ORIGINAL RESEARCH

THE PREVALENCE OF SENNA TORA IN PENINSULAR MALAYSIA

Azimah Abd. Kadir [1*], Nor A. Ismail [2], Nurin I. M. Zulkifli [2], Farah F. Haron [2], Michael D. Day [3], Quentin Paynter [4], Che A. A. Che Omar [1] and Maizatul A. Yahya [1]

[1] Industrial Crops Research Centre, MARDI Headquarters Serdang, Selangor

[2] Agrobiodiversity and The Environment Research Centre, MARDI Headquarters Serdang, Selangor

[3] Queensland Department of Agriculture and Fisheries, Australia

[4] Manaaki-Whenua Landcare Research, New Zealand

* Corresponding author: michael.day@daf.qld.gov.au

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Abstract

Senna tora, an important medicinal plant in Malaysia, is a major introduced pasture weed in the Pacific island nation of Vanuatu. This weed contains toxic compounds, including sennosides, which can be harmful to livestock if ingested in large quantities. The seeds spread easily, leading to infestations in pastures and rangelands. A biological control program to mitigate its impacts in Vanuatu commenced, with funding from the New Zealand government. Early literature searches and climate matching suggested that Southeast Asia was the most promising region to survey for natural enemies. Therefore, surveys were conducted to determine the distribution of *S. tora* in Malaysia, which will help identify the best places to search for potential candidates for biological control. Field studies were conducted within a 30-60 km radius of the first location chosen based on accessible roads and near water resources. The distribution of *S. tora* in Malaysia occurred mostly along the west coast of Peninsular Malaysia. The highest density of *S. tora* was observed in Johor, followed by Negeri Sembilan and Pahang. Perlis had the lowest density, while other states fell in between. This weed is most abundant in abandoned areas, shrubland, and near rivers.

Keywords: abundance, density, distribution, frequency, gelenggang kecil, weed.

Introduction

Weeds pose a significant threat to agriculture and global biodiversity. Depending on the crop and plant type, yield losses resulting from weed infestations could run from 10% to 90% (Flessner et al., 2021). These invasive weeds compete with other crops for nutrients, light and space, ultimately reducing crop yields (Gebrekiros et al., 2018).

However, prolonged use of herbicides could cause deleterious effects on our environment and ecosystem (Buhler, 2002; Baki, 2004). However, weeds can also be managed by non-herbicidal methods, which include the use of biological control agents.

A common practice for controlling weeds is to spray herbicides. This is due to their availability in the market, fast results, and ease of application.

Biological control is more environmentally friendly, as the agents are host-specific and attack only the target weed. Biological control is also cost-effective and sustainable. Numerous examples exist of major weeds being successfully controlled through the use of biological control agents (Winston et al., 2014).

Senna tora (L.) Roxb. (Fabaceae) [syn. *Cassia tora* L.] is a small woody shrub (1-2 metres tall), native to Central America and distributed throughout India, Sri Lanka, West China, Southeast Asia and other tropical regions (CABI, 2022). It is now found in 41 countries or islands, including the United States (GBIF, 2024). Its ability to invade and dominate pastures and disturbed areas underscores the necessity for effective management strategies to mitigate its spread and impact.

In its native range, *S. tora* is often grown for its visual significance as an ornamental plant blossom in parks or gardens. The leaves are edible and have therapeutic applications. The seeds can also be utilised to relieve dizziness, inflammation, and headaches. In Indonesia, the Philippines and Malaysia, the plants are utilised to remove intestinal worms, and the seeds and leaves are used to treat skin diseases and as a laxative (Bhandirge et al., 2016; Akbar, 2020).

The whole plant, roots, leaves, and seeds have been widely used in traditional Indian and South Asian medicine. Young leaves can be cooked as a vegetable, and roasted seeds are used as a substitute for coffee. *Senna tora* is used as a natural pesticide in organic farms. Mixed with guar gum, it is used in mining and other industrial applications (Pawar and Lalitha, 2014). In Malaysia, *S. tora* is locally called '*gelenggang kecil*'.

However, *S. tora* is considered a major weed in numerous countries in the Pacific. In these countries, it is mainly a weed of pastures, outcompeting preferred species. In some areas, *S. tora* has completely taken over paddocks, rendering them unproductive, resulting in significant losses in production and income.

Senna tora is also toxic to cattle if ingested (Macfarlane and Shelton, 1986; CABI, 2022). For many farmers in the Pacific region, conventional control using herbicides is not feasible due to the size of the infestations and the cost of chemicals. Therefore, biological control is the only long-term sustainable means to manage this weed.

Senna obtusifolia (L.) H.S. Irwin & Barneby (Fabaceae) has been a target weed for biological control, particularly in the USA and Australia. *Alternaria cassiae* Juriar & Khan (Pleosporaceae) was formulated as a mycoherbicide and has provided greater than 96% control of *S. obtusifolia*, resulting in increased yields of soybeans (Parsons and Cuthbertson, 1992). Therefore, there might be some specific biological control agents for *S. tora* as well.

