# Study of Fiddler Crab Density in Relation to Soil Properties and Soil Carbon Sequestration in Ban Modtanoi Mangrove Forest, Kantang District, Trang Province.

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## Abstract

This study investigated the relationship between fiddler crab population density, soil properties, and carbon sequestration in the Ban Modtanoi mangrove forest, Trang Province, Thailand. Soil samples were collected from a depth of 30 centimeters at two locations: the community enterprise area and the pier area. Soil properties were analyzed following the GLOBE Soil Protocol, and soil organic carbon was estimated using the Loss-on-Ignition method. The results showed that the pier area had a significantly higher mean fiddler crab density than the community enterprise area, with 90.5 and 44.8 individuals per square meter, respectively. The higher crab density was associated with improved soil physical properties, including higher soil moisture, lower soil temperature, and a clay loam soil texture that retained more water and organic matter than the sandy clay loam soil in the community enterprise area. Both locations had a soil pH of 6 and very low levels of nitrogen, phosphorus, and potassium. However, the pier area contained higher organic matter (6.92%) and soil organic carbon (2.65%) than the community enterprise area (4.36% and 1.54%, respectively). These findings suggest that greater fiddler crab population density is associated with improved soil properties and increased carbon sequestration. Burrowing and bioturbation enhance soil porosity and structure, promoting the accumulation and burial of organic matter in deeper soil layers. Therefore, fiddler crabs play an important ecological role in increasing the blue carbon sequestration potential of mangrove forests.

Keywords : Mangrove Forest, Fiddler Crab, Soil Properties, Carbon Sequestration

## Introduction

Earth's ecosystems consist of complex interactions between living organisms and the physical environment, with natural mechanisms that continuously maintain the stability and balance of matter and energy. One crucial process is the carbon cycle, which is the transfer of carbon through the atmosphere, land, and oceans to create a natural equilibrium suitable for the survival of all living things. Especially, carbon sequestration in the form of Soil Organic Carbon (SOC) is a carbon pool on Earth that has a massive volume, more than the volume of carbon in the atmosphere by three times. The stability of this mechanism depends on the integrity of the components by having physical, chemical, and biological factors as co-determinants.

Currently, the world is experiencing impacts from climate change caused by greenhouse gas emissions, especially carbon dioxide ($CO_2$), which accounts for more than 65 percent of all greenhouse gases. According to statistics, global atmospheric carbon dioxide levels have continuously increased since 1990 and are projected to rise up to the year 2026, a situation considered a major cause of the intensifying global warming crisis. Mangrove ecosystems, which are highly efficient carbon sinks known as Blue Carbon, are facing a crisis from area destruction by human activities, such as urbanization and aquaculture, resulting in a massive amount of previously sequestered carbon being lost back into the atmosphere.

Mangrove plants absorb carbon dioxide and store it in the form of biomass and organic matter in the muddy soil, which facilitates long-term sequestration. Benthic organisms like fiddler crabs (Uca spp.) act as ecosystem engineers through their burrowing behavior, which helps improve soil structure, increase aeration, and promote nutrient cycling. However, at present, the population density of fiddler crabs tends to decrease due to human disturbance. Although there have been some studies on the physical impacts of burrowing, research data clearly showing how different densities of the fiddler crab population affect soil quality and carbon sequestration efficiency is still considered insufficient in the academic field.

Therefore, the research team is interested in studying the density of fiddler crabs in relation to soil quality and carbon sequestration capacity in the mangrove forest area of Ban Modtanoi, Kantang District, Trang Province. The study utilizes a research methodology according to the principles of the GLOBE Soil Protocol to analyze the physical and chemical properties of the soil and calculate the soil organic carbon content (%OC) from the loss on ignition percentage (%LOI). This study focuses on investigating the biological role of fiddler crabs that helps promote natural processes, aiming to obtain crucial data that will be used as a guideline for planning mangrove resource conservation and supporting the development of the area into an efficient natural carbon sink for sustainability, aligned with the Sustainable Development Goals.

