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SOIL ANALYSIS OF BARN SWALLOW (*HIRUNDO RUSTICA*) NEST'S (NORTHEASTERN OF ALGERIA)

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Abstract

This work consists of analyzing the Barn Swallows nest's soil (Hirundo Rustica) which was nested in the northeastern Algeria, particularly in the Mila region (Beinen), the Guelma region (Town-Center and Bouchegouf) and, the Oum El Bouaghi region (Ain el Baida). This species of birds uses different materials to build their nests, whose main component is the existing meadow soil. This study is contributes to knowing the bird strategy on nest building and materials chosen in it. From there, we have done weight chemical analysis according to the Vatan model; the results obtained are represented in the Czerminski diagram; for the organic matter quantification, we have used Walkley and Blacket method, and ecological analysis was according to ANOVA model. The weight chemical analysis results showed us loamy sandstone or marly sandstone soil type on the Northside of the study area (Mila region) and marly sandstone, sandy-marly loams, marl, and marly-sandy limestones on the Southside of the study area (Guelma and Oum El Baouaghi region), the organic matter analysis results showed non-aggressive soils and the ecological analyzes revealed a significant difference between the nest's compositions of each region except for the loam which has an F = 1.4857 and P = 0.2681. So, the Barn Swallows have a very precise strategy in choosing construction materials for their nests. For that, we recommend to characterize those construction materials by other studies (plasticity, mechanical resistance, mineralogy etc.).

***Keywords**: BARN SWALLOWS; CONSTRUCTION MATERIALS; NEST; STRATEGY; WEIGHT CHEMICAL; ECOLOGICAL ANALYSIS; ALGERIA.*

Introduction

Barn Swallows (*Hirundo Rustica*) are very faithful to their nesting site; they return to the same places to lay their eggs [1]. Usually, they renew the pre-existing nest or rebuild a new one in the same place if it's damaged [2, 3]. Their nest is built with soil (mud) [2, 4, 5], on the one hand, reinforced with straw and amalgamated by saliva [6] and on the other hand, presenting particular characteristics of the nest's construction such as particle cohesion, support adhesion, ease handling during construction, resistance degree for various contraction factors (swelling) and traction during several spawning year's successes [7].

The studies have shown a relationship between the male's reproductive success and nest quality of *Hirundo Rustica*, but there are few works in the world [7, 8, 9, 10] except in terms of habitat site selection, territory quality and, feather material properties, that we mention the papers of *M.L.P. Thompson* [2]; *T.D. Mazgajski* [11]; *J. Sériot and D. Alvès* [12]; Z. *Dolenec* [13]; *E. Pikula* [14]; *M. Beklova et al.* [15]; ***M.** Al-Rawy and George* [16]. But there are no

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studies, in Algeria, about the texture or building materials proprieties of the nests, especially Barn swallows.

To know the strategy in the choice of nest's building materials for Swallows which nested on some sites in Algerian Northeastern (Mila, Oum el Bouaghi and Guelma), we analyzed the soil that constituted it. This contribution is a weight chemical analysis to extract the element percentages compose these soils (sand, loam and, carbonates), the organic matter to determinate the nest's soil aggressiveness and, the ecological analysis to understand the strategy of choice of these components according to their availability on reproduction site (different compositions for each nest) or the material quality used, whatever their existing places (a similar composition for all nests).

Material and Methods

Study site

The studied region occupies the Northeastern part of Algeria (Fig. 1). It's bordered on the North by Jijel, Skikda, Annaba and, Constantine, on the East by Taref, Souk Ahras and Tebessa, on the West by Setif and, on the South by Tebessa, Khenchela and Batna. This region is characterized, in the North, by predominance detrial deposits, a low vegetation cover and an important orographic aspect; a very uneven relief and showing remarkable topographic contrasts [17,18, 19, 20, 21], on the South, is characterized by a diversified relief and a significant forest cover [5]. Geologically, the outcropping areas range from Neocomian to Plio-Quaternary age [22, 23, 24] with a subhumid to semi-arid climate [25, 26] and, geomorphologically, the region is dominated by high plains dotted with depressions [27, 23, 28].