In an attempt to manage the weed in Vanuatu, a biological control programme funded by the New Zealand government undertook native range field surveys to search for potential natural enemies of *S. tora*. This paper documents the distribution of *S. tora* in Peninsular Malaysia to determine the most suitable regions for surveying potential biological agents.

Materials and Methods

Field surveys

Initially, the field surveys were conducted in five Peninsular Malaysia states: Selangor, Negeri Sembilan, Melaka, Johor and Perak. These surveys were conducted from January to December 2021. Another six states were surveyed from January to September 2022.

Three of the states, Penang, Kedah and Perlis, are located in the northern part of Peninsular Malaysia, while the other three states, Kelantan, Terengganu and Pahang, are located in the eastern part of Peninsular Malaysia.

Observations were made along the main roads and riverbanks, with an interval of 30-60 km. Farmlands, wastelands, residential lands, and agricultural lands around the survey spots were considered in the survey. The geographical coordinates were recorded using the apps MAPS and Google Earth and plotted using Google Maps.

Sample identification

Plant samples of *S. tora* were gathered as part of the survey activities. The healthiest plants, free from insect and disease damage, were chosen as samples. These selected plants were allowed to dry, then wrapped in damp tissue and placed in sample bags before being transported to the laboratory.

In the laboratory, the samples were dried at a temperature of 40°C to 50°C before being mounted on herbarium paper. The samples were then morphologically characterised as herbarium specimens.

Sampling description

In order to describe the sampling that occurred, frequency refers to the proportion of sampling units (such as plots or quadrats) in which a particular weed species occurs (Nkoa *et al*., 2015). This indicates the extent to which a weed is prevalent within a given area or population. Abundance describes the total number or biomass of weeds present in a specific area. It provides information about the overall population size of a weed species.

Abundance can be measured by counting individual plants or estimating their total biomass. It is essential for assessing the impact of weeds on ecosystems or agricultural systems. Density represents the number of individuals of a weed species per unit area. It quantifies how closely spaced the weeds are within a given plot or field.

The weed density was measured in a quadrat of 0.5 m x 0.5 m, randomly placed on the survey spots. Density was calculated as applied by Tauseef et al. (2012).

For the abundance calculation, a formula was used based on the one employed by Kilewa and Rashid (2014).

Density = total number of *S. tora* plants/total area of a quadrat ($1m^2$)

Frequency (%) = number of quadrats with *S. tora* x 100/total number of quadrats used at each site

Abundance = total number of *S. tora* plants in all quadrats/total number of quadrats in which *S. tora* occurred.

Statistical Tests

The difference in the mean number of *S. tora* between the locations was analysed by analysis of variance using a single factor in SAS version 9.4.

Results and Discussion

Morphological characterisation of *S. tora*

Senna tora can grow 30–150 centimetres tall. The leaves are pinnate, with leaflets mostly arranged in three opposite pairs. They are obovate in shape with a rounded tip 3.0–6.0 cm long and 1.0- 4.0 cm wide. Pale yellow flowers occur in pairs in the axils of leaves, with five petals.

The pods are somewhat flattened or four-angled, 10–25 cm long, and sickle-shaped, hence the common name "sicklepod." Each pod contains 30–50 seeds.

Moreover, similar species to *S. tora* (Figure 1) were also found during the collection, specifically *S. obtusifolia.* Both species showed identical morphological characteristics and were difficult to distinguish; both also gave off a strong, unpleasant smell. However, they can be distinguished by the presence of two glands in *S. tora* leaves (Figure 2) and only one gland in *S. obtusifolia* (Figure 3).

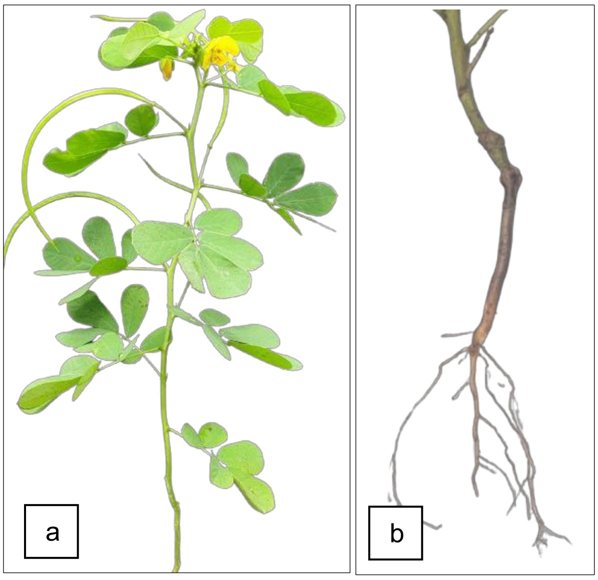

Figure 1. Morphology of *S. tora* (a) shoot system (b) root system

Figure 2. *S. tora* with two glands

Figure 3. ***S. obtusifolia*** **with one gland**

According to Takano et al. (2002), *S. tora* have flowers near the branches' terminal, while the inflorescence position in *S. obtusifolia* was at the main axils. However, there are still many disputes between these two species. Generally, any plant with similar characteristics was considered *S. tora* in this survey. Several sample collections were kept as herbarium voucher specimens for future reference (Figure 4).