## Methodology

### 1) Study Area Designation

The study area was designated in the mangrove forest around Ban Modtanoi, Koh Libong Sub-district, Kantang District, Trang Province. Two data collection sites were established: Site A, located near the community enterprise at the coordinates of 7.3078° N and 99.4178° E, and Site B, located near the pier at the coordinates of 7.3086° N and 99.4175° E. Each site measured 10x10 meters.

Within both data collection sites, five sampling plots measuring 0.5x0.5 meters were randomly placed.

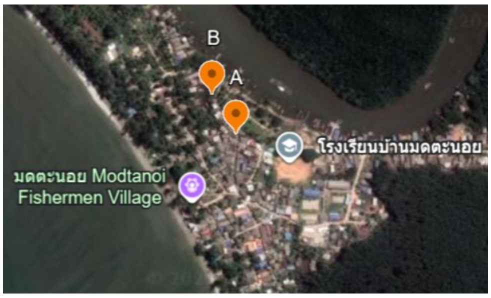


**Figure 1** Study sites at Ban Modtanoi, Kantang District, Trang Province.

**2) Data Collection**

**2.1 Fiddler Crab Density**

Count the number of crab burrows within the 5 sampling plots in both data collection sites. Average and record the obtained results.

**2.2 Soil Sampling**

Collect soil samples at a depth of 30 centimeters from each designated sampling area using a soil core sampler.

**3) Soil Quality Data Collection**

**3.1 Soil Texture**

Feel the soil texture and examine it according to the field soil texture classification guide. Record the obtained results.

**3.2 Soil Color**

Pick a soil pellet from the soil sample and observe the characteristics of the soil pellet. If it is dry, moisten it slightly with water from the prepared bottle. Break the soil pellet into 2 parts. Stand so that the sunlight passes over your shoulder onto the soil color chart and the soil sample being measured. Record the obtained results.

**3.3 Temperature**

Use a thermometer to measure the temperature at a depth of 5-10 centimeters. Read the soil temperature value and record the obtained results.

**3.4 Soil pH**

Weigh 20 grams of dry and sieved soil sample and pour it into a beaker. Add 20 milliliters of distilled water. Use a glass stirring rod to stir the soil for 30 seconds, then let it rest for 3 minutes. Repeat this process 5 times. When the soil has been stirred completely for 5 times, let it sit until the soil in the beaker settles, and clear water will be visible at the top. Dip a universal indicator paper into the clear water area above, being careful not to dip it down to touch the soil layer below. Compare the changed color of the paper with the standard color chart specified on the side of the universal indicator box to read the obtained pH value. Record the experimental results.

**3.5 Soil Nutrients NPK**

Weigh 25 grams of dry and sieved soil and pour it into a plastic cup. Add 80 milliliters of distilled water so that the soil to water ratio equals 2.5 : 8. Then use a glass stirring rod to stir the soil for 30 seconds and leave it for 3 minutes. Do this consecutively for 5 times. When the soil has been stirred completely for 5 times, let it sit until the soil in the beaker settles, and clear water will be visible at the top area (soil solution).

**Nitrogen (N) Measurement:**

Use a pipette to draw 2.5 milliliters of the soil solution and place it into a test tube.

Then add 1 packet of HI 3895-N reagent into the soil solution. Close the test tube cap, shake for about 30 seconds, and let it sit for 5 minutes to allow the color to develop. Compare the pink color of the solution with the standard color chart showing nitrogen levels in the soil test kit. Record the obtained results.

**Phosphorus (P) Measurement:**

Prepare the soil solution in the same way as the nitrogen test. Then add 1 packet of HI 3895-P reagent into the soil solution. Close the test tube cap, shake for about 30 seconds, and let it sit for 5 minutes to allow the color to develop. Compare the blue color of the solution with the phosphorus chart in the soil test kit. Record the obtained results.

**Potassium (K) Measurement:**

Prepare the soil solution in the same way as the nitrogen test. Use a pipette to draw 0.5 milliliters of the soil solution and place it into a test tube. Add distilled water to achieve a total volume of 2.5 milliliters. Add 1 packet of HI 3895-K reagent into the soil solution. Close the test tube cap, shake for about 30 seconds, and let it sit for 5 minutes to allow the color to develop. Compare the blue color of the solution with the phosphorus chart in the soil test kit. Record the obtained results.

