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# Probing species' information initially obtained with citizen science: implications for ecological management

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**Abstract**. Due to the natural engagements of citizen scientists, they have the advantage of species encounters, thus leveraging their significance in biodiversity studies. When a citizen scientist reports a suspected new species, an investigation may first require studies on taxonomy and biological analysis. There are cases, however, when their reports pertain to already known species that may still need investigations (species' occurrence and distributions), considering different ecological viewpoints. With this premise, we conducted a field survey (station-based visual data collection) to probe the extent of the distribution of two species described with citizen science engagements. We also explored the species-associated cultural practices in the community. Our results reveal the occurrence and distributions that vary in spatiotemporal contexts, validating the contribution of citizen science to the distribution record. With ecological management perspectives, we provide the following notions: conservation plans for the "rare" species and eradication programs for the invasive species on the island.

**Keywords:** Citizen science, monitoring, biodiversity, "rare" and invasive species, Catanduanes Island, *Portunus convexus, Lissachatina fulica.*

## 1. Introduction

In many facets of environmental studies, Citizen Science (as CS hereafter) imparts in collecting data especially when information may not be easily obtained. CS initiatives are becoming more popular in the Philippines with various organizations and institutions engaging in ecological projects, probably due to locally occurring issues between the community and the environment. This has produced several CS studies in the country which are primarily based on ecosystem services, conservation, and biodiversity (Madera & Habito, 2019; Araujo et al., 2020; Abreo & Kobayashi, 2021; Licuanan & Mordeno, 2021).

The Philippine ecosystems are known for their diverse terrestrial and marine biodiversity (Brown & Diesmos, 2009; WWF, 2023) being one of the 17 megadiverse countries (Mittermeier et al., 1999). However, current challenges have caused the loss of large numbers of wildlife in the country (Conservation International-Philippines, 2006), signifying the need for conservation, including the population inventory and abundance of extant species. With the efforts of several organizations, species inventory and conservation, are becoming more evident with the community-based approach. For instance, several new species or new locality records have already been described with the help of citizen scientists (as CSs, hereafter) (Naive et al., 2017, 2022, 2023; Ang et al., 2020; Mape et al., 2021; Salaga et al., 2021), although these studies have occurred relatively recently. In Catanduanes Island, for instance, species monitoring and conservation are arguably becoming more significant, with the current issues on biodiversity utilization and economic development (Aldea et al., 2014, 2015; Aldea & Masagca, 2016; Aldea, 2022, 2023).

Due to their traditional engagement with the natural landscapes, CSs may have a large probability of species encounters, hence their roles in species information. In many cases, CSs may report a new species or a record of a previously known species, wherein the scientists may follow a further confirmation using morphological, laboratory, or some ecological tests. There are cases, however, when reports pertain to already known species that may still need distributional investigations considering ecological viewpoints. With this premise, we conducted an ecological field survey to probe the earlier information (obtained from CSs) about the occurrence of the two species on the island. Specifically, we aimed to elucidate the distribution of the "rare" crab *Portunus convexus* and the invasive snail *Lissachatina fulica* in both spatial (stations) and temporal contexts (diurnal-nocturnal distribution for the crab, and monthly distribution for the snail). We also described the folks' cultural information associated with the two species and provided notions in delivering environmental approaches for both of them.

## 2. Methodology

### 2.1. Locale of the Study

Catanduanes Island has a land area of 1,511.5 km$^2$ and a population of 271,879 in 2020 (PSA, 2022), located east of Luzon. It is the smallest province of the Bicol Region of the Philippines, both in terms of land area and population (PSA, 2022). Its coasts are bordered by the Pacific Ocean (Philippine Sea) to the east and north, Lagonoy Gulf and Cabugao Bay to the south, and Maqueda Channel to the west where it is closest to Mainland Luzon (Caramoan Peninsula).

