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Papers

Evaluation of the Hypotheses on the Formation of Earth Mound Fields in the Federal District of Brazil Through Landscape Element Analysis

Thyego Pery Monteiro de Lima [1]
Rodrigo Studart Corrêa [2]

Keywords

Landscape Metrics
LiDAR
Phytophysiognomy
Morphometry
Altimetry

Abstract

The Brazilian Savanna houses Earth Mound Fields (EmF), which represent the rarest phytophysiognomy among the fourteen present in the Federal District of Brazil (FDB). However, the EmF origin remains a subject of debate, and biotic and abiotic hypotheses propose divergent mechanisms for EmF's mound formation. To shed light on the subject, this study evaluated the spatial configuration of 197 EmF on the FDB landscape and characterized their structure. The identified EmF across the FDB territory were georeferenced and overlaid onto aerial images from 2009. The area of each EmF was manually vectorized and its configuration was evaluated using landscape metrics. The structures of four EmF were examined using laser profiling (LiDAR), incorporating metrics related to occupation, morphology, and dispersion. In addition, the elevation of mounds' tops and the adjacent surfaces was analyzed to assess the altimetric continuity between these elements. The identified EmF spread over 6,556 ha, representing 1.2% of the FDB's territory. Regarding the biotic hypothesis, the metrics associated with the dispersion of EmF's mounds, their volume, and basal area do not align with the characteristics of termite mounds attributed to the species reported as mound builders. Additionally, the altimetric continuity between mounds' tops and the external surfaces adjacent to EmF supports the abiotic hypothesis for mound formation.

[1] Universidade de Brasília– PPGCA, Brasília, DF, Brazil. pery.monteiro@gmail.com
[2] Universidade de Brasília– PPGCA, Brasília, DF, Brazil. rodmanga@gmail.com

INTRODUCTION

The Cerrado biome spans the Brazilian Central Plateau and consists of a complex vegetation formation that covers approximately 23% of Brazil's territory (Ribeiro;Walter, 2008; Souza *et al*., 2020). The various vegetation formations of Cerrado are arranged in a mosaic, where phytophysiognomies alternate and blend according to relief, soil type, and fire incidence (Oliveira, 2014). In this context, Earth Mound Fields (EmF) appear within the landscape (Ribeiro; Walter, 2008). Essentially, EmF are characterized by small rounded elevations (mounds), ranging from 0.3 to 20 m in diameter and 0.2 to 2 m in height, distributed across flat or gently undulating terrain (Oliveira-Filho, 1992). The investigation of approximately 180 EmF in the Federal District of Brazil (FDB) has revealed that they exist associated with hydromorphic soils, terrain with slopes between 2% and 5%, and pediplain areas (Lima; Corrêa, 2021). In 2020, the FDB Law No. 6,520 established EmF as areas of preservation, recognizing the importance of this phytophysiognomy and enhancing its chances of preservation.

The first investigations on EmF in Brazil date back to the 1960s and proposed hypotheses regarding their origin (Cole, 1960; Eiten, 1972; Mathews, 1977), which consider both biotic and abiotic factors (Ponce; Cunha, 1993). Under the biotic hypothesis, the mounds would be constructed by termites, involving different stages, each corresponding to the action of a different species (Mathews, 1977). The initial colonization would occur by the species most tolerant to soil moisture (*Armitermes cerradoensis*), while the final mound construction would be carried out by the species least tolerant to soil moisture (*Cornitermes snyderi*). In this sense, *A. cerradoensis* would be directly responsible for the location of each mound in the field, and *C. snyderi* would be responsible for giving a mound the final morphological characteristics.

The abiotic hypothesis advocates that the genesis and evolution of EmF are related to surface and subsurface water dynamics where they occur. Surface runoff over the soil would lead to differential laminar erosion, forming mounds due to the lowering of the surrounding terrain (Silva *et al*., 2010). Consequently, the mounds would be residual structures that survived erosion (Araújo Neto *et al*., 1986; Araújo Neto, 1981; Baptista *et al.,* 2013; Furley, 1986), and the termites would have later colonized them due to the drier environment on the mounds compared to the surface lowered by erosion (Silva *et al*., 2010).

The study of landscape elements where EmF occur can shed light on their origin and formation processes. Landscapes are dynamic systems, and their structures reflect the spatial patterns of their elements and the connections between them (Gkyer, 2013). In this context, the Light Detection and Ranging system (LiDAR) can enhance topographic surveys and improve the understanding of the landscape where EmF are present. The LiDAR system is an active remote sensing method that measures the time between the emission of a laser light pulse from space and the moment it returns from the Earth's surface (Estornell *et al*., 2011). Such information can then be used to determine land elevations, the height of objects above the Earth's surface, and the height of tree canopies, for instance. Moreover, it enables the rapid, precise, and detailed collection of large quantities of georeferenced data, presented as three-dimensional point clouds. Despite the high computational cost of storing data, the LiDAR system enables various territorial applications, including studies of the vegetation's biophysical aspects and detailed topographic surveys of a terrain (McGlone, 2004; Mendonça; Paz, 2022).