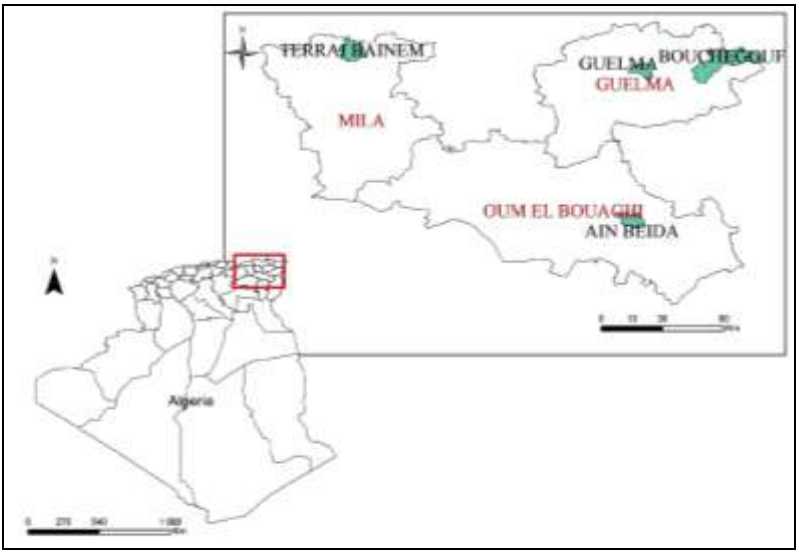

Fig. 1. Map of the studied region and the three sampling sites

Sampling

To reach our goal, we collected 16 nests from four sites at the end of 2018 breeding season: from the Guelma region (Bouchegouf 4 nests and Town-Center 3 nests), from the Oum el Bouaghi region (Ain el Beida 5 nests) and, the Mila region (Beinen 4 nests) (Fig. 1).

Sample analysis

Weight Chemical analysis

After preparation of essential tools, we followed the *A. Vatan* protocol (1967) [29] to carry out the weight chemical analysis where:

We take a determined weight of soil mixing and sieving (0.063 mm) wet to separate the sand from the loams and carbonates. After drying it, we get the weight of sand.

We Take a weight of soil fraction ≤ 0.063 mm and put it in a beaker, add the diluted HCl (10 %), then stir and heat at the same time at a temperature below 80 °C. As the handler proceeds, the carbonates volatilize until the negative effect of HCl.

Finally, a sufficient amount of distilled water is added. The sample particles are allowed to settle for one day; the distilled water is poured and, the operation is repeated 2nd and 3rd time for confirmation.

The sample is dried at about 100 °C; then, we obtained the weight of loams and carbonates.

The percentage of loams, carbonates and sands is calculated.

Organic Matter (OM)

After the preparation of essential material, we used the Walkley and Blacket method to determine the organic matter of our samples:

In the control, we put the Mohr salt in a burette (10 mL of biochromate, 20 mL of sulfuric acid and, six drops of ferroxine) and stir the mixture magnetically, where green color is observed and until this mixture becomes red under the effect of ferroxine, we obtain Mohr salt volume (a).

For the test, we take 1g of soil (m) in a beaker; add 20 mL of sulfuric acid and 10 mL of biochromate. After 30 minutes, we added six ferroxine drops, stirred the mixture, measured and added droplets to Mohr salt; if the color of the mixture turned red; we closed the burette and took the reading volume (b).

The organic matter (OM) rate obtained is calculated according to the following formula:

$$\mathbf{OM\ (\%) = C_{organic} \times 1.724}$$

$$\text{with } C_{organic}\ (\%) = ((a-b) \times f \times 0.0006 \times 1.16 \times 100)/m$$

where: - $C_{organic}$ - the organic carbon content of the air-dried soil sample, (%); a - the volume of Mohr's salt solution 0.2N used to titrate the control sample, (mL); b - the volume of Mohr's salt solution 0.2N used for the titration of the analyzed sample, (mL); f – factor of Mohr's salt solution 0.2N; 0.0006 g of organic carbon equivalent to the consumption of 1 mL of Mohr's salt 0.2N, respectively to the equivalent consumption of the oxidant used to oxidize organic matter; 1.16 = correction coefficient of the organic C content in relation to the recovery percentage of C, (86 %); m – the amount of analyzed soil, (g); 100 – factor for percentage reporting. The result is recalculated for 100 g of oven-dried soil at 105 °C.