**3.6 Soil Moisture**

By using the determination of lost weight compared between the soil weight before baking at 105°C (grams) and the soil weight after baking at 105°C (grams).

$$\% \text{ Humidity} = \frac{(W_{wet} - W_{dry})}{W_{wet}} x100$$

Where: $W_{wet}$ = weight before baking (grams)

$W_{dry}$ = weight after baking (grams)

**3.7 Soil Organic Matter Content**

By using the Loss on Ignition method (Jones, 2001) through the determination of lost weight compared between the soil weight after baking at 105°C (grams) and the soil weight after burning at 400°C (grams) for a duration of 4 hours. Record the weight after burning (Global Soil Doctors Programme, 2020).

$$\% \text{ LOI} = \frac{(W_{dry} - W_{fire})}{W_{dry}} x100$$

Where: $W_{wet}$ = weight before burning (grams)

$W_{dry}$ = weight before burning (grams)

**Result and Discussion**

The results of the study on fiddler crab density in relation to soil quality and soil carbon sequestration capacity in the mangrove forest area of Ban Modtanoi, Kantang District, Trang Province, are as follows:

**Table 1** Shows the density of fiddler crabs in each study site.

| Study Site | Fiddler Crab Density (individuals/square meter) |
|---|---|
| A | 44.8 ± 1.92 |
| B | 90.5 ± 9.98 |

**Table 2** Shows the results of the soil quality examination in each study site.

| Study Site | soil quality | | | | |
|---|---|---|---|---|---|
| | Soil Texture | Temperature (°C) | Soil Color | Moisture (%) | pH |
| A | Sandy Clay Loam | 37 | Very dark grayish brown | 17.28 | 6 |
| B | Clay Loam | 31 | Very dark gray | 22.85 | 6 |

**Table 3** Shows soil fertility, soil organic matter content, and soil carbon sequestration capacity.

| Study Site | Soil fertility | | | %LOI | %OC |
|---|---|---|---|---|---|
| | N | P | K | | |
| A | trace | trace | trace | 4.36 | 1.54 |
| B | trace | trace | trace | 6.92 | 2.65 |

The population density of fiddler crabs has a significant relationship with soil quality and carbon sequestration potential, detailed as follows:

In terms of physical properties, the area with high crab density (Site B) near the pier has higher soil moisture and a soil texture of Clay Loam, which retains water and organic matter better than the area with low crab density (Site A) near the community enterprise, which has a soil texture of Sandy Clay Loam. This reflects the role of fiddler crab burrowing activities in increasing soil pore space, promoting water and air circulation, which is consistent with the research by Mokhtari et al. (2016).

In terms of chemical properties, the pH values and macronutrients (N, P, K) in both areas show no difference, remaining at a very low level (Trace). This demonstrates that crab density affects physical structure more than inducing short-term chemical changes, which aligns with the concept of Bioturbation by Booth et al. (2019) regarding direct impacts on sediment structure. Regarding soil carbon sequestration capacity, the area with high crab density possesses significantly higher organic matter content (%LOI) and organic carbon (%OC) because burrowing behavior enhances the accumulation and burial of organic matter into the soil layers. This is consistent with the study by Almeida et al. (2023), which states that crab activities influence organic matter distribution and long-term carbon sequestration.

## Conclusions

This study concludes that fiddler crab density is an important biological factor that enhances carbon sequestration efficiency in mangrove forests. Crab activities improve the physical properties of the soil, both in terms of moisture and soil texture structure, which facilitates the accumulation of organic matter. Consequently, the area with high crab density shows a clearly higher soil organic carbon content (%OC) than the area with low density. This data emphasizes that fiddler crabs are not just common living organisms, but act as "ecosystem engineers." This serves as a guideline for planning mangrove resource conservation and supporting the development of the area into an efficient natural carbon sink for sustainability, aligned with the Sustainable Development Goals.

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