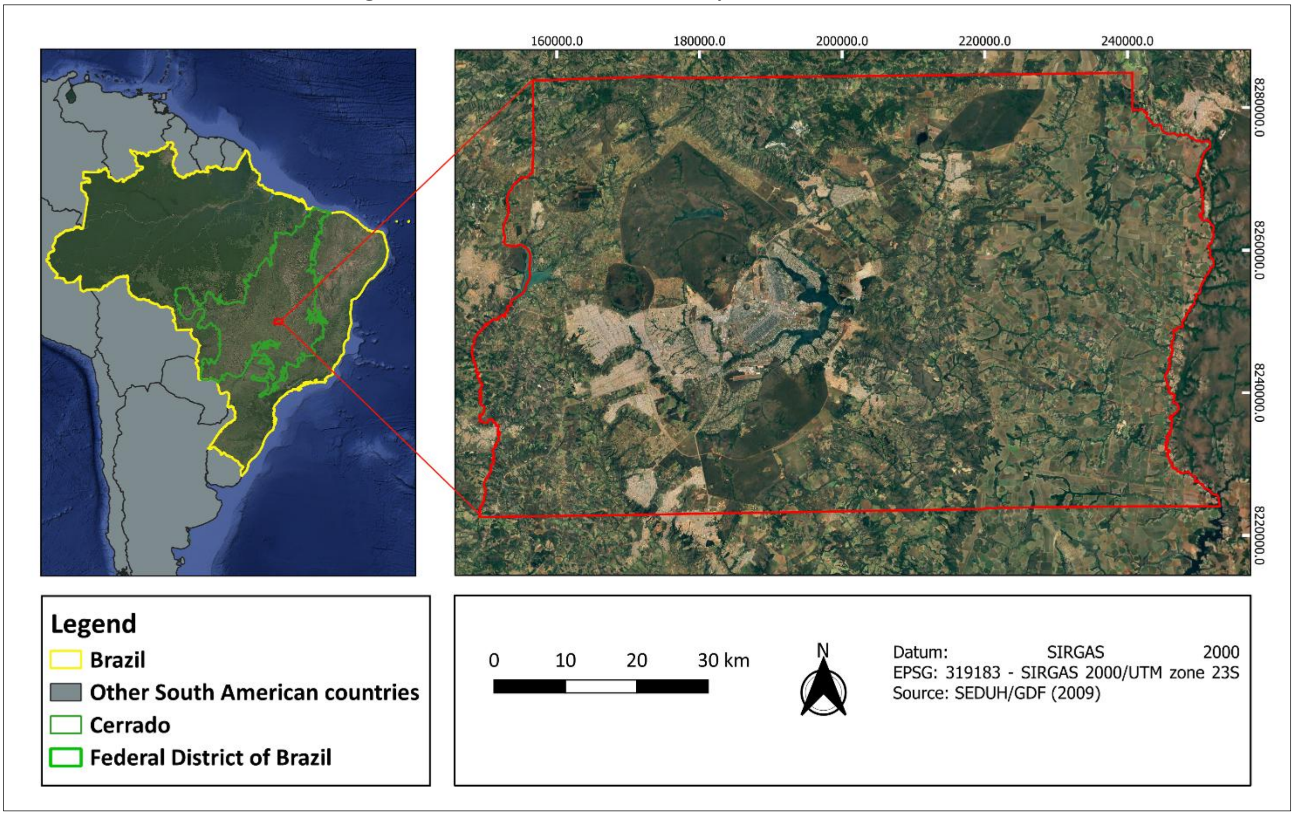
Similarly, landscape metrics serve as valuable tools for characterizing its elements and assessing its structural complexity (Longo *et al*., 2024; Ribeiro *et al*., 2020). Despite the existence of studies on the association between EmF and landscape elements in the FDB (Araújo Neto *et al*., 1986; Araújo Neto, 1981; Lima; Corrêa, 2021), there has yet to be a local assessment of EmF configuration and structure. Thus, the investigation of the configuration and structure of this phytophysiognomy has the potential to shed light on issues related to the processes associated with EmF genesis and conservation. Given this context, the objective of this study was to (1) evaluate the hypotheses on EmF formation through the assessment of their configuration in the landscape, and (2) characterize their structure.

MATERIALS AND METHODS

Study area

The study area encompasses the Federal District of Brazil (FDB), spanning 5,814 km² within the Brazilian Central Plateau, at altitudes ranging from 900 to 1,300 m (Figure 1). The study area's topography varies from flat to undulating, with a mean annual temperature ranging from 19 and 23°C. The region receives approximately 1,500 mm of annual precipitation, with 85% of it occurring between November and April (INMET, 2022).

Figure 1 -. Location of the study area in Brazil



Source: The authors (2025), based on SEDUH/GDF (2009).

Mapping Earth Mound Fields (EmF) in the Federal District of Brazil (FDB)

From 2017 to 2022, Earth Mound Fields (EmF) within the Federal District of Brazil (FDB) were identified in situ and georeferenced using a Garmin Etrex Camo GPS device, utilizing the WGS 84 Datum. The obtained coordinates were subsequently input into ArcGIS 10.8 software, reprojected to the SIRGAS 2000/UTM Zone 23S coordinate reference system (EPSG: 31983), and overlaid onto a mosaic of aerial photographs of the FDB territory to delineate each EmF's area. This mosaic comprised aerial photographs with a spatial resolution of 1 m (GSD), covering the entirety of FDB territory (SEDUH/GDF, 2009).

The aerial photographs mentioned above were captured between July 8, 2009, and August 9, 2009, using an UltraCam-XP camera mounted on an aircraft flying at an altitude with a maximum variation of 5% relative to the average terrain level (SEDUH/GDF, 2009). The selection of the 2009 imagery enabled the manual vectorization of EmF's polygons along their respective boundaries, employing a fixed visual scale of 1:2,500. Lima (2023) highlights that the number of EmF in the FDB remained consistent between the date of the aerial imagery and the date of in situ identification and that the average area of these fields exhibited no statistically significant differences.

Sampling sufficiency of Earth Mound Fields (EmF)

Following the *in situ* identification and georeferencing of the EmF, sample sufficiency was evaluated (Eq. 1) (Fávero *et al.*, 2009; Triola, 2013), considering different scenarios of confidence levels (90% and 95%), sampling errors (5% and 10%), and hypothetical populations of EmF originally present in the FDB (400, 500, 1,000 e 10,000 units). The scenarios considered appropriate for sample representativeness were those in which the calculated sample size was less than or equal to 197 EmF.

$$n = \frac{z^2 .p .q .N}{e^2 (N-1) + z^2 .p .q} \quad \text{Eq. (1)}$$

Where:

n: number of samples individuals;
z: abscissa of the standard normal distribution, given a fixed confidence level;
p: proportion estimate. The value of 0.5 was adopted to maximize the sample size, ensuring greater reliability, as recommended by Fávero *et al.* (2009);
q: equals to 1 – p;
N: population size;
e: sampling error.