Ecological analysis

The obtained results have expressed as a percentage: for each nest, statistical treatment is carried out by STATISTICA software (V8), on the one hand, the representation of results on ternary diagrams according to Czerminski's model of the soil classification used for nest building in each region, on the other hand, an ANOVA variance analysis to understand the relationship between independent quantitative (loams, carbonates and sand, percentages) and explanatory qualitative variables (nest, region).

Results and Discussions

Weight Chemical analyzes.

The results obtained are grouped in the below table (Table 2) and represented on ternary graphs (Fig. 2).

Table 2. Results of weight chemical analysis for the nest's soil examined the three regions

		Sample	Sands (%)	Loams (%)	Carbonates (%)	Organic Matter (%)
Mila region (Beinen)		M1	78.55	10.42	11.03	2.10
		M2	57.28	32.55	10.18	3.54
		M3	73.10	24.47	2.42	2.44
		M4	58.52	34.52	6.96	-
Oum El Bouaghi region (Ain El Beida)		OB/R1	29.71	29.32	40.97	4.82
		OB/R2	42.82	35.73	21.45	
		OB/R3	20.70	30.87	48.43	3.25
		OB/R4	56.22	15.23	28.55	4.99
		OB/R5	30.83	25.58	43.59	4.70
Guelma region	**Town-Centre**	TC1	27.71	35.25	37.04	3.25
		TC2	2.80	39.93	57.27	-
		TC3	19.33	36,63	44.05	-
	Bouchegouf	GB1	52.42	21.03	26.55	3.25
		GB2	37.86	43.15	18.99	6.43
		GB3	39.46	36.35	24.19	4.70
		GB4	48.41	33.20	18.40	2.39

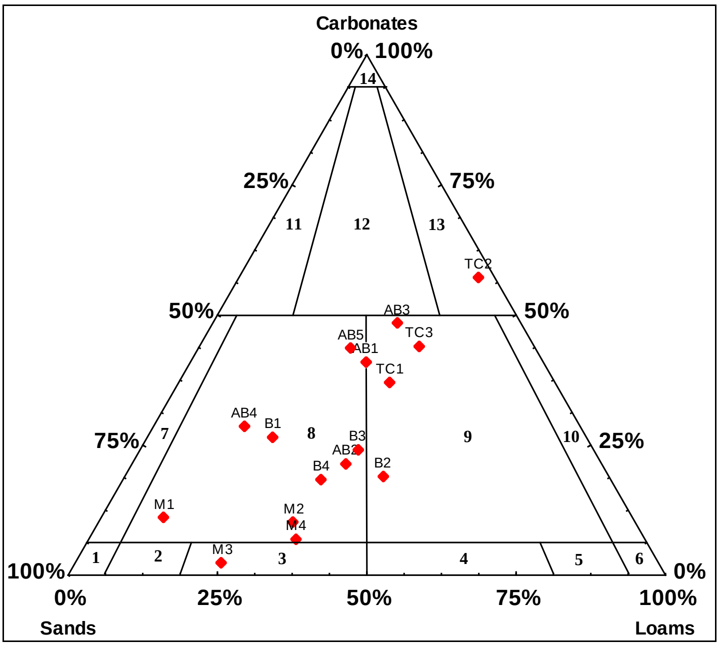

Fig. 2. Ternary presentations of chemical-weight results analysis and sedimentary rock classifications according to the Czerminski method:
M - Beinen (Mila); AB - Ain el Baida (Oum el Boaghi);
TC - Town Center (Guelma), B: Boucheguouf (Guelma);
1. Loam; 2. Marly loam; 3. Loamy marl; 4. Marl; 5. Marly limestone;
6. Limestone; 7. Sandy loam; 8. Marly-sandy laom; 9. Sandy-marly limestone;
10. Sandy limestone; 11. Loamy sandstone; 12. Marly sandstone;
13. Limestoneous sandstone; 14. Sandstone

The samples examined showed the predominance of sands in the North side region (Mila) and the marl (carbonate rock) for southern side (Guelma and Oum el Bouaghi) (Table 2). The results representation of these samples on the ternary diagrams, according to Czerminski's model, has generally given to the Mila region (Beinen site); loamy sandstone and marly sandstone, for the Oum el Bouaghi region (Ain el Beida site); marly sandstone, sandy-marly loams and marly-sandy limestones and for the Guelma region (Bouchegouf and Town-Center sites); marl, marly sandstone; sandy-marly loams and marly-sandy limestones (Fig. 2).