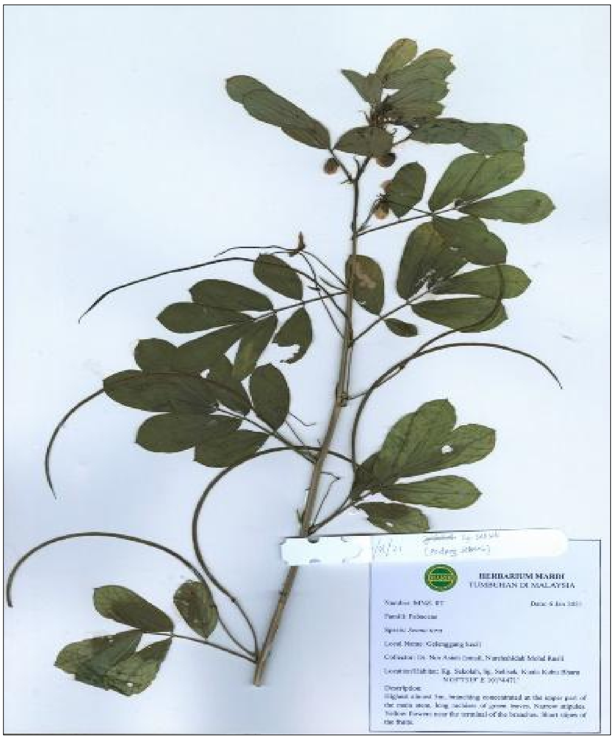

Figure 4. ***S. tora*** **sample kept in herbarium collection at MARDI**

Location and distribution of *S. tora* infestations

Senna tora was commonly found in abandoned areas, along roadsides, in agricultural areas, in residential areas, and near rivers and streams (Figure 5). *Senna tora* was often found in open, dry fields such as lemongrass cultivation plots. These environments, which lack irrigation systems, dry soil, and hot temperatures, are particularly susceptible to infestations (see Figures 5-7).

Senna tora is an annual plant and completes its life cycle within one growing season. Poppenwimer et al. (2023) suggested that annuals are favoured in hot and dry regions. Meanwhile, in paddy fields, infestations typically occur at the edges due to the presence of water in the field. If not managed, *S. tora* can aggressively take over these spaces, displacing the main crops and preferred plants.

The survey results in 11 states of Peninsular Malaysia indicated that *S. tora* was most common along the west coast areas of Peninsular Malaysia. It was found less frequently and did not grow so vigorously on the east coast of Peninsular Malaysia (see Figures 8-12).

Figure 5. ***S. tora*** **infestations in Peninsular Malaysia: (a) near a residential area; (b) adjacent to a paddy field**

Figure 6 *S. tora* **infestations in Peninsular Malaysia: (c) near a lemon grass cultivation plot; (d) roadsides**

Figure 7 *S. tora* **infestations in Peninsular Malaysia: (a) near a stream; (b) grazing lands**