Configuration of Earth Mound Fields (EmF)

After vectorizing the EmF, their configuration was characterized by using landscape metrics (Chart 1). The calculation formulas are provided in the supplementary material.

Chart 1 - Metrics for the Earth Mound Fields (EmF) in the Federal District of Brazil (FDB) and their respective categories, according to Lang and Tiede (2003), McGarigal and Marks (1995)

Metric (unit)	Category
Number of EmF (unit)	Area and border
Mean area (ha)	
Total area (ha)	
Mean border (km)	
Total border (km)	
Border density ($m.ha^{-1}$)	
Mean shape index (dimensionless)	Form
Mean fractal dimension (dimensionless)	
Mean perimeter-to-area ratio (dimensionless)	
Mean nearest-neighbor distance (km)	Proximity
Proximity index (dimensionless)	

Source: The authors (2025).

Structural characterization of Earth Mound Fields (EmF)

For EmF's structural characterization, four fields exceeding 10 ha, identified as preserved in the Mapping of Urban and Urbanizable Areas of the Federal District (scale 1:1,000), were selected (Terracap, 2016). These EmF were designated as EmF_9, EmF_15, EmF_32, and EmF_37. The airborne LiDAR survey has an average point density of 4 points per square meter, reaching up to 12 points per square meter in some areas (Terracap, 2016). The resulting point clouds were then processed through automated filtering and thematic classification based on identified elements such as soil, vegetation, and buildings.

The LiDAR-derived point clouds from Terracap (2016) were used as input data for generating the Digital Terrain Model (DTM) and the slope map. Triangulated Irregular Network (TIN) interpolation was used to generate a surface composed of triangles connecting the nearest neighboring points (Isenburg; Olaya, 2019). For the development of the DTM and slope map, only ground points were used, enabling the identification of the geomorphometric characteristics of the existing mounds in the EmF. For this terrain modeling, a spatial resolution of 20 cm was adopted, following the approach of Barbosa *et al.* (2021).

The microrelief of each mound in the selected EmF was delineated using the slope map, following Sales *et al.* (2019), who identified a 20% slope as the most accurate threshold for cartographically representing mound features. The DTM of the four EmF, along with the vector files delineating the mounds, enabled the calculation of metrics that describe the structure of these environments (Chart 2), as outlined by Redcatch GMBH (2022), Lang and Tiede (2003). The formulas used for the calculations are provided in the supplementary material.

Chart 2 - Metrics for characterizing the structure of Earth Mound Fields (EmF) in the Federal District of Brazil (FDB) and their respective categories, calculated according to Lang and Tiede (2003), Mcgarigal and Marks (1995)

Metric (unit)	Category
Number of EmF (unit) Occupation density (mounds.ha^{-1}) Border density (m.ha^{-1})	Occupation and border
Mean area (m^2) Mean height (m) Mean volume (m^3) Mean shape index (dimensionless) Mean fractal dimension (dimensionless)	Morphology
Mean nearest neighbor distance (m) Clark and Evans Dispersion index (dimensionless)	Proximity and Dispersion

Source: The authors (2025).

Altimetric variation of mounds and adjacent surfaces

Based on the DTM of the four selected EmF and following the method used by Sales (2021) and Sales *et al.* (2021), the elevation of mounds' tops and the adjacent surfaces was analyzed to assess the altimetric continuity between these elements. Starting from the EmF boundaries, an internal buffer of 50 m was defined. Within this range, the number of mounds and the maximum elevation of each selected mound were recorded.

Subsequently, an external buffer of 50 m was defined and within it, points were selected for altimetric characterization of the surface adjacent to the EmF. Unlike Sales (2021) and Sales *et al.* (2021), who used a 120 m buffer, this study employed 50 m buffers due to the proximity of the investigated EmF to urban areas. Additionally, anthropized areas, as mapped by SEDUH/GDF (2021), were excluded from the analysis. This exclusion was intended to prevent altimetric sampling in built-up areas, thereby avoiding interference from urbanized surfaces Furthermore, it is important to note that points on the adjacent surfaces were selected randomly, in the same quantity as the number of mounds within the internal buffer. This procedure was applied to all four selected EmF (EmF_9, EmF_15, EmF_32 and EmF_37).