### 2.2. Species Preliminary Information and Sampling Method

We found crab carapaces (two empty shells) on a rocky beach in November-December 2021, while the snail was personally informed by some CSs in December 2021 (many local social media activities about the snail were also available at that time). Considering the possibility that the species are from the island, we initially investigated them (including the related community practices) through preliminary interviews in the community (February-March 2022). Preliminary communication has drawn information that the crab is present on the island (despite its "rare" record in the country). Likewise, information obtained about the snail revealed its presence primarily due to associated crop infestations. Information on the specific location and distribution of both species, however, was still limited. We then interviewed work-based CSs (intertidal gleaners, farmers, homeowners) and they voluntarily agreed to provide data on the species distribution, taken as part of their daily routine for two weeks. The preliminary data were obtained

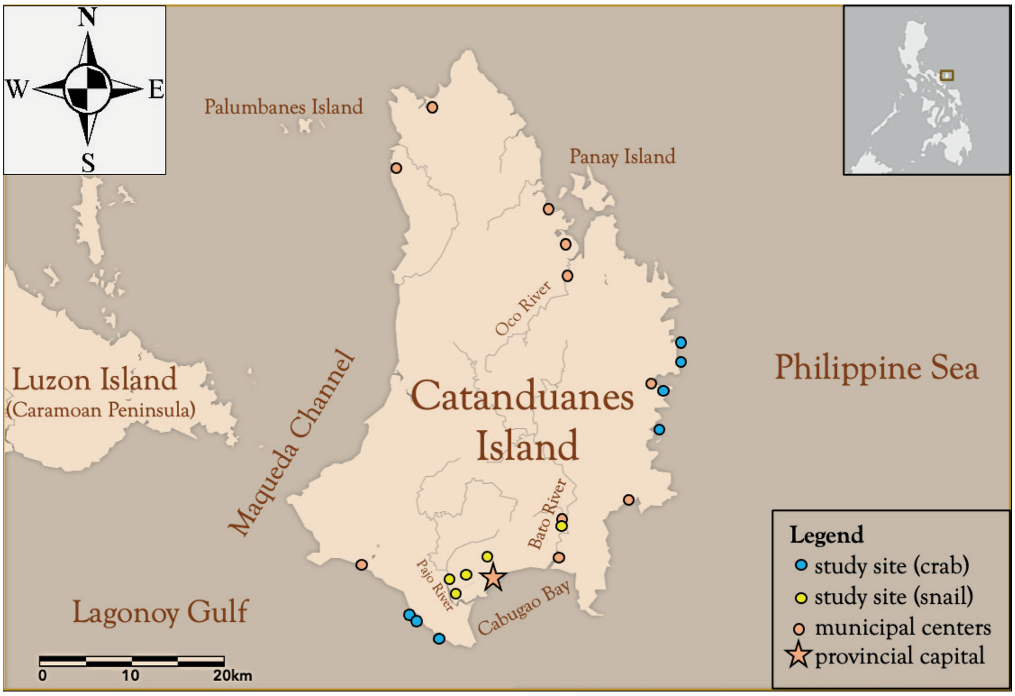


**Figure 1.** Map of Catanduanes Island with its location in the Philippines (inset photo). Map generated with ARC-GIS (2023)

before the start of the field observation survey. To probe the occurrence of the species and quantify their distribution, we conducted an Ecological Field Survey (quadrat methods), using Stratified Random Sampling (SRS) from October to December 2022 for the crab *Portunus convexus* and from April 2022 to February 2023 for the snail *Lissachatina fulica*. The visual survey (walk and periodic actual observation) was adapted as it was the closest nature to the work of intertidal gleaners (for the crab) and farmers or homeowners (for the snail). Locations that were deemed representative of the totality of the area based on spatial and other categories (e.g., distance from the shore, depth, habitat cover, gleaning site preference, etc.) were first considered, wherein random identification of the quadrats was followed to ensure the representativeness of the microsites on each station. The study used SAS-JMP software for all statistical analyses.