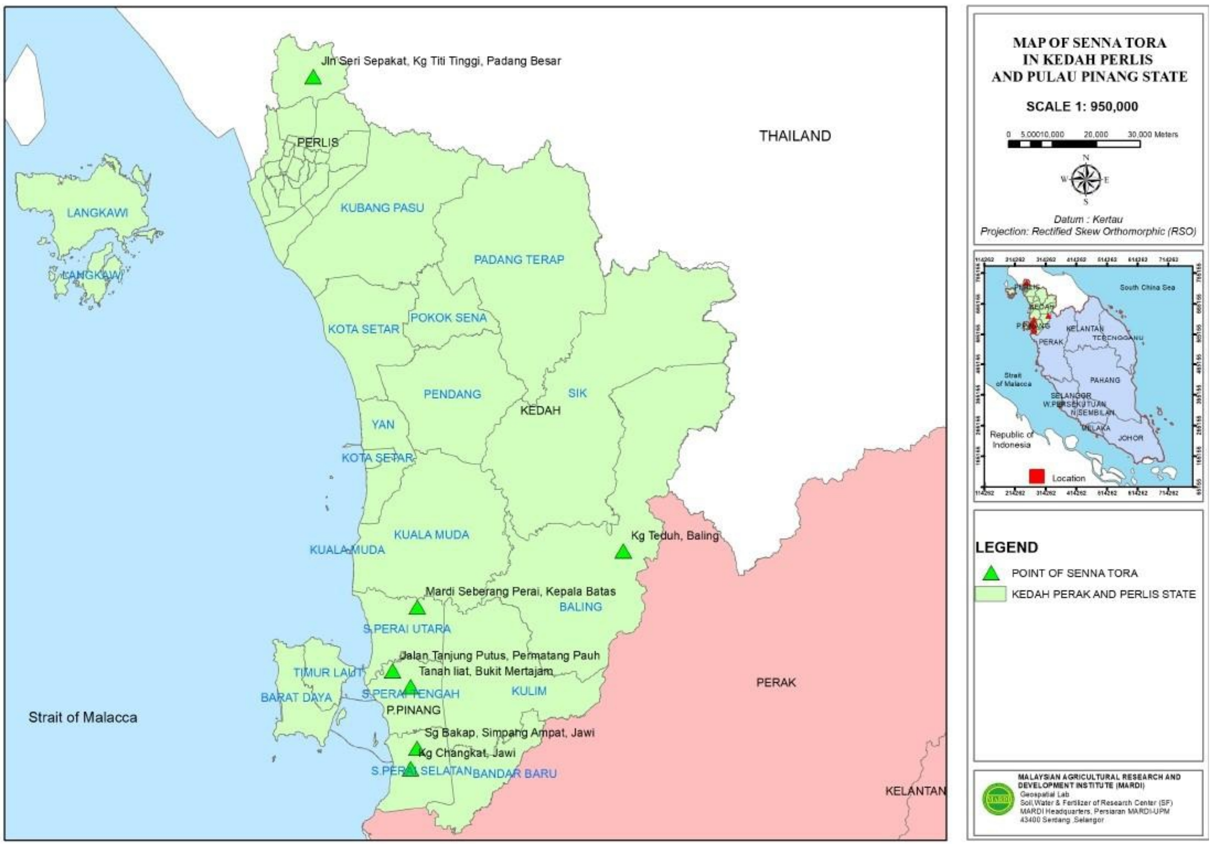

Figure 8 Distribution of ***S. tora*** **in Peninsular Malaysia – States of Perlis, Kedah, P. Pinang**