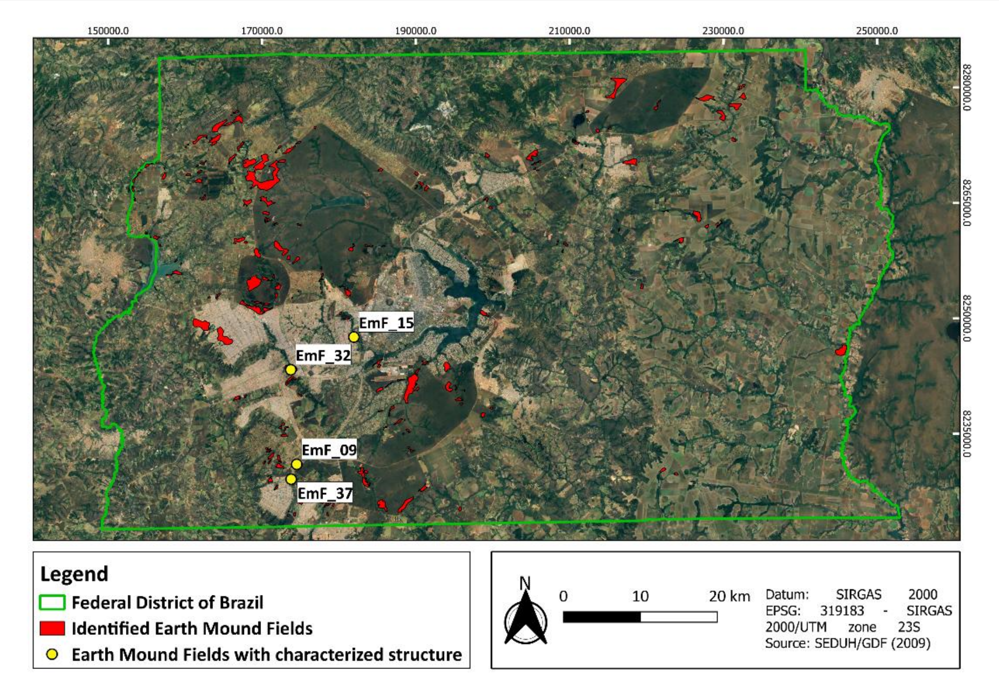
Data normality was verified using the Kolmogorov-Smirnov ($p = 0.01$), as recommended by Fávero *et al.* (2009) and Triola (2013). Since the normal distribution was rejected, the non-parametric Mann-Whitney test ($p = 0.01$) was chosen to assess significant differences between the altitudes of the mound's tops and the adjacent surfaces of the fields.

RESULTS

The 197 Earth Mound Fields (EmF) identified in the Federal District of Brazil (FDB) (Figure 2) had a mean area of 33.3 ± 69.7 ha and a mean perimeter of 2.7 ± 2.9 km. Despite the variability of landscape metrics, the sample sufficiency calculation indicated that the 197 EmF were representative for a hypothetical population of up to 10,000 EmF, with a 95% confidence level and a 10% sampling error, making them significantly representative of this study.

The identified EmF spread over 6,556 ha, representing 1.2% of the FDB's territory. It was found that approximately 90% of the identified EmF presented an area smaller than 100 ha and a perimeter shorter than 5 km. Only EmF_153 exceeded 300 ha in area and 15 km in perimeter (Table 1).

Figure 1 - Earth Mound Fields (EmF) identified in the Federal District of Brazil (FDB) and EmF selected for their internal structure characterization (EmF_9, EmF_15, EmF_32, EmF_37)



Source: The authors (2025), based on SEDUH/GDF (2009).

Table 1 - Landscape metrics for Earth Mound Fields (EmF)

Metric (unit)	Valor
Number of EmF (unit)	197
Mean area (ha)	33.3 ± 69.7
Total area (ha)	6,556.1
Mean border (km)	2.7 ± 2.9
Total border (km)	529.2
Border density (m.ha^{-1})	80.7
Mean shape index (dimensionless)	1.5 ± 0.4
Mean fractal dimension (dimensionless)	1.28 ± 0.04
Mean perimeter-to-area ratio (dimensionless)	0.02 ± 0.01
Mean nearest-neighbor distance (km)	0.86 ± 1.58
Mean proximity index (dimensionless)	36.5 ± 315.7

Source: The authors (2025).

Structure of Earth Mound Fields (EmF)

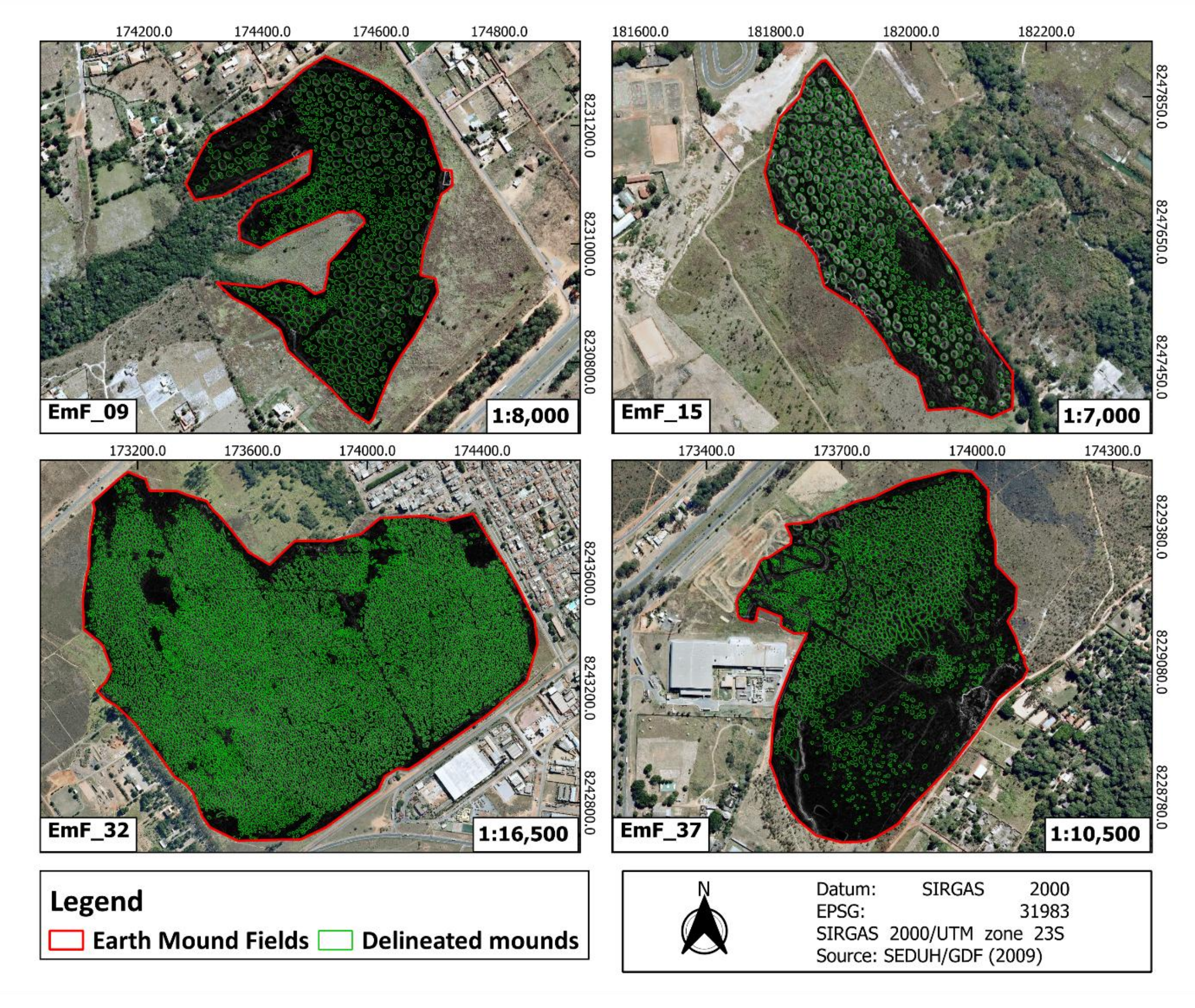
The area of the four EmF selected for structural characterization (EmF_9, EmF_15, EmF_32, EmF_37) totaled 193 ha, with approximately 10,200 mounds available for the calculation of structural metrics (Table 2 and Figure 3). While the metrics exhibited similar variations, some mound groups showed notable structural differences. For instance, EmF_15 exhibited a mound density 32% lower than the mean for its group. Additionally, EMF_32 covered a total area nearly seven times larger than the average of other EmF, featuring larger and more voluminous mounds. The Clark and Evans Dispersion Indices confirmed that the mounds in all four selected fields are distributed in a non-random, dispersed pattern.

