Study of Fiddler Crab Density on Soil Properties and Carbon Sequestration in Mangrove Soils, Ban Modtanoi, Kantang District, Trang Province

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Abstract

This study on the effects of fiddler crab density on soil properties and carbon sequestration in mangrove soils was conducted in Ban Modtanoi mangrove forest, Kantang District, Trang Province. The objectives of the study were to examine the effects of fiddler crab density on soil properties and to compare the amount of carbon sequestration in mangrove soils at Ban Modtanoi, Kantang District, Trang Province. The GLOBE Soil Protocol was employed to analyze the physical and chemical properties of the soil, and soil organic carbon (%OC) was calculated from the loss on ignition (%LOI) at a combustion temperature of 450°C. The results showed that areas with higher fiddler crab density exhibited significantly greater carbon sequestration capacity. Site B (the pier area), which had a fiddler crab density of 80 individuals per square meter, showed a high soil organic carbon content of 2.65 %OC and an organic matter content of 6.92 %LOI. In contrast, Site A (the community enterprise area), with a lower crab density of 44.8 individuals per square meter, exhibited lower values, with 1.54 %OC and 4.36 %LOI. In addition, Site B had higher soil moisture (22.85%) and a clay loam soil texture, whereas Site A had lower soil moisture (17.28%) and a sandy clay loam texture. Both sites had a soil pH of 6 and contained only trace amounts of N, P, and K nutrients.

Keywords: *Mangrove forests, Fiddler crab, Soil quality, Carbon sequestration*

Research Questions:

1. Does fiddler crab density correlate with mangrove soil properties?
2. How does fiddler crab density affect the amount of organic carbon sequestration in mangrove soil?

Objectives:

1. To study the effects of fiddler crab density on soil properties in mangrove forests.
2. To compare the amount of carbon sequestration in mangrove soil in areas with different densities of fiddler crabs.

Hypotheses:

1. Fiddler crab population density significantly affects soil properties in mangrove forests.
2. Higher fiddler crab density leads to increased soil carbon sequestration.

Introduction:

At present, climate change driven primarily by the increasing concentration of greenhouse gases, particularly carbon dioxide (CO_2), has severely disrupted the balance of ecosystems worldwide. Mangrove forests have therefore emerged as critical target ecosystems for climate change mitigation due to their high capacity for carbon sequestration, especially through the long-term accumulation of soil organic carbon. The carbon sequestration efficiency of mangrove soils results from complex interactions among physical, chemical, and biological factors. Among these, soil-dwelling organisms such as fiddler crabs play a key role through their burrowing activities, which enhance soil structure, increase aeration, and influence biogeochemical processes that promote carbon accumulation in deeper soil layers.

However, despite the current decline in fiddler crab populations, studies that clearly demonstrate the spatial relationship between fiddler crab density, soil properties, and carbon sequestration efficiency remain limited. Therefore, this study aims to investigate the effects of fiddler crab density on the physical and chemical properties of soil, as well as carbon sequestration potential, in the mangrove forest of Ban Modtanoi, Trang Province, Thailand. The study applies the standardized methodology of the GLOBE Soil Protocol to generate empirical data that can support conservation, restoration, and sustainable management of mangrove ecosystems as natural carbon sinks.

Materials

1. Quadrats
2. Measuring Tape
3. Hot air Oven
4. Muffle Furnace
5. Digital Scales
6. Thermometer
7. Soil NPK Test Kit
8. Universal Indicator
9. Soil Color Chart
10. Crucible

Methods

1) Study sites

The study area was established in the mangrove forest at Ban Modtanoi, Koh Libong Subdistrict, Kantang District, Trang Province, Thailand. Two sampling sites were selected. Site A was located near the community enterprise area at latitude 7.3078° and longitude 99.4178°, while Site B was located near the pier at latitude 7.3086° and longitude 99.4175°, as shown in Figure 1. Each site covered an area of 10 × 10 m. Within each site, five 0.5 × 0.5 m quadrats were randomly selected for sample collection.

Figure 1: Location of Ban Modtanoi, Kantang District, Trang Province, Thailand, and the study sites.

2) Data Collection

1. Fiddler Crab Density

Fiddler crab density was determined by counting the number of crab burrows within five randomly selected quadrats at each study site. The burrow counts were averaged and recorded as crab density for each site.

2. Soil Properties

Soil properties were measured following the GLOBE Soil Protocol. Parameters included soil texture, soil color, soil temperature, pH, soil nutrients, and soil organic matter. A 50 × 50 cm quadrat was placed at each sampling location, and soil samples were collected from the surface down to a depth of 30 cm. Approximately 400 g of soil was collected from each quadrat and stored separately for laboratory analysis.