A sampling for *P. convexus* was conducted on the coasts of the island where the crab's occurrences were initially reported. We categorized the stations (habitats) as seagrass-algae areas (as SAA, hereafter), coral reefs, and mudflats, and established a total of 120 quadrats of 3 $m^2$ (each habitat with 40 quadrats). All quadrats have a distance of >50 m from each other. The activity had approximately 2 hours of field observation in every sampling trip. Fifteen quadrats (5 in each habitat) were investigated per sampling schedule. The substrate cover of the SAA was dominated by seagrass species in all cases (>80% percent cover), although algae (mainly macroscopic brown algae) sometimes dominated the canopy cover up to 70%, of which many may be "non-permanent" or drifting. Isolated coral clumps or coral areas within or near the reef margins were identified (randomized in the sampling) to eliminate the need to step on top of the corals. The field survey was conducted both day and night during the spring low tide minimum (within 3 days of the lowest tides). Portable Solar LED lights were used during the night sampling. Many crabs were gently handpicked (they are relatively less aggressive and modest swimmers compared to other crabs), but in several cases, dip nets were used to capture them. The sampling had a catch-and-release method, where crabs were released immediately after the observation in each quadrat. Only crabs with ≥ 1 cm carapace width were included in the count. We did not include individuals with a carapace width of < 1 cm because smaller individuals of other species resemble the crab of this size while visualization was difficult in smaller individuals (observation during preliminary visits). Thus, including them may potentially affect the accuracy of data. Samples were observed and identified (in situ) following morphological characterizations by Crosnier (1962), Apel & Spiridonov (1998), Vannini & Innocenti (2000), and WoRMS (2023) through a museum collection sample (See https://www.marinespecies.org/aphia.php?p=taxdetails&id=1061745) (we also had preliminary trips on the site for initial observation of the species, before the actual sampling).

For *L. fulica*, the sampling stations were identified with Stratified Random Sampling representing household areas and plains and shrubland vegetation (plains and shrublands as one group), simple random sampling on each station was followed after the SRS. Thirty quadrats were established in each station (each quadrat having 3 $m^2$) where observations were bi-monthly conducted throughout the sampling period (April 2022-February 2023). Snails were observed early in the morning (6:00-8:00 AM) through a visual (field) survey and counted those located on the surface of the ground or vegetation, including vertical distributions (e.g., individuals climbing on rocks, trees, and banana plants). Our preliminary observation also determined that other snails in the area have a resemblance to smaller individuals of this species, and that visualization was difficult in the smaller individuals due to thick vegetation and uneven terrain in some areas. Only living individuals were counted (≥ 1 cm total shell length); snails under the aestivation stages, if present, were included in the survey. Additional interviews for the snail's infestation on crops (within or near household premises) were included. Specimens were observed directly on-site. We identified the species following morphological characterizations by Salgado (2010), Sow-Yan (2019) (with considerations on the closely related species *L. immaculata*), including database information, such as the Global Invasive Species Database (2023) (See http://www.iucngisd.org/gisd/species.php?sc=64), and MolluscaBase (2023) (See https://molluscabase.org/aphia.php?p=taxdetails&id=881469#images).

## 3. Results and Discussions

### Case 1. The "rare" swimming crab *Portunus convexus* De Haan, 1835

The crab (Fig. 2A) has an Indo-Pacific distribution where it is mainly recorded in areas surrounding the Indian Ocean, such as Madagascar, Somalia, Indonesia (Apel & Spiridonov, 1998; Vannini & Innocenti, 2000) and in the southernmost region of the Philippines (Jingkatal & Ramos, 2019). With the exception of the work of Jingkatal and Ramos (2019) and possibly with the photos shown by Aldea (2023), the crab is little known in the Philippine literature, even when referring to its synonymized names in the World Register of Marine Species (WoRMS, 2023) (See https://www.marinespecies.org/aphia.php?p=taxdetails&id=1061745). This is in contrast with many portunid crabs that are well-sampled and studied in the country, as shown in the studies of Estampador (1959), Motoh & Kuronuma (1980), Nieves et al. (2013), Subang et al. (2020) and Mendoza et al. (2022). Many local studies are also focused on the culture of the highly economically important crustaceans. Among surveys of edible and economically important crustaceans in the country, the species is "unknown" to our knowledge.