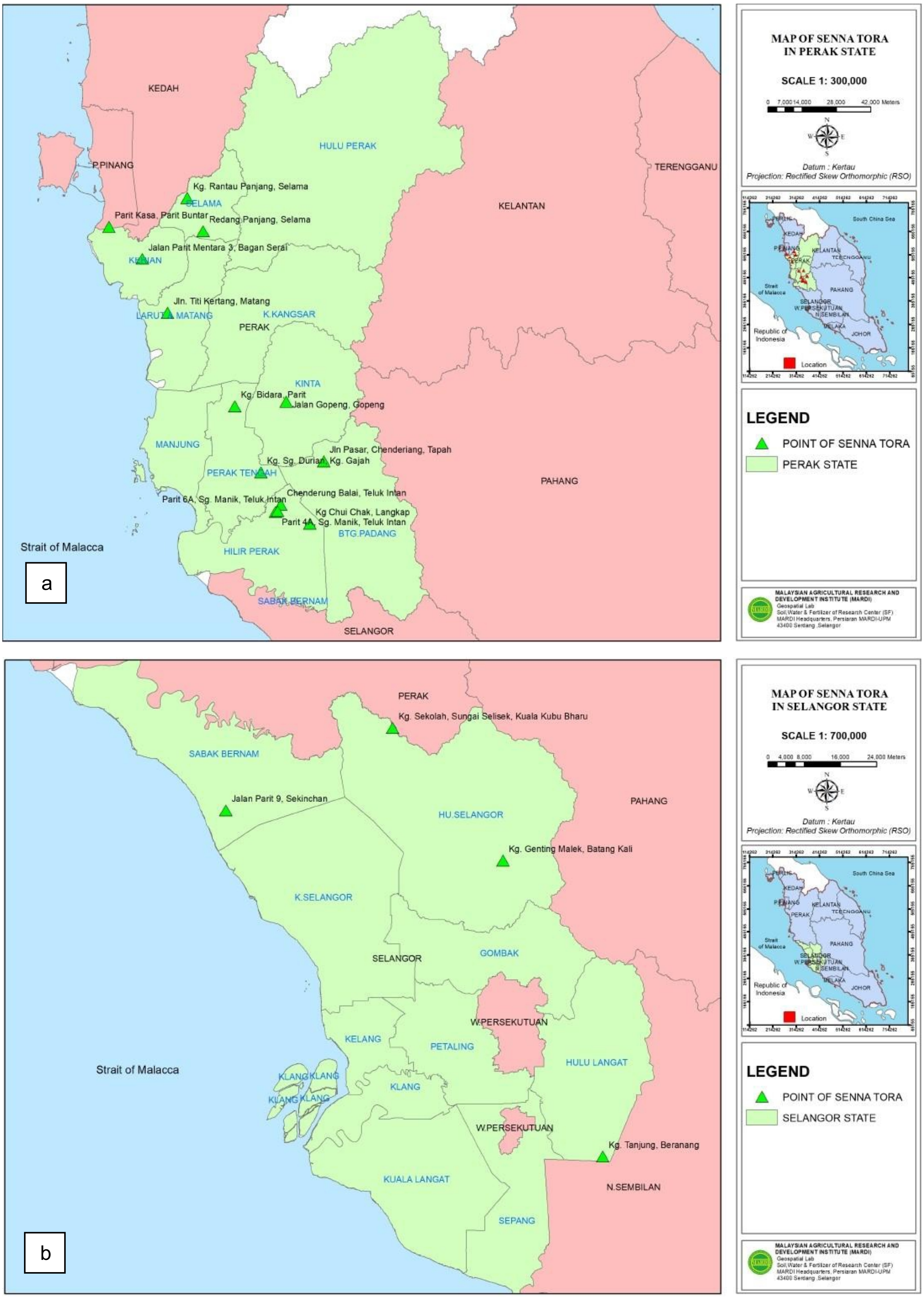

Figure 9 Distribution of *S. tora* in Peninsular Malaysia States of (a) Perak (b) Selangor

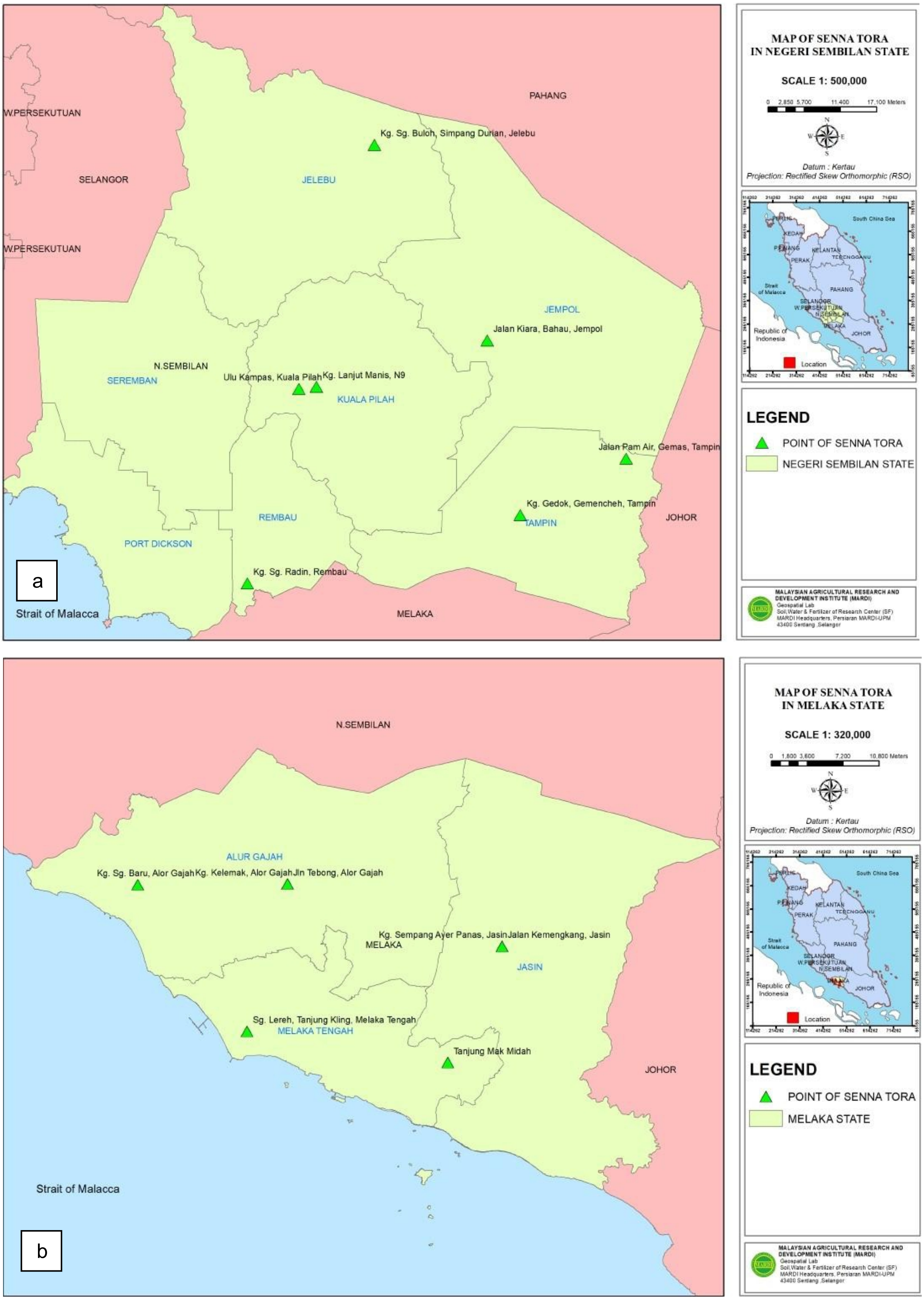

Figure 10 Distribution of *S. tora* in Peninsular Malaysia, (a) Negeri Sembilan (b) Melaka