Table 2 - Descriptive structural metrics for the selected Earth Mound Fields (EmF)

Metric	Earth Mound Field			
	EmF_9	EmF _15	EmF _32	EmF _37
EmF's total area (ha)	14.00	11.26	133.26	34.45
Number of mounds (unit)	778	444	7,350	1,620
Occupation density (mounds.ha^{-1})	56	39	55	47
Total border (m)	20,124	12,232	260,187	44,577
Border density (m.ha^{-1})	4,394,6	4,432.6	3,796.1	4,543,0
Mean area (m^2)	58.8 ± 52.7	62.0 ± 50.3	93.1 ± 63.5	60.5 ± 51.6
Mean height (m)	0.7 ± 0.4	0.9 ± 0.4	1.0 ± 0.4	0.7 ± 0,4
Mean volume (m^3)	19.4 ± 24.1	22.6 ± 26.5	39.2 ± 34.8	17.7 ± 21.1
Mean shape index (dimensionless)	1.049 ± 0.05	1.063 ± 0.06	1.080 ± 0.09	1.072 ± 0.08
Mean fractal dimension (dimensionless)	1.779 ± 0.24	1.746 ± 0.22	1.650 ± 0.16	1.750 ± 0.21
Mean nearest neighbor distance (m)	1.7 ± 1.3	1.5 ± 2.0	0.8 ± 1.2	1.4 ± 2.4
Clark and Evans Dispersion index (dimensionless)	1.4	1.2	1.5	1.2

Source: The authors (2025).