Driven by the initial information, we followed a series of photo-sharing discussions with work-based CSs (all are intertidal gleaners) to elaborate on the information about the crab. Information from the CSs is based on the data they obtained as part of their daily routine as gleaners. The initial information implied that the "rare" crab has a nocturnal occurrence, is relatively less aggressive compared to other crabs, has a specialized spatial distribution, (seagrass-algae areas), and is virtually caught only during gleaning, a coastal utilization in the intertidal areas at low tide where folks obtain edible species from the intertidal areas (Aldea, 2023). In all cases, gleaners catch the crab during the night gleaning, a relatively less known resource utilization method in coastal areas. Being "rare" of the crab further increases as only a few localities and families are known for gleaning it, although most have narrated that the practice was long taught by their ancestors. All these described the common occurrence of the species but it might have just been "rarely" known due to limitations on its temporal and spatial distribution as well as peoples' utilization practices. Actual field samplings were followed after obtaining information from the work-based CSs (intertidal gleaners).

The sampling (Fig. 2B) found that the distribution of *P. convexus* concentrates on the SAA (F-Ratio= 150.69; $p < 0.01$; Tukey's-HSD Test on SAA vs coral reefs and SAA vs mudflats, $p < 0.01$; on coral reefs vs mudflats, $p = 0.99$) (Fig. 2C) with a maximum of 23 individuals caught in a 3 $m^2$ area. This suggests that the crab is significantly more abundant in SAA than in other habitats. The crab population revealed an average of 11 individuals per 3 $m^2$ quadrat in SAA during night sampling, which is also significant, in contrast, to the daytime distribution (t-Ratio= 12.94; $p < 0.01$) (Fig. 2D). We believe that the changing algal canopy on the SAA may influence the crab abundance, but investigating on this aspect is beyond the scope of the study. Interestingly, the *P. convexus* population was higher than other portunid crabs at night sampling, demonstrating its nocturnal habit and