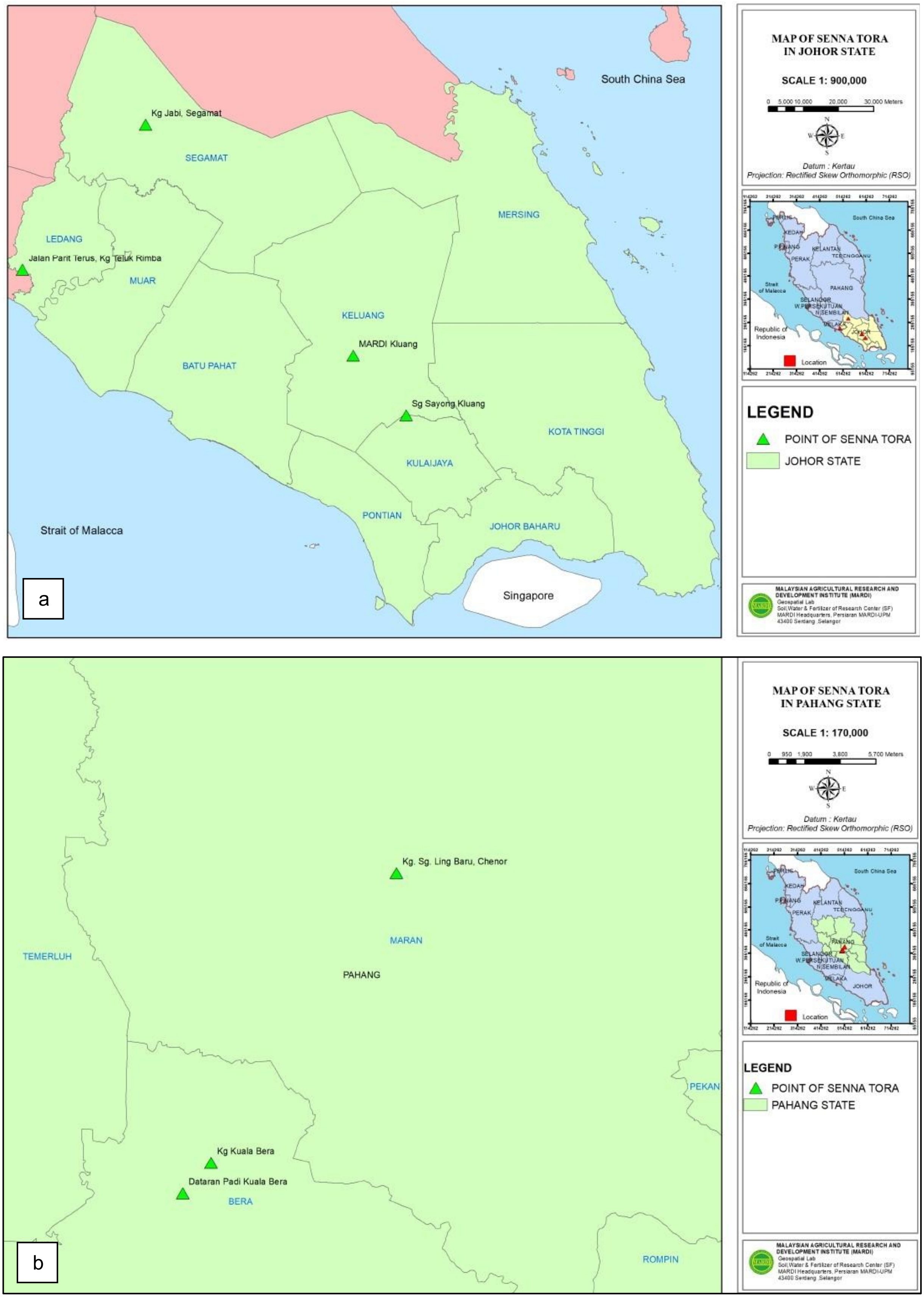

Figure 11 Distribution of *S. tora* in Peninsular Malaysia (a) Johor (b) Pahang

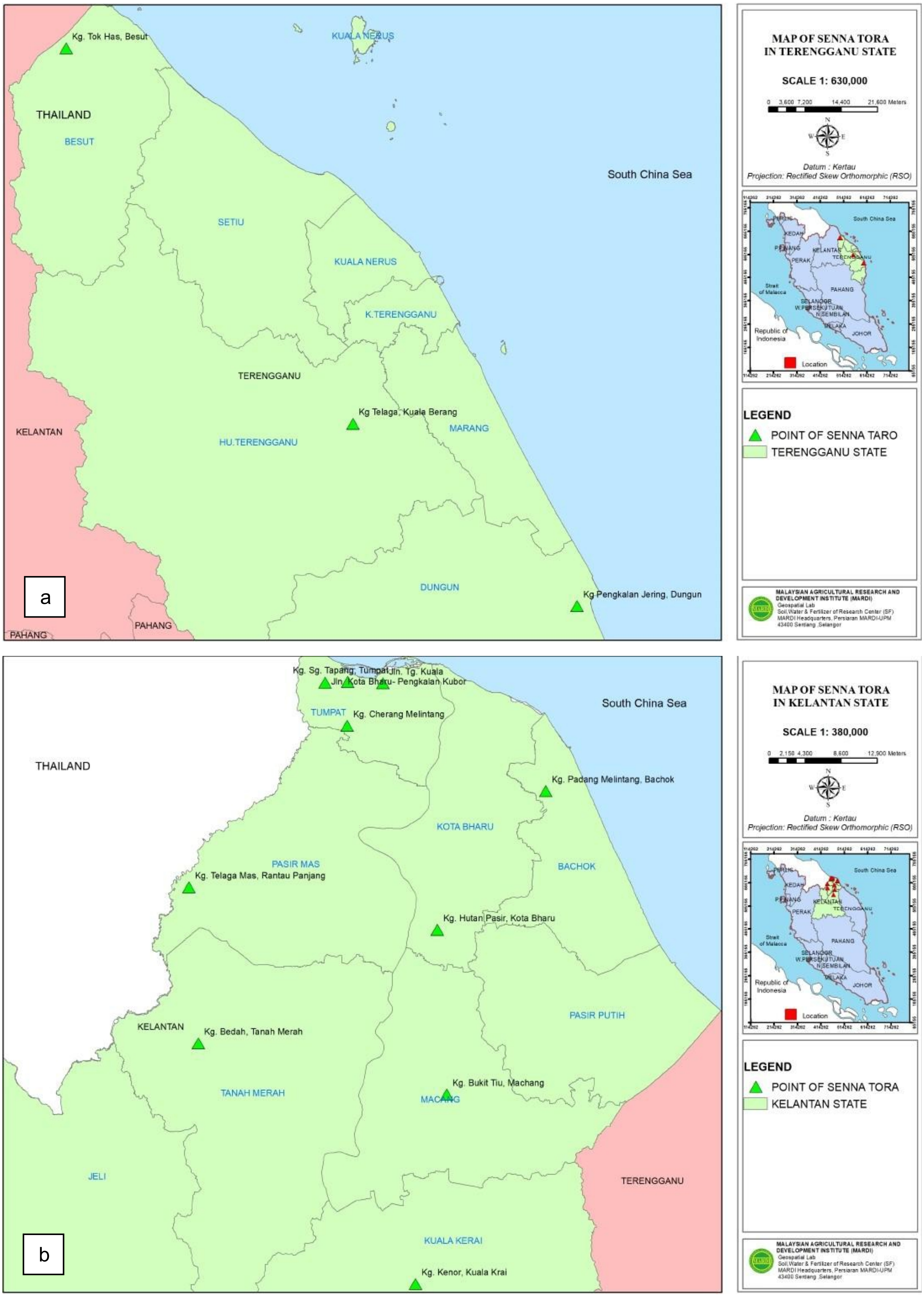

Figure 12 Distribution of *S. tora* in Peninsular Malaysia States of (a) Terengganu (b) Kelantan

Density, frequency and abundance of Senna tora at different sites

Table 1 shows the distribution of *S. tora* across nine states in Peninsular Malaysia. The states with the highest density of *S. tora* were Johor (34.0 plants/m²), Negeri Sembilan (24.7 plants/m²), Kelantan (19.6 plants/m²), Perak (18.7 plants/m²) and Pahang (13.4 plants/m²).

The highest weed frequency of *S. tora* was detected in Negeri Sembilan (73% of quadrats), followed by Johor (54%), Kedah (50%), Kelantan (50%), Melaka (42%) and Perak (42%). Johor (81.9 plants/m²) and Negeri Sembilan (61.1 plants/m^2) had the highest abundance of *S. tora.*

The variation in density suggests that certain states provide more favourable conditions for *S. tora* growth. Johor, with the highest density and second-highest frequency, likely has more suitable habitats and a large soil seed bank. Schwartz-Lazaro and Copes (2019) state the seed bank will decrease if consistent control measures are implemented. However, this weed has been observed to grow uncontrollably in the absence of intensive management. Negeri Sembilan and Pahang also offer conducive environments, supporting vigorous populations of *S. tora*. In addition, these states have different agricultural systems, with non-granary areas where active control is practised less often. In contrast, states such as Kedah, Perak, and Selangor, which have granary areas, use herbicides more frequently than other states.