Figure 2 - Delineated mounds in EmF_9, EmF _15, EmF _32, and EmF_37

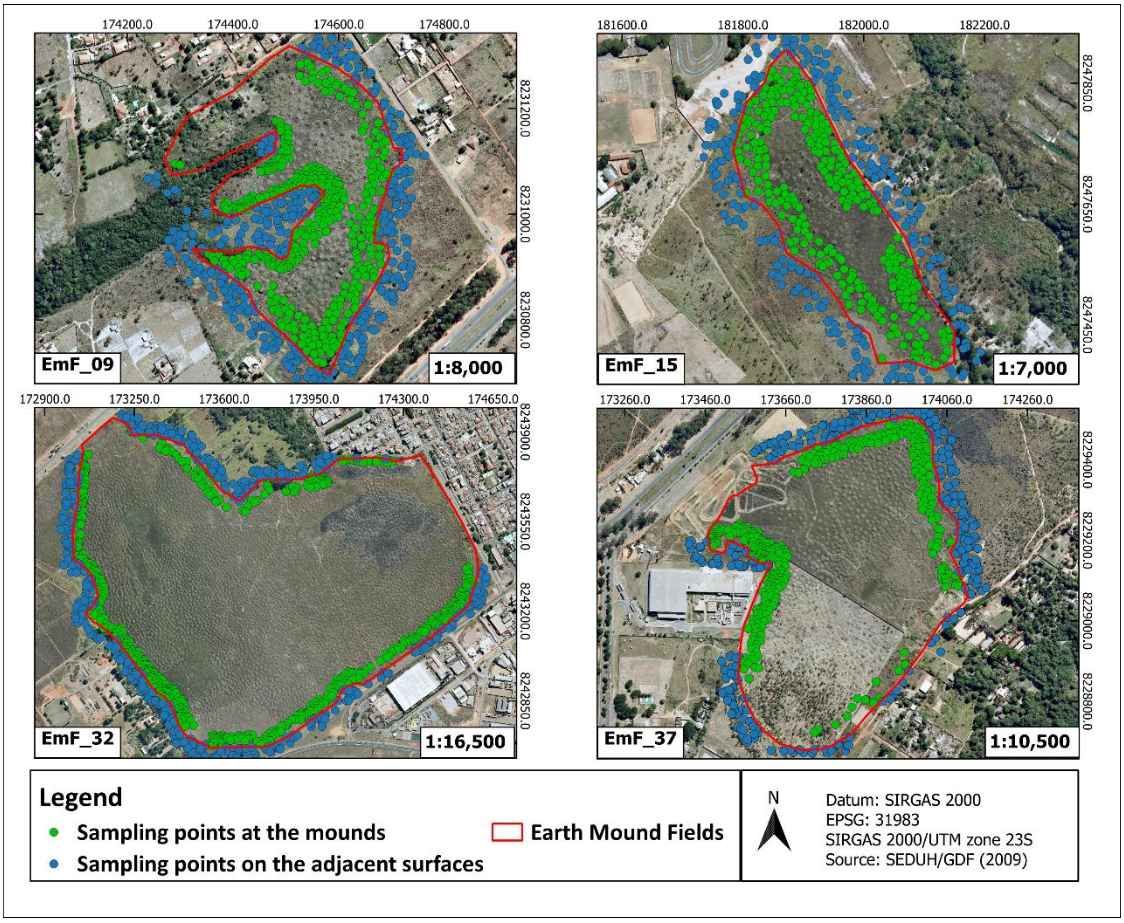


Source: The authors (2025), based on SEDUH/GDF (2009).

Altimetric variation of mounds and adjacent surfaces

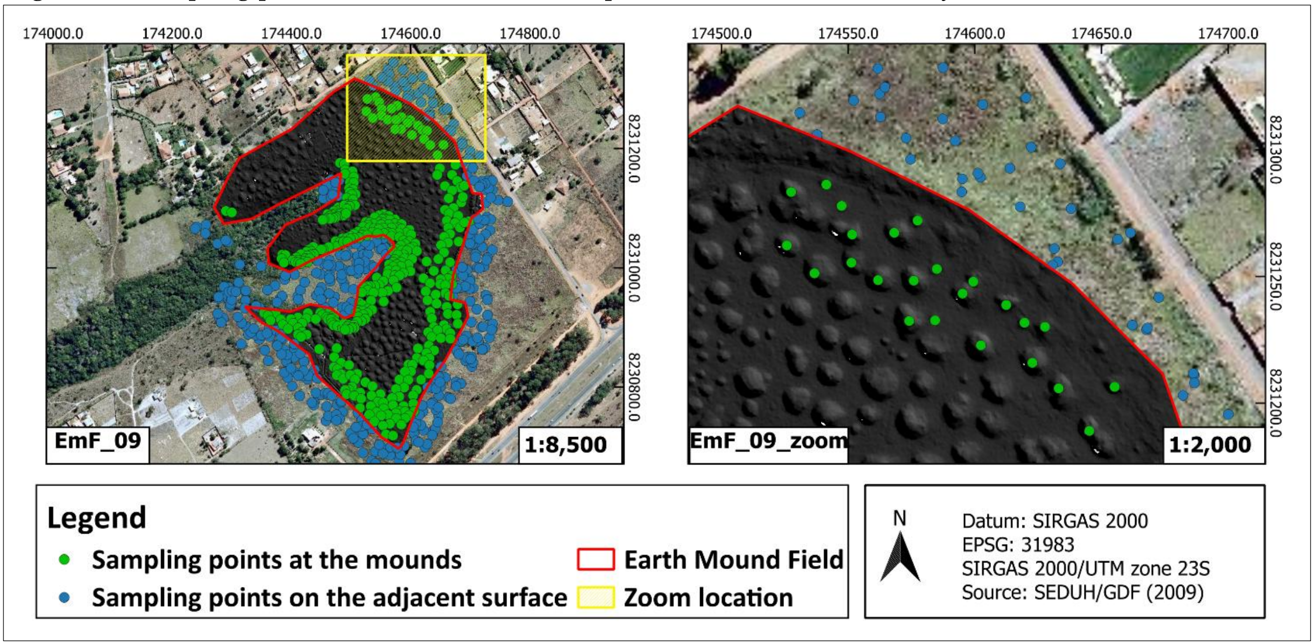
A total of 382 mounds were identified within the internal buffers of EmF_9, 260 in EmF_15, 477 in EmF_32, and 279 in EmF_37. Correspondingly, the same number of points (382, 260, 477, and 279) were delineated on the adjacent surfaces of each respective EmF (Figure 4) for altimetric comparison. Anthropized areas (SEDUH/GDF, 2021) were excluded to prevent altimetric sampling in built-up zones and eliminate the influence of urbanized surfaces (Figure 5). The altitudes measured at the tops of mounds and at the adjacent surfaces showed no statistically significant differences, as determined by the Mann-Whitney test (Figure 6).

Figure 3 - Sampling points for altitudes at the mounds' tops and on the adjacent surfaces