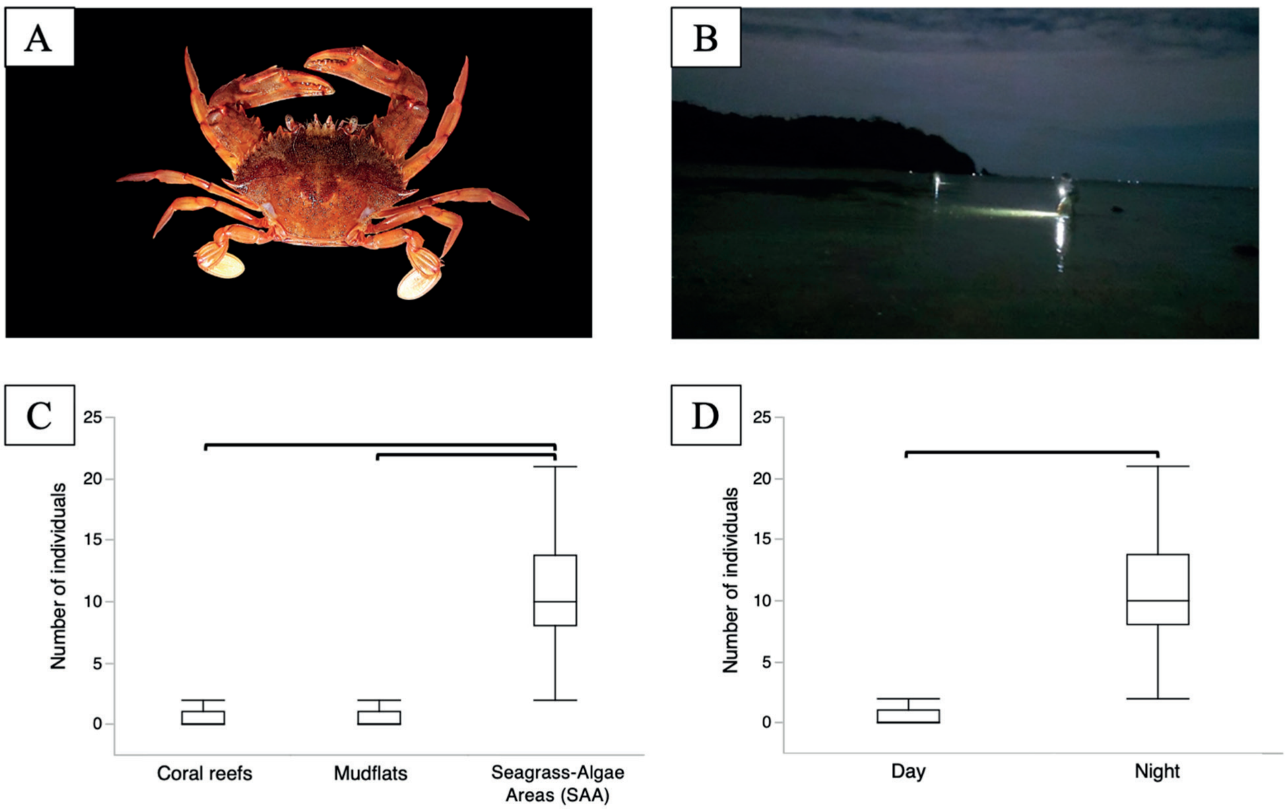


**Figure 2.** The swimming crab *P. convexus*. Male specimen (Carapace Width, 4.7 cm) showing the two lateral pale spots on the posterior carapace (2A). The crab was caught at night sampling during a full moon (2B). ANOVA-Tukey's HSD Test (2C) shows a higher abundance of the crab in SAA (SAA VS coral reefs, SAA VS mudflats, $p < 0.01$; coral reefs VS mudflats, $p = 0.99$) (box plot). The abundance was significant during the night sampling (2D) (t-Ratio = 12.94; $p < 0.01$) (box plot). In some cases, the "constantly changing" canopy in the seagrass meadows is made up of 10%-70% algae, but substrate cover is predominantly seagrass in all cases (>80%). Bracketed groups are significant ($p < 0.01$).

"common" prevalence against other species, considering the habitats described in this study. All this information revealed the occurrence and distribution of the crab on the island, as earlier described by the CSs.

Perhaps another reason for its being "rare" is due to the belief that it is "best to cook" (or to partially cook, for later consumption) immediately after catching. This makes its consumption primarily in the households of a coastal village (selling it to the main market may need more time and scheduling, which may affect the crab's quality as CSs perceived). These probably make the crab less visible in the market compared to other crabs such as *Scylla serrata* and other commercialized portunid species. Nevertheless, it is likely an important commodity in the coastal areas, especially for low-income families. CSs describe that the visible "roe", the yellowish or reddish internal substance, is usually higher in the crab (relative to body size) than several other commercialized species, arguably one of its best qualities. Owing to its strong flavor, the crab is prepared into different menus, some of which are exclusively known only in specific coastal zones. With the indigenous utilization of the local areas (despite being "rarely" known), the potential use of the crab as one of the economically important crustacean species on the island may be explored for sustainability solutions.

### Case 2. The invasive land snail *Lissachatina fulica* (Bowdich, 1822)

The Giant African Snail *L. fulica* (Fig. 3A) is an introduced species found in several coastal zones and other low-lying communities on Catanduanes Island. It is native to East Africa (Raut & Barker, 2002; Sarma et al., 2015) and possibly released to the island through the pet trade. Various pest-management agencies in the world list the snail as an invasive species (USDA-APHIS, 2005; TISI, 2014; GISD, 2023; USDA-NISIC, 2023). Our initial communications with CSs obtained information that the occurrence of the snail on the island started in 2019 (or possibly earlier), but wider dispersion is probably more recent as the destructive impact on crops is getting more reported by the CSs, particularly through social media. Some CSs reported that native snails in their areas are no longer observed since the appearance of the *L. fulica.*

Succeeding communications with CSs (this time work-based farmers or homeowners) asked for their snail encounters as part of their daily routine. Narrations revealed infestation of the snail on their garden or farm crops, which occurs rapidly about 15-30 days after they first noticed the snails in the area (Day 1), and infestation has been reoccurring since then. Some practices that the CSs are doing or disseminating include killing the snail by crushing it or feeding it to ducks and other livestock. They also reported that many households utilize the snail for food such as the modified *"Sisig"* (a local dish with pork as the usual main ingredient), substituting the pork with the snail's meat. The infestation, however, as CSs claim, keeps emerging even when potential methods for controlling the species are done. This shows that local reports of the species are primarily driven by the crops' infestation of the snail as well as abrupt cultural practices (adaptive measures) that have arisen for the control of the species.