The soil components rates for nests collected from Beinen (Mila region): loamy sandstone is from 10.42 to 24.47 % for loams, 2.42 to 11.03 % for carbonates and, 73.10 to 78.55 % for sands and, for marly sandstone are from 32.55 to 34.52 % for loams, 6.96 to 10.18 % for carbonates, 57.28 to 58.52 % for sands and 2.10 to 3.54 % organic matter contents. These rates differ to those we found in Ain el Beida (Oum el Bouaghi region), where it's marked- : sandy-loamy sand and sandy-marly sand; from 42.82 to 56.22 % of sand, 15.23 to 35.73 % for loam and, 21.45 at 28.55 % of carbonates, also for sandy-loam or sandy loam- : from 20.70 to 30.83 % for sands, 25.58 to 30.87 % for loam, 40.97 to 48.43 % for carbonates and 3.25 to 4.82 % of organic matter contents. For the nests that were taken from the Guelma region (Bouchegouf and Town-Center sites) their components are different from those of the Mila region (Beinen site) and, they are similar to those of the Oum el Bouaghi region (Ain El Beida site) where we note: Sandy loam and loamy loam, from 2.80 to 27.71 % of sand, 35.25 to 39.93 % for loam and, 37.04 to 57.27 % for carbonates, also for loamy-loamy sands and loamy-sands from 37.86 at 52.42 % of sand, 21.03 to 43.15 % for loams, 18.40 to 26.55 % for carbonates and, 2.39 to 6.49 % of organic matter contents (Table 2). These rates totally differ from those recorded for chemical-weight analysis results for Mila Basin soil's where they recorded very high values of clays (72.36 to 98.86 %), low to moderate carbonates (0.86 to 17.33 %), low sands (0.12 to 12.75 %) and, low organic matter, sometimes trace (0.05 to 0.73 %) [18, 30, 31, 32, 33, 34, 35, 36].

Therefor, these results show high sand contents on the Northern side of the study area (Mila) (reaches 80 %), average carbonate contents (reaches 30 %), low loam levels (reaches 11%), and organic matter (reaches 4%). For the Southern side of the studying region (Guelma and Oum el Bouaghi), these results show low to moderate contents (19 to 50 %), average carbonates (reaches 50 %), loams reached 40% and, low organic matter levels (up to 6 %). These percentages present, on the one hand, the geological position of each soil used to collect nest-building materials; for example, the sampling site in the Mila region is characterized by the Miocene cover (sandstone) and, the other sites (Bouchegouf, Ain el Baida, Town-Center of Guelma) are located in the highlands (Guelma and Oum el Bouaghi basin) which are characterized by the dominance of carbonate rocks. On the other hand, more than the construction method followed by the swallows in nest building (concrete plus reinforcement) and the existing land use in the perimeter of existence, these results also show the best selection of building materials, their nests; where we marked : more than 50 % of sands and in places reaches 80 %; this content represents with straws and the frame of nests, more than 30 % of carbonates ($CaCO_3$) and, loam plays the cementing role to concreting because they ensure constituents adhesion of nests between them and reflects a good mechanical resistance index of soils [37], low or trace of organic matter (less than 4 %) reflects the low corrosion of nests constituents and consequently the non-aggressiveness of these soils [38].

ANOVA variance analysis

The results of this analysis are summarized in Table 3 and, they are interpolated in the graphs below (Figs. 3, 4 and 5)

The statistical results show a highly significant difference between the samples; the loam, carbonates and, sand percentages are specific for each nest (Figs. 3, 4 and 5) [Loam: (ANOVA $F = 04.9900$, $P = 0.0000$); carbonates: (ANOVA $F = 181.9076$, $P = 0.0000$) and sand: (ANOVA $F = 200.1649$, $P = 0.0000$)], however, depending on the regions, loam percentage has similarity (ANOVA F = 1.4857, P = 0.2681) which is not the case of sand and carbonates (ANOVA F = 15.6239, P = 0.0001) - (ANOVA F = 11.8020, P = 0.0006) (Table 3).