Laboratory analyses included soil texture, soil color, soil temperature, soil pH, and soil nutrients, as well as the determination of soil organic matter using the Loss on Ignition (%LOI) method to calculate soil organic carbon (%OC).

The remaining soil samples were weighed prior to oven-drying and then dried at 95°C for 24 hours to determine soil moisture content. After drying, the samples were weighed again. To determine organic matter content, the dried soil samples were further combusted at 450°C for 4 hours, reweighed, and the percentage of organic matter was calculated.

3. Data Submission

All collected data were submitted to the GLOBE Data Entry system.

Results

Preparation of a science project on the study Fiddler Crab Density on Soil Properties and Carbon Sequestration in Mangrove Soils, Ban Modtanoi, Kantang District, Trang Province

Table 1: Density of Fiddler Crabs and Soil Properties at Each Study Site

Site	Fiddler Crab Density (individuals/m²)	Soil Properties									
		Soil Texture	Soil Color	Temperature (°C)	Moisture Content (%)	pH	Soil Nutrients			%LOI	%OC
							N	P	K		
A	44.8 ± 1.92	Sandy Clay Loam	Very Dark Grayish Brown	37	17.28	6	trace	trace	trace	4.36	1.54
B	80.0 ± 8.63	Clay Loam	Very Dark Gray	31	22.85	6	trace	trace	trace	6.92	2.65

The results showed that Site B had a higher density of fiddler crabs than Site A. The density at Site B was 80.0 individuals per square meter, whereas Site A had a density of 44.8 individuals per square meter.

Regarding soil properties, Site B, which was characterized by sandy clay loam soil, exhibited a higher average soil moisture content (22.85%) compared to Site A, which had clay loam soil with an average moisture content of 17.28%. Soil temperature at Site A was

37°C, while Site B recorded a lower temperature of 31°C. The soil pH values at both sites were similar, ranging from neutral to slightly acidic. Soil nutrient analysis revealed that nitrogen (N), phosphorus (P), and potassium (K) were present only at trace levels in both areas.

In terms of soil organic matter and carbon content, Site B showed higher values of %LOI and %OC than Site A. Site B had 6.92% LOI and 2.65% OC, whereas Site A had 4.36% LOI and 1.54% OC, indicating a greater carbon sequestration potential in areas with higher fiddler crab density.

Discussion and Conclusion

Based on the analysis of the relationship between fiddler crab density, soil properties, and carbon sequestration in the mangrove forest of Ban Mod Tanoi, the discussion and conclusions can be summarized as follows.

The density of fiddler crab populations showed a significant relationship with soil properties and carbon sequestration potential, which can be discussed in three main aspects:

Physical soil properties: Areas with higher crab density (Site B) exhibited higher soil moisture and a clay loam soil texture, which is more effective at retaining water and organic matter than areas with lower crab density (Site A), characterized by sandy clay loam soil. This pattern reflects the role of crab burrowing activity, which increases soil porosity and enhances water and air circulation within the sediment. These findings are consistent with the study by Mokhtari et al. (2016), which highlighted the influence of burrowing organisms on sediment structure.

Chemical soil properties: Soil pH and macronutrient levels (N, P, and K) at both sites showed no marked differences and were present only at trace levels. This suggests that crab density has a stronger influence on physical soil structure than on short-term changes in soil chemical properties. This observation aligns with the concept of bioturbation described by Booth et al. (2019), where biological activity directly alters sediment structure rather than chemical composition.

Carbon sequestration potential: Areas with higher crab density showed substantially greater organic matter content (%LOI) and soil organic carbon (%OC). This is likely due to burrowing behavior that promotes the accumulation and burial of organic material within the soil profile. These results support the findings of Almeida et al. (2023), who reported that crab activity plays a crucial role in organic matter redistribution and long-term carbon storage in mangrove ecosystems.

This study concludes that fiddler crab density is an important biological factor enhancing carbon sequestration efficiency in mangrove forests. Crab burrowing activity improves soil physical properties, particularly soil moisture and structure, which facilitate organic matter accumulation. As a result, areas with higher crab density exhibited significantly higher soil organic carbon (%OC) than areas with lower crab density. These findings emphasize that fiddler crabs are not merely common mangrove inhabitants but function as "ecosystem engineers," supporting the role of mangrove forests as highly effective natural carbon sinks.