The sampling revealed that there is a high population of *L. fulica* in several localities, with an average of 33 individuals per 3 $m^2$ in October (peak month) (maximum of 42 individuals per 3 $m^2$ in the vegetation near households and community). An observation of a bush clearing in heavily infested sites (non-sampling areas) temporarily reduced the visible population, but it rose again in about two months. We observed the snail's presence on horticultural crops (e.g., papaya, banana, etc.), but we observed it on the native plant *Ficus pseudopalma* as well (Fig. 3B). The snail was significantly present on vegetation near households and community establishments (Fig. 3C), although some were in more open areas (plains and shrublands) outward from the edge of household clusters (t-Ratio= -19.30; $p < 0.01$). This can be due to the vicinity of the snail's introduction (urban areas) and to the availability of many horticultural crops near human settlements that the snail is known to infest (USDA-APHIS, 2005; Albuquerque et al., 2008; Ramdwar et al., 2018).

The snail population was present throughout the sampling period (average of 19 individuals per 3 $m^2$ in household and community vegetation), but significantly differs in many months (except October-August) which suggests its changing population distribution in a year with a sharp decrease from December to February (high precipitation months) (F-Ratio= 233.40; $p < 0.01$; Tukey's HSD Test, All month pairs (except August & October), $p < 0.01$; August and October, $p > 0.05$) (Fig. 3D). As the snail benefits from conditions associated with rainy seasons in a tropical area where it has been introduced (Da Silva et al., 2022), the low-frequency distribution during the study (December until February) may be primarily explained by human perturbation (e.g., collection of snails for food in some areas, etc.), especially with the coinciding Holidays and long vacation periods (December-January). In the forests, however, the snail's temporal distribution may be different (less fluctuating), which may have implications for the snail's capacity to destroy vegetation in the wild.

An additional interview was conducted in the households (head of the family) to indicate the snail's invasive occurrence in the current setting. Thirty-four (34) (83%) of the 41 homeowners (usually with heavily infested garden vegetables and ornamental plants), reported the presence of the snail in their house yards. The oldest perceived occurrences (five responses) in their house yards were in 2020 (around the time of the earliest COVID-19 lockdowns), although one homeowner perceived a sighting at a roadside in 2019 (Pearson Chi-Square: $X^2 = 41.12$, $p < 0.01$ [perceived occurrence in the current study VS 2020's]). This suggests the significant prevalence of the snail in the area compared with the perceived earlier occurrence. Few believed that other pests, were responsible for the current crops' damage, possibly because the snail had only recently dispersed, or had not yet dispersed in their house vicinities. The "heavy" (vs "negligible") damage is based on the perception of respondents in the degree of the consumed (eaten) part of the plants, including the impact on marketability for some economically important plant species. They observed that the snail consumes crops at night, although it is not uncommon to see it crawling in the early morning or late afternoon. To the best of our knowledge (including all reports from CSs), the infestation of the snail has not yet been observed in the interior forests of the island, although some reports were noted from households near or within the forest's boundaries with the communities. Nevertheless, all these sources of information strongly suggest the invasiveness of the snail on the island.

## 4. Conclusions and Recommendations

Citizen science generated a significant contribution to the information on the occurrence and distribution of the two species, which were probed through natural observation using field surveys. This validates the importance of citizen science engagements in species monitoring and conservation. Specifically, we derive the following notions:

1. The crab's "rare" status may only be an artifact of its seasonality, spatial and temporal distribution (diurnal-nocturnal), as well as utilization practices of the community. This study, nonetheless, emphasizes the importance of its conservation program, especially considering its economic