Table 3. Percentages variations of components in the nests and region:

	N	Intercept		Region	
		F	*P*	*F*	*P*
Loams	16	204.9900	0.0000	**1.4857**	**0.2681**
Carbonates	16	181.9076	0.0000	15.6239	0.0002
Sands	16	200.1649	0.0000	11.8020	0.0007

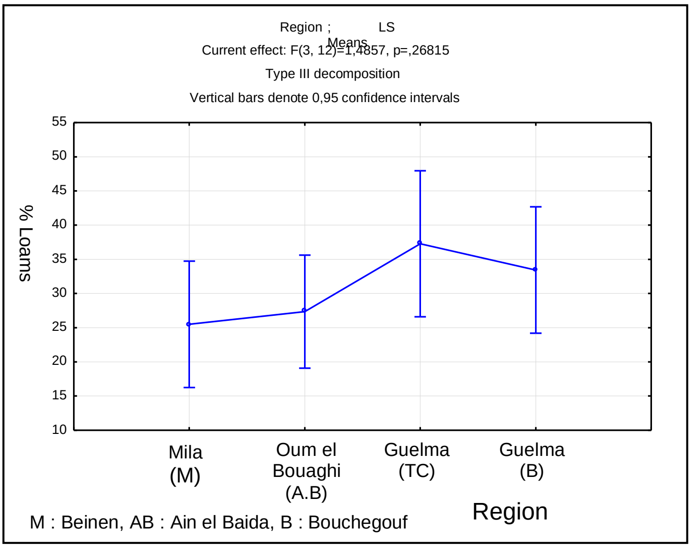

Fig. 3. Graphical presentation of loams percentage using ANOVA tests across sites

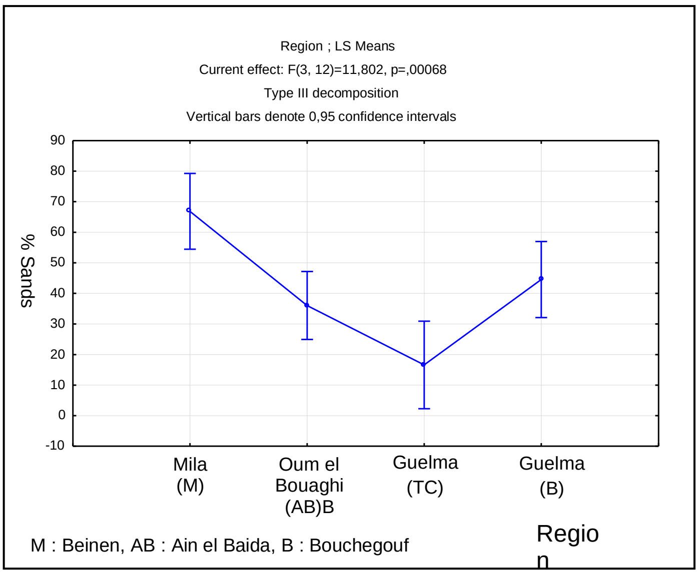

Fig. 4. Graphical presentation of sands percentage using ANOVA tests across sites

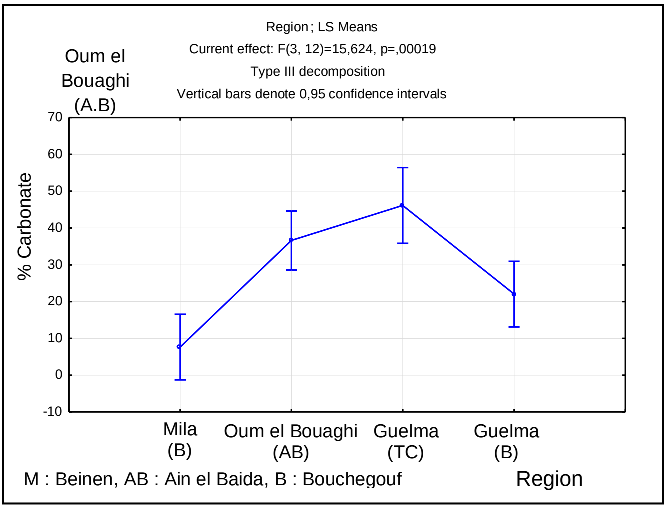

Fig. 5. Graphical presentation of carbonates percentage using ANOVA tests across sites