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GLOBE's databases

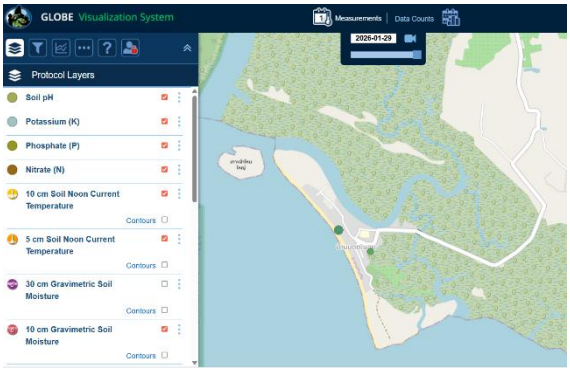

Figure 2: Entering soil quality into GLOBE Data Entry

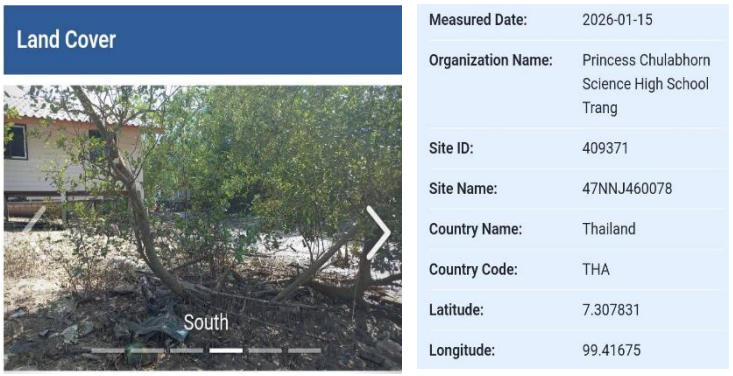

Figure 3 : Record data into GLOBE Land cover

(Optional) Badges

1. **I am an Earth System Scientist**

This research demonstrates a systemic linkage between the biosphere, represented by fiddler crab populations, and the lithosphere/pedosphere, represented by soil properties in mangrove ecosystems. The research team applied the standardized GLOBE Soil Protocol to investigate biological interactions through the process of bioturbation, which influences carbon dioxide dynamics in the atmosphere via the soil's capacity to sequester organic carbon. Empirical data analysis reveals that changes within one Earth system component can directly disrupt or regulate the balance of the Earth system as a whole, highlighting the interconnected nature of biospheric, pedospheric, and atmospheric processes.

2. **I make an Impact**

This study originated from local observations of declining fiddler crab population density in the mangrove forest of Ban Mod Tanoi. The research team connected this localized ecological issue to the broader global challenge of climate change. The findings clearly demonstrate that fiddler crab density directly affects carbon sequestration efficiency in mangrove soils. These results provide concrete, community-oriented recommendations for mangrove conservation as a nature-based solution to enhance natural carbon storage mechanisms. In doing so, the research contributes positively to sustainable coastal resource management and strengthens climate resilience within the Ban Mod Tanoi community.

3. **I am a Collaborator**

This research project was successfully executed through a multi-sectoral collaboration mechanism, which encompassed the integration of knowledge between students and advisors, the connection of local wisdom from the community, and the continuation of knowledge from past research (Longitudinal Data Integration). This strategic collaboration resulted in research data that is complete in its temporal dimension and possesses a high level of scientific reliability. The implementation of the research project regarding the effects of fiddler crab density on carbon sequestration utilized a collaborative model with clearly defined and synergistic roles. Regarding the research team, Ms. Natthawanee and Ms. Waratchaya held primary responsibility for technical processes in the field and laboratory. They proceeded by establishing sampling plots (Quadrats) of 10 x 10 meters and utilizing sampling frames of 0.5 x 0.5 meters to assess fiddler crab population

density through burrow surveys. This included analyzing soil chemical properties according to the GLOBE Soil Protocol using a Muffle Furnace at 450°C to calculate the soil organic carbon percentage (%OC) and managing the dataset for submission into the GLOBE Data Entry system. These processes were conducted under the supervision of Mrs. Sirikwan and Ms. Neungreuthai, expert advisors who played a pivotal role in academic Quality Control. They provided guidance on hypothesis formulation and verified the accuracy of scientific measurement instruments, such as NPK test kits and pH meters, to ensure that the research process adhered to international scientific principles. A critically important dimension of this research was the cooperation received from the community enterprise and the public in Ban Modtanoi, who acted as providers of in-depth contextual knowledge regarding ecological history and trends in coastal resource changes, including support in logistics and access to strategic sampling sites. Furthermore, the research team integrated data with past research projects (Senior Research Integration) to perform a comparative analysis between historical data and current findings. This coordination between the research team, advisors, the community, and existing databases allowed the research to identify trends in area recovery and carbon sequestration potential significantly, leading to the proposal of natural resource conservation guidelines grounded in sustainable community-based cooperation.