. **3D movement representation of two individuals of *Coleodactylus meridionalis*. The color gradient varies between the height from the ground (0 cm) and the maximum height reached. (a) Subject CM30; (b) Subject CM38. Short description: The 3D illustration made it possible to include the height reached, distance and turning angles (points) of *C. meridionalis* in the same plot. In the gradient on the right, the warmer colors (red, orange) represent the greater heights (~25 - 30 cm), and the colder colors (shades of blue) the heights closer to the ground (~10 - 0 cm).**

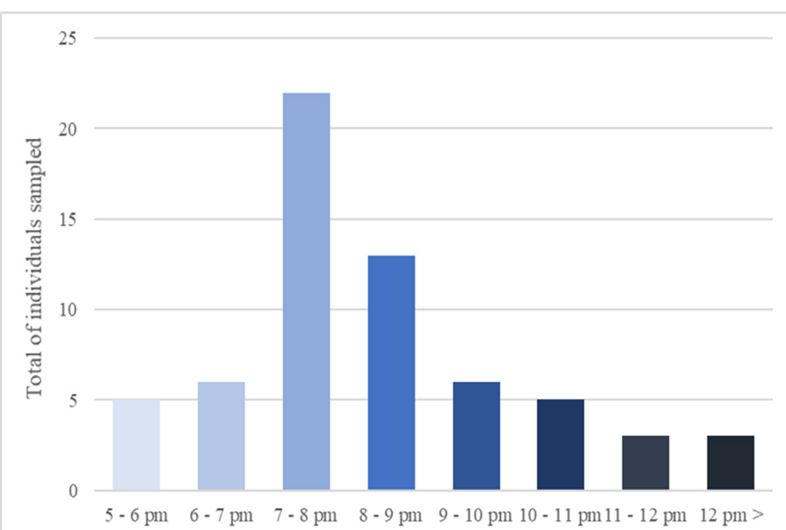

Figure 6. **Histogram representing the frequency of collected individuals in each time interval. Short description: We recorded the number of individuals collected per time period (every 1 hour) between 5 pm and 12:30 pm. The time interval when it was possible to see and collect the individuals was between 7 pm and 9 pm.**

characteristics, the population's ecological interactions, and habitat attributes. Research on movement ecology can gather a richness of data that fills gaps about these dynamics and answers simple questions in writing and complex when answered: why, when, where, and how these organisms move (Nathan et al. 2008). In this study, we focused on "when, where, and how" *C. meridionalis* individuals move, as the "why" refers to a physiological state of the organism not yet assessed.

When and where to move

Although the literature considers *C. meridionalis* an exclusively diurnal species, our experience in southern Bahia found these individuals active from dusk. During the day, when air and substrate temperatures are relatively higher, these animals stay inside shelters like logs, leaves, and burrows, emerging as soon as the light and temperature decrease (personal observation). The definition of a diurnal habit may be related to specificities of the localities where the species was previously studied in the states of Ceará, Paraíba, Pernambuco, and Sergipe (Silva et al. 2015, Moura-Filho et al. 2021, Teixeira et al. 2021, Feitosa et al. 2022). Furthermore, these records were not primarily focused on characterizing and tracking the movement of these individuals.

As this is a short-term monitoring (two hours per day for each individual), the primary and most common type of movement recorded in *C. meridionalis* was foraging. This movement involves not only the food search. The individual may also be moving away from an area with possible predators, searching for a potential mate, or even exploring different climatic conditions available in the microhabitat (Demšar et al. 2015). Moreover, this movement is not random and results from the organism's choices, mainly "where and when to go" (Pyke 1983).

In this study we classified the movements of *C. meridionalis* as foraging on a spatiotemporal scale, comparing them with other movements such as migration and dispersal (Jeltsch et al. 2013). Throughout the tracking campaigns, the lizards' movements maintained the same pattern regardless of the time of year. It was possible to observe the beginning of foraging, where individuals kept their trails in places with the possibility of prey and away from predators, prioritizing food and safety (Jeltsch et al. 2013).

No invertebrates, such as spiders, crickets, and cockroaches, were in the leaf litter within the forest patches around the areas where the lizards were collected. This observation may be linked to one of the most important causes of death in lizards: predation, which is affected not only by larger vertebrates but also by predatory invertebrates such as spiders (Maffei et al. 2010, Vitt & Caldwell 2013, Alcantara et al. 2015, Almeida et al. 2015, Oliveira et al. 2017). Throughout monitoring, we did not witness any records of predation on *C. meridionalis* by vertebrates. However, we did observe these animals being preyed upon by spiders, crickets, and ants (R.S. Roseno et al. unpublished data). We did not find any individuals of *Coleodactylus meridionalis* in the areas where these predators lived, and these lizards' tracks were always far away from these locations. If we were actively looking for *C. meridionalis* in a particular location and it had large invertebrates, we couldn't spot any of these lizards in the surrounding area. An example of this personal observation during the fieldwork was that it was possible to see *C. meridionalis* foraging in the middle of the trail, away from the margins where *Ctenus*, *Ybyrapora,* and *Lasiodora* spiders were seen. These observations corroborate the literature, in which the act of foraging does not always involve a target or end point (Nathan et al. 2008). On some occasions, foraging and habitat use may be the primary driver of the escape from the location of predators, avoiding aggressive encounters and predation.