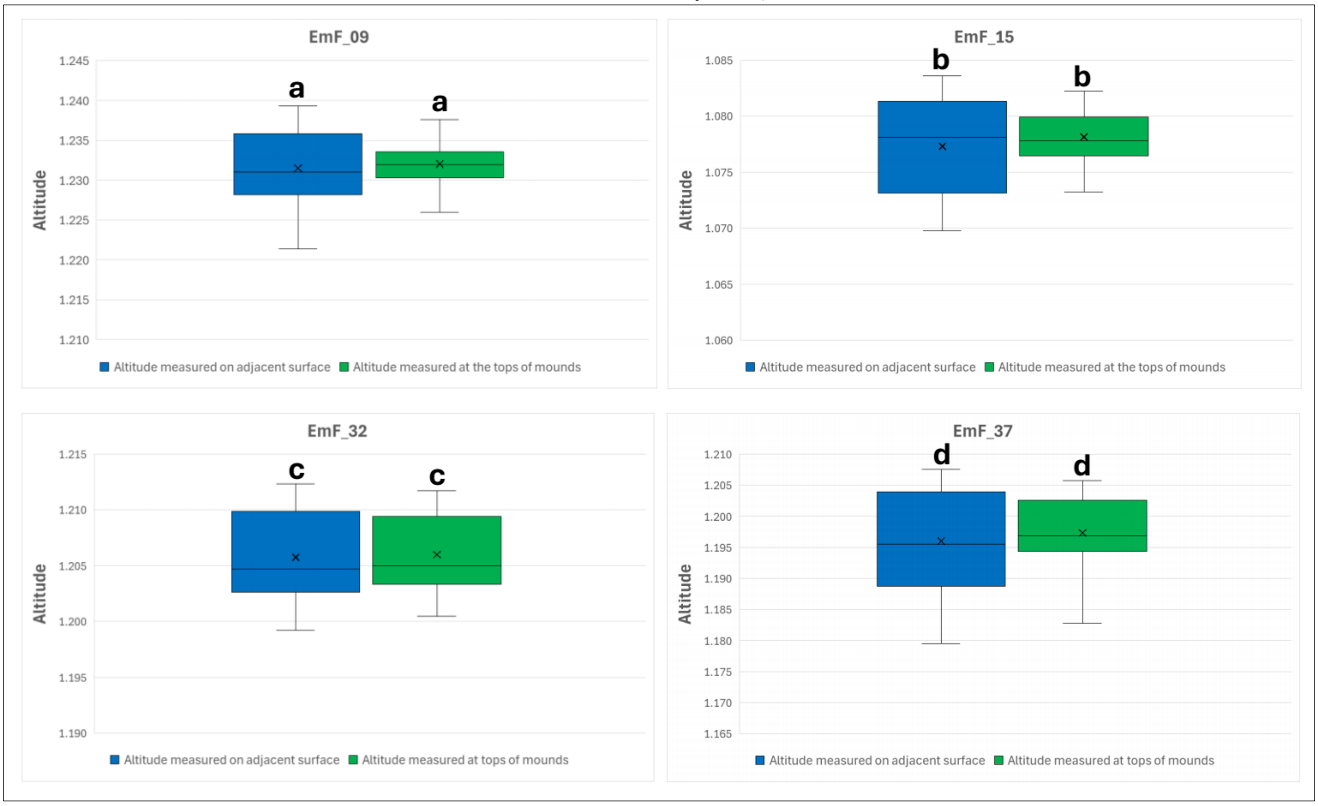
Source: The authors (2025), based on SEDUH/GDF (2009).

Figure 4 - Sampling points for altitudes at the tops of mounds and on the adjacent surface to EmF_9



Source: The authors (2025), based on SEDUH/GDF (2009).

Figure 5 - Distribution of altitudes (m) measured at the tops of mounds and on external adjacent surfaces (diagrams sharing the same letters indicate no significant median differences according to the Mann-Whitney test)



Source: The authors (2025).

DISCUSSION

The Earth Mound Fields (EmF) in the Federal District of Brazil (FDB) have predominantly been found in association with hydromorphic soils and slopes of 2 to 5%, which lead to slow surface water runoff (Lima; Corrêa, 2021). This condition supports the hypothesis that mound formation is a result of differential erosion processes (Silva *et al.*, 2010), where surface water runoff would shape the landscape through erosion. It would result in elongated EmF, captured by the mean shape index (Lang; Tiede, 2003). In this respect, perfectly circular fragments have a shape index equal to 1, which increases as the shape of the fragment becomes more elongated, irregular, and complex (McGarigal; Marks, 1995).

Phytophysiognomies along river courses, such as Gallery Forests and Riparian Forests (Ribeiro; Walter, 2008), tend to present more elongated and linear shapes, resulting in shape index values greater than 1. Neves *et al.* (2013) have calculated a shape index of 2.6 for the Gallery Forests in the FDF area, while Riparian Forests with minimal to no anthropogenic influence in other Brazilian biomes have exhibited shape indices ranging from 2.0 (Riedler *et al.*, 2013) to 2,3 (Aguiar *et al.*, 2011). Rivers, naturally the most elongated forms, have an approximate shape index of 4.4 (Vasilică-Dănut *et al.*, 2019).

The previous studies of EmF in the FDB have exhibited a mean shape index of 1.5, positioning them between a perfectly circular shape and riparian vegetation. When the EmF were grouped into quartiles based on the variation in shape index, those in the quartile with the highest indices had an average value of 2.1, bringing them closer to the form of riparian environments (Aguiar *et al.*, 2011; Neves *et al.*, 2013; Riedler *et al.*, 2013). In a second grouping based on size variation, the EmF with the largest areas had a mean shape index of 1.8. This suggests that larger EmF tend to be more elongated, possibly reflecting more intense water erosion, likely due to the larger drainage slope.

The mean shape index of EmF supports the hypothesis that the formation of this phytophysiognomy is driven by hydric dynamics

(Silva *et al.*, 2010), as surface runoff is a natural process capable of imparting elongated shapes to these areas, similar to riparian environments. Given that the hydric dynamics of EmF, characterized by surface water runoff (Castro Júnior, 2002) and lateral subsurface water flow (Fulan *et al.*, 2020), among other factors, these processes help explain the form observed in the EmF evaluated in this study.

The metrics characterizing the occupation, morphology, and dispersion of the EmF's mounds were consistent with those found in other studies. Specifically, the occupation density here observed, ranging from 39 to 56 mounds.ha^{-1}, aligns with the values reported in Araujo Neto *et al.* (1986) in the FDB territory and in Sales *et al.* (2021) in Minas Gerais state, who have found densities of 26 to 61 and 36 mounds.ha^{-1}, respectively. The mean basal area of the EmFranged from 59 to 93 m², which is comparable to the 82 to 150 m² reported by Araújo Neto (1981) in the FDB, ≤ 10 - 103 m² observed by Silva *et al.* (2020), and Sales *et al.* (2021) in Minas Gerais state.