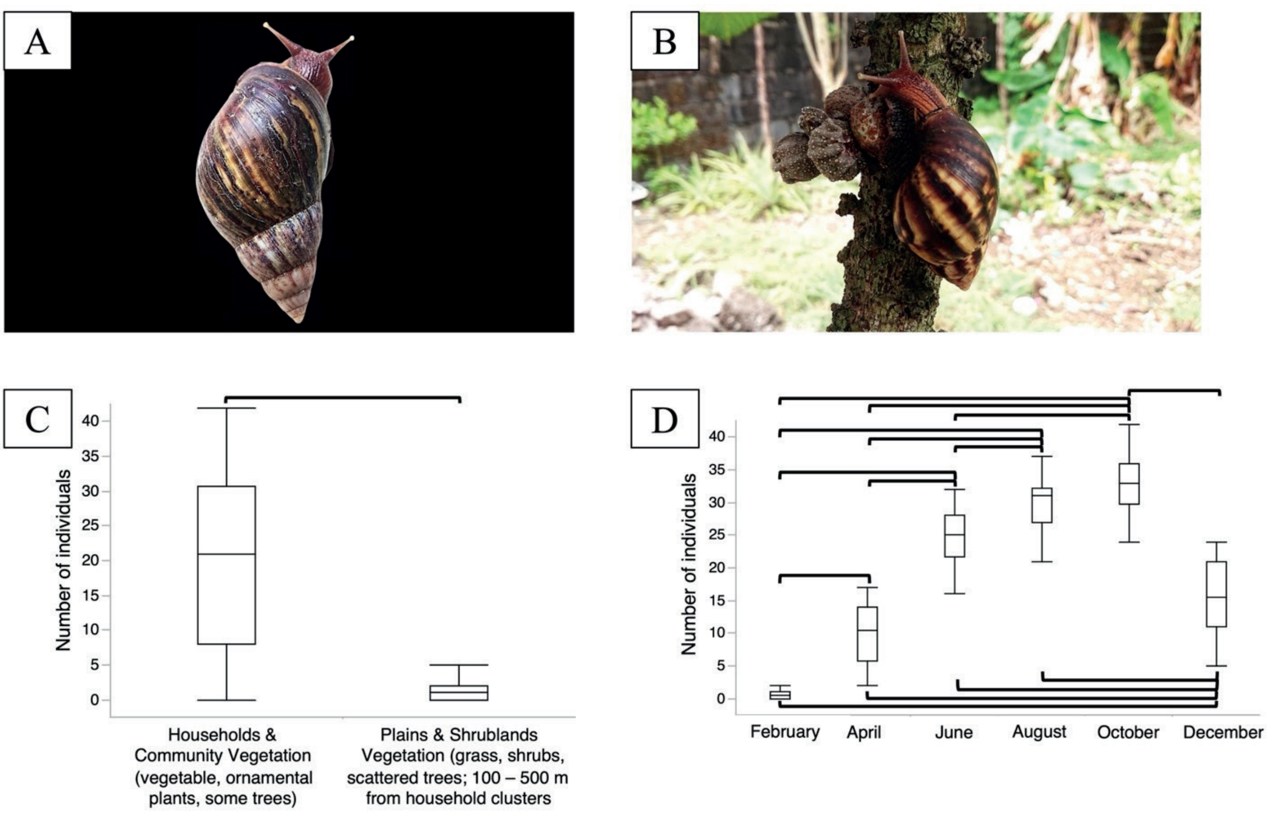


**Figure 3.** The invasive snail *Lissachatina fulica*. An individual with a Total Shell Length of 7.5 cm (3A) and a smaller individual (6.3 cm) found on *Ficus pseudopalma* (3B). Most sightings on *F. pseudopalma* were on smaller plants with height of < 1.5 m. Large individuals have relatively dull coloration. A significant difference in the population detected in household & community vegetation against adjacent plains & shrublands vegetation (t-Ratio= -19.30; $p < 0.01$) (3C) (box plot). Except for August and October (Tukey's HSD Test; $p > 0.05$), ANOVA-Tukey's HSD Test revealed that the population is significantly different in all sampled months ($p < 0.01$), with the highest population recorded in October (data on distribution in the vegetation near households and community) (3D) (box plot). Bracketed groups are significant ($p < 0.01$).

potential, which might have just been ignored due to its "rare" nature.

2. The snail shows a strong invasive nature on the island suggesting the importance of policy formulation relevant to its eradication program as well as prevention strategies for other communities. As the invasion status is probably successive, it is necessary to continue its monitoring, especially in the protected areas that may be vulnerable to invasive species.

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