Leaf-litter and rock cracks are the microhabitats known and most used by *C. meridionalis* during foraging (Werneck et al. 2009). However, we observed that this species could explore different surfaces of the environment, climbing on fallen trunks and even trees as recorded in Figure 7. On these surfaces and in its surroundings, we noted the presence of individuals of the orders Araneae, Blattodea, and Hymenoptera, which may indicate foraging for food. In addition, *C. meridionalis* is usually found near termite mounds and anthills, which comprise most of the species' diet, along with

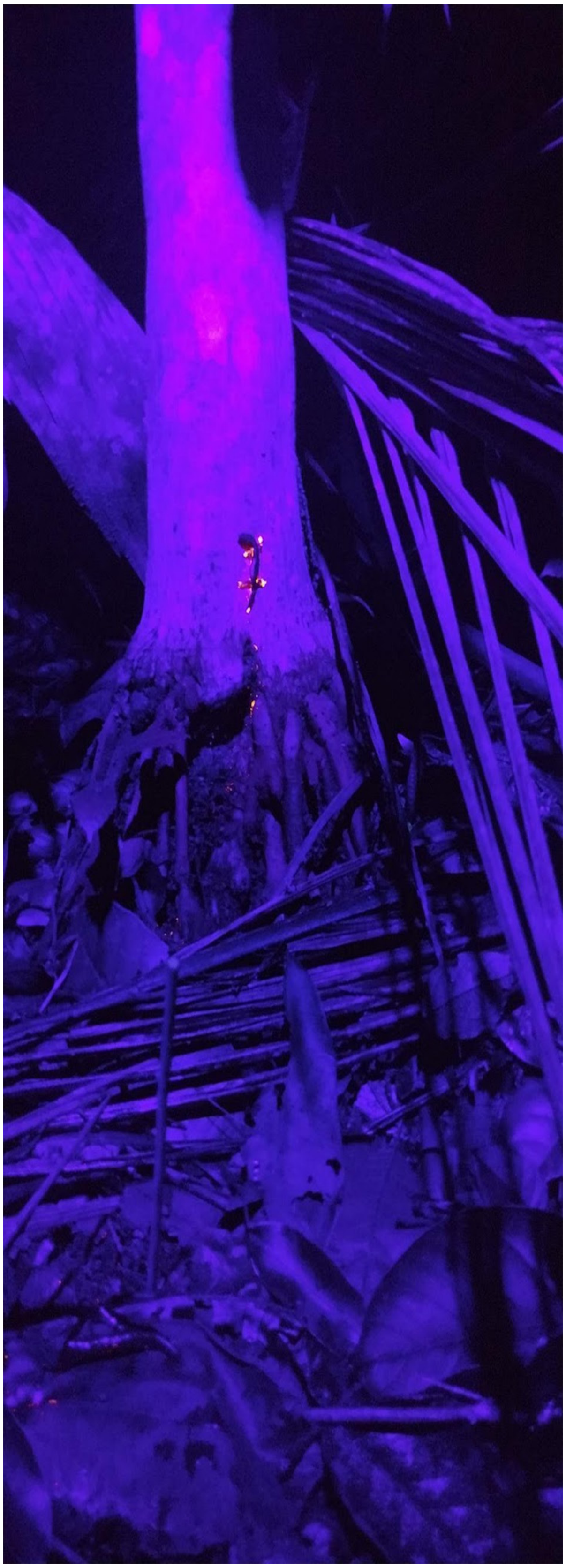

Figure 7. Record of *Coleodactylus meridionalis* during monitoring climbing a tree trunk. Photo by the author. Short description: At the end of a track, we noticed this individual of *Coleodactylus meridionalis* climbing the trunk of a tree. Near the roots and along the trunk was a considerable number of small ants, which are probably part of these lizards' diet.

Hemiptera (Silva et al. 2015, Teixeira et al. 2021). The record of climbing trees is unprecedented for the genus *Coleodactylus*, being only recorded at the level of the family Sphaerodactylidae (Oda 2008).