The building material analysis of two swallows nests (*Petrochelidon Pyrrhonota and Hirundo Rustica*) reported by *L. Delbert et al.* [8], showed that- : the materials used are interspecific similarity of the two species in which they were found. Enraged that the main component is the sand with modest amounts of loam and little clay. Specifically, sand particles accounted for 61.4±0.8 % to 56.4±1.1%, respectively, for mud samples from Barn Swallow nests; while loam particles accounted for 25.7±0.9 % to 31.5±2.9 % (values are the means ± deviation). The average amount of clay in the mud samples was similar for both species, 12.7±0.7 % to 11.9±0.6 %, respectively. In most localities, the mud in the nests of White-Fronted Swallows contains more sand and fewer loam particles than those from Barn Swallow nests. So, there is no recognizable trend between sites.

The absence of a significant difference between the loam percentages of the three regions (Fig. 5) confirms the qualitative choice of nest-building materials and the sandy-loam or sandy loam soils, according to *P. Buss* [39], constitutes the best mud for building a nest. These results are confirmed by the works of *I.O. Dimitrios et al*. [7], which expose the mineralogical and textural characteristics of nest building geomaterials used by Barn Swallows (*Hirundo Rustica*) where in this study they show: the types of clay and loam used for nest building, this species have a tendency to use clay minerals as cement, especially smectite and illite and if these minerals are not present in the adjacent area, it uses the halloysite, kaolinite or chlorite. Also, the number of clay minerals on the nests is low; that indicates this species can accurately identify the nesting material properties. The most non-clay minerals used are white or uncolored, easily accessible, low-density such, as quartz, feldspar and, calcite. The analysis of granulometric distribution revealed that-: the number of fine elements (clay) in the nest is relatively small, and it's having larger grain particles decreases, At the same time, the white-fronted Swallow (*Petrochelidon Pyrrhonota*) preferred coarse particles (quartz) and the preferences of the tired swallow (*Delichon urbica*) lie between the other two species. Therefore, the three Hirundinidae species have different nest-building strategies; it depends on the nest architecture [7].

So, our results confirm that the Barn Swallows have a precise strategy for choosing the building materials for their nests and opt for specific soil types to maintain their stability over several years during several breeds and several years, which give another fidelity concept of a family place to this bird.

Conclusions

The various soils of the Barn Swallow's nest are taken from four sites; Mila (Beinen), Oum el Bouaghi (Ain el Baida), Guelma (Town-Center and Bouchegouf) gave:

The weight chemical analysis of soils for the Mila region (Beinen site) gave the loamy sands and marly sands with an average of 22.47 % for loam, 6.725 % for carbonate and 67.91 % for sands, Oum el Bouaghi region (Ain el Beida site), where the soil is marl-sandy loams and sandy marly limestones; average of 38.46 % of sand, 25.48 % of loams and 34.94 % for carbonates and for Guelma region (Bouchegouf and Town-Center sites) their soils are marl, marly sandstone, sandy-marly loams and marly-sandy limestones; average of 27.61 % of sand, 32.09 % of loams and 77.67 % of carbonates.

The organic matter analysis revealed that the soil used for the nest's construction has low or trace levels (less than 4%), which reflects a low constituent's corrosion of nests and consequently the non-aggressiveness of soils.

The ecological analysis showed a highly significant difference between samples; the percentages of loams, carbonates and, sand are specific for each nest [Loam: ANOVA; carbonates: (ANOVA F = 181.9076, P = 0.0000) and sand: (ANOVA F = 200.1649, P = 0.0000)] which reflects that the Barn Swallow has a quantitative choice of the nest building material where the loamy and clayey soil are the best mud for solid and stable building for several years also several laying and which confirms species fidelity.

Therefore, it is important to cross the physical and chemical details of loam types, clay and, sand used in nest construction to better understand about their importance to stable and resistant states against different environmental factors.

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