The observed mean height of the mounds, ranging from 0.7 to 1 m, is partially consistent with the heights from 0.05 to 2 m reported by Araujo Neto *et al.* (1986), 0.7 m recorded by Silva *et al.* (2020), and the 1.3 m reported by Sales *et al.* (2021). The mean mound volume, ranging from 18 to 39 m³, aligns with the 0.01 to 141 m³ reported by Araujo Neto *et al.* (1986), de 21 m³ by Silva *et al.* (2020), and 0,4 - 286 m³ by Sales *et al.* (2021). Lastly, the mean distance to the nearest mound, between 0.8 and 1.7 m, fits within the range 0.2 - 18 m reported by Sales *et al.* (2021).

Some of the mounds' metrics in this study challenge the biotic hypothesis for their origin. The Clark and Evans Dispersion Index for the mounds, averaging 1.30, differs from the 0.86 reported by Kreutz *et al.* (2010) for Armitermes cerradoensis termite mounds, the species responsible for mound location on EmF, according to the biotic hypothesis. These results indicate that mounds exhibit a non-random, dispersed distribution, whereas the termite mounds of Armitermes cerradoensis follow an aggregated pattern (Kreutz *et al.*, 2010).

Similarly, *Cornitermes snyderi* and *Cornitermes silvestrii*, described as synonyms by Cancello (1989) and Valério (2006), form termite mounds with a flattened shape, expanding more in width than in height (Valério, 2006). In a study on termite species in pastures, Czepak et al. (2003) reported a higher occurrence of *C. snyderi* mounds, with a mean basal area of 0.54 m² and a maximum of 0.80 m². *C. snyderi* mounds can reach a basal area of 0.80 m² (Mathews, 1977), and these values contrast sharply with the EmF's mounds here studied, which reached a mean basal area over seventy times larger. Among the 10,200 EmF's mounds mapped in this study, the smallest one measured 2.3 m², which is four times larger than the mean of *C. snyderi* termite mounds reported by Czepak *et al.* (2003).

Still within the scope of the morphological characteristics of these mounds and their compatibility with the hypothesis of origin by termite action, it was found that the volume of EmF's mounds and *C. snyderi* termite mounds differ significantly. Based on the dimensions of termite mounds reported by Mathews (1977) and Czepak *et al.* (2003), it is estimated that nests of this species reach a maximum volume of 0.21 m³. However, the mean volume of the mapped EmF's mounds is about one hundred times larger than this value. It is observed that only 0.6% of the 10,200 mounds mapped had a volume equal to or smaller than those reported by Mathews (1977) and Czepak *et al.* (2003) for *C. snyderi* termite mounds.

The abiotic hypothesis for the genesis of the EmF' mounds analyzed in the FDB is supported by the altimetric analysis of landscapes where they appear. The findings in this study indicated altimetric continuity between the external surfaces adjacent to the EmF and the tops of the mounds in the EmF, as no significant altimetric differences were detected between these sets. The alignment between mounds' tops and the surrounding terrain once again suggests that the land around the mounds has been lowered, supporting the idea that EmF's mounds are remnants of differential erosion (Araujo Neto *et al.*, 1986; Furley, 1986; Silva *et al.*, 2010). Similarly, Sales *et al.* (2021) have observed that the EmF's tops were aligned with the surrounding plateau in their study area.

Previous studies conducted at different times in the FDB support the findings of Sales *et al.* (2021) as well as the results presented here (Furley, 1986; Silva *et al.*, 2010). Field investigations carried out in the FDB between 1976 and 1986 revealed that water flow and lateral infiltration eroded the upper margins of EmF, contributing to the formation of new mounds (Furley, 1986). This same study was the first to document the existence of altimetric continuity between the mounds' tops and the adjacent terrain surface.

Silva *et al.* (2010) have hypothesized that if EmF's mounds were raised by termites from the moist surface, originally occupied by a wetland, the organic matter beneath these structures should exhibit an isotopic signature of C_4 plant species, which contrasts with the C_3 + C_4 signature typical of savanna formations. Phytosociological surveys of the vegetation on EmF's mounds and the analysis of soil texture and chemistry complemented their hypothesis. Silva *et al.* (2010)'s results have indicated that the floristic composition on EmF's mounds, soil texture, soil chemical fertility, as well as the isotopic composition of the organic matter, were consistent with an area once occupied by a savanna formation of Cerrado. Thus, the evidence suggested that EmF's mounds were formed by differential soil erosion that had lowered the terrain (Silva *et al.*, 2010).

According to the biotic hypothesis, the elevation of EmF's mounds by termites should have raised the mounds' top above the surface of the adjacent terrain, as explained by Ponce and Cunha (1993). However, this altimetric elevation did not occur in the mounds analyzed in this study or in other similar ones (Furley, 1986; Sales *et al*. 2021; Silva *et al.*, 2010).

FINAL CONSIDERATIONS

Due to their relatively small area within the landscape, the Earth Mound Fields (EmF) emerge as the rarest phytophysiognomy among the fourteen ones found in the Federal District of Brazil (FDB), covering only 1.2% of the FDB's territory . The abiotic genesis hypothesis for this phytophysiognomy, attributed to water erosion, has been supported by the findings of this study, which revealed EmF's configurations consistent with surface water runoff and similarities to the elongated shapes typical of riparian environments. Furthermore, our results do not support the hypothesis that EmF have been created by the successive actions of different termite species. The metrics related to the dispersion of EmF's mounds, their volume, and basal area do not align with the characteristics of termite mounds built by the species traditionally associated with EmF. Additionally, the altimetric continuity between the mounds' tops and the adjacent external surfaces of the fields contradicts the biotic hypothesis, further reinforcing the abiotic hypothesis for the formation of this phytophysiognomy.

FUNDING SOURCE

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AUTHORS CONTRIBUTION

Thyego Pery Monteiro de Lima: Conceptualization, Data Curation, Formal Analysis, Writing – Original Draft.

Rodrigo Studart Corrêa: Conceptualization, Methodology, Writing – Review and Editing.