The interaction between environmental and individual factors shapes the choice to move or stay still in a shelter, waiting for environmental conditions to become favorable for locomotion (Pyke 1983). On one of the first days of monitoring, heavy rainfall hit the Villa 5 study area and made it impossible to identify the sequence of steps through the fluorescent powder as it began to fail and spread in the leaf litter. Since all release sites had been properly marked, we returned the next day and found two of the five individuals released the night before hidden in the same place (they still had the fluorescent powder on their bodies), possibly while taking shelter from the rain (which persisted during the night) under a large leaf. These individuals were recaptured and released on this second night in the field, and we did not observe any changes in their movements that would have prevented them from moving the night before had they not been hindered by the rain. The data from the first day was not incorporated into the analysis as it was totally influenced by the heavy rain. In the last half hour of monitoring (6:30-7:00 pm and 8:30-9:00 pm), it was possible to see a reduction in the individuals' footsteps, with some using underground burrows for refuge at the end of the monitoring (~00:00 am).

How to move

Combined with environmental conditions, the ability to move (e.g., walk, jump, fly) affects “when and where” the organism will move (Nathan 2008). We identified some types of movement in *C. meridionalis* individuals that ranged from walking, running, and jumping. The latter is performed to escape predators and possible threats, such as hand-picking (Oliveira et al. 2020). During monitoring, we observed all these locomotion types. The walking was recorded mainly after the release of the individuals, and the walking/running was visualized during the animals’ activity moment in the leaf litter.

Since we could follow the species’ intrinsic movements during tracking, we corroborated the efficiency of the fluorescent powder methodology when adding mineral oil without harming the individuals. The durability of the fluorescent powder and oil varies depending on the substrate humidity (i.e., dry, wet). However, after two hours of tracking, the lizards still had the fluorescent mixture on their legs and ventral region, allowing medium-term tracking (with reapplication of the mixture after approximately four hours). This method is the most effective and least invasive for tracking this species because of its small size and low body weight and has already been used for different purposes in small mammals, amphibians, lizards, and snakes (Dodd 1992, Rittenhouse et al. 2006, Nicolas & Colyn 2007, Furman et al. 2011). Since our purpose was to observe and learn about the habitual movement of the species, we can state with our results that there is no significant relationship between their weight and foraging ability. However, we observed individuals weighing <0.1g reaching mostly 200 cm of distance in a sequence of steps, which may be related to an ontogenetic factor, where adults move more than nestlings. There are no records of neonate weight for *C. meridionalis* yet. However, Oliveira et al. (2015) recorded the snout-vent length of neonates being on average 12.9 mm, these being slightly than *C. natalensis* with a range of 0.02 to 0.04 g was identified for nestlings soon after hatching, which may be related to the weight and age of the individuals tracked here (Sales et al. 2020).

Coleodactylus meridionalis is a thigmothermic and semi-fossorial species, meaning its body temperature varies according to the temperature of the microhabitat. Substrate temperatures during the individuals’ activity period ranged from 22.9 to 25.1°C, which falls within the microhabitat annual thermal gradient recorded in this Atlantic Forest fragment (i.e., 20-35°C, Carilo Filho et al. 2021). Our results show a negative relationship between substrate temperature and the total distance covered by the individuals, indicating that their locomotor performance is likely to be negatively affected by an increase in environmental temperature. This physiological pattern was also found for other Sphaerodactilids, including *Chatogekko amazonicus* and *Gonatodes humeralis* (Diele-Viegas et al. 2018). Further studies are needed to test this hypothesis for *C. meridionalis*.

Under usual environmental conditions (i.e., constant and mild temperature, light, and rainfall), *C. meridionalis* forages 1.5 m on average, which may be related to its small body size. Furthermore, non-random and exponentially short movements reflect the absence of extreme environmental conditions (e.g., heavy rainfall) that force individuals to modify their daily habits by reducing, increasing, or randomizing their movement (Nathan et al. 2008).

Although the number of individuals tracked during the day was insufficient to make any conclusion, when considering abundance, encounter frequency, and movement, we can conclude that *C. meridionalis* presents a crepuscular/nighttime activity in the Atlantic

Forest fragments of Bahia. Our efforts have secured promising results for three of the four main components that make up the movement framework, where only individuals' physiological states have not yet been included in the analyses, which is part of our future goals. This is the first work to measure, describe, and test hypotheses of the movement ecology of a species in the family Sphaerodactylidae. We believe our results can strengthen and guide future work involving other lines of research (e.g., ecophysiology, evolution) for the species and its congeners.

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RSR, DPM, MS planned the experiments and analyses; RSR, DPM, LSS, LMCF realized the experiments; RSR, LSS, LMCF, PRN, GGE collected environmental data; RSR, LMDV performed data analyses and led the writing of the manuscript; RSR, DPM, LMDV analyzed the results; all authors reviewed and approved the final version of the manuscript.