Malaysia is the top user of herbicides among Southeast Asian countries (Casimero et al., 2022). However, active control is not applied in all states, which gives the opportunities for weeds to grow better in non-granary areas than in granary areas. Perlis, which is the smallest state in Peninsular Malaysia, exhibits the lowest abundance of *S. tora*.

This is possibly due to factors such as competition, herbivory, or limited resources due to the small state. Tessel et al. (2016) state that weed species may be more prevalent in larger states that offer a greater likelihood of suitable habitat, resources, and ecological variability, all of which contribute to a higher level of species diversity.

The possibility of new species colonisation is also increased by seed dispersal and species migration and is usually more widespread across larger areas. The frequency provides insights into how often *S. tora* occurs in each state. Negeri Sembilan stands out due to its frequent occurrences, suggesting widespread distribution and adaptability. Perlis lacks *S. tora* occurrences, emphasising its rarity or absence in that region.

Besides tabulating *S. tora* distribution by states of Peninsular Malaysia, Table 2 documents the distribution of *S. tora* in different regions of Peninsular Malaysia, such as the north, south, middle and east.

The highest density of *S. tora* was encountered in the east region (34.7 plants/m^2), followed by the middle region (11.7 plants/m^2) and the north region (6.7 plants/m^2).

Table 1. Average density, abundance and frequency of *S. tora* in every state in Peninsular Malaysia

State	Density (plant/m²)	Frequency (%)	Abundance (plant/m²)
Johor	34.00	54	81.90
Kedah	6.45	50	15.40
Kelantan	19.60	50	27.70
Melaka	14.50	42	21.90
N. Sembilan	24.70	73	61.10
P. Pinang	6.96	36	23.80
Pahang	13.40	39	32.40
Perak	18.70	42	20.90
Perlis	0.80	20	4.00
Selangor	5.20	30	16.00
Terengganu	2.70	30	8.50

The south region has the lowest density (5.4 plants/m^2). The eastern region had the highest abundance (42.5 plants/m^2), followed by the middle region (24.2 plants/m^2). The northern region has an abundance of 19.7 plants/m^2, and the south region has the lowest abundance (12.9 plants/m^2).

The frequencies for the north region were 40 occurrences, the east region was 70 occurrences, the south region was 37.5 occurrences, and the middle region was 47.5 occurrences. The frequencies of occurrence of *S. tora* were not significantly different among the regions. The statistical analysis only indicated that there were significant differences in density and abundance among the regions (Table 2).

Table 2. The average of *Senna tora* distribution representative state of the region in Peninsular Malaysia

Region	Density (plant/m^2)	Frequency (%)	Abundance (plant/m^2)
Northern	6.70 b	40 a	19.73 b
Eastern	34.7 a	70 a	42.53 a
Southern	5.4b	37.5 a	12.9 b
Middle	11.7 b	47.5 a	24.18 ab

Means with the same letter are not significantly different at P≥0.05 with the LSD test.

The distribution of *S. tora* can be influenced by several factors. First are the ecological preferences such as specific habitats, i.e. well-drained soils, open areas, or disturbed sites. Soil pH, moisture levels, and light availability might also play a role in its distribution.

Efficient seed dispersal allows *S. tora* to colonise new areas. Wind, water, and animals aid in spreading seeds. The pods can throw seeds up to 5 m as they open. Seeds can be carried by streams, overland flow and in mud attached to the feet and fur of animals. They also move in contaminated mulch and mud on machinery, vehicles and footwear. Although the species is generally unpalatable, livestock nibble on the pods and seeds will pass through the animals and disperse when the animals are moved about (Mohler et al., 2021).

Conclusions

The findings of this study show that the states in Peninsular Malaysia with the highest densities of *S. tora* are Johor, Negeri Sembilan, and Pahang. *Senna tora* is primarily found in abandoned fields, roadsides, agricultural lands, and near water sources, usually thriving in disturbed environments.

Therefore, surveys to find potential biological control agents for Vanuatu and other countries in the Pacific region should first be conducted in these states. Indeed, preliminary surveys have found numerous lepidopterous larvae, leaf-feeding beetles and a pathogen. These are yet to be formally identified.

The high density and frequency of *S. tora* in some regions of Peninsula Malaysia emphasise the potential threat the weed poses to agricultural productivity, biodiversity, and pasturelands in this country, too. Given the rapid spread and adaptability of *S. tora*, further investigations into understanding the socio-economic impact of *S. tora* on local farming communities are warranted so that sustainable management strategies for the weed can be developed.

The presence of natural enemies, such as pathogens and herbivorous insects, suggests potential for biological control efforts. Further efforts should focus on identifying effective biological control agents, assessing their feasibility, and integrating them into weed management programs.

The knowledge gained from this study serves as a foundation for future research and policy recommendations. Effective control measures, including monitoring and integrated weed management approaches, are crucial to mitigate the spread of *S. tora* and minimise its impact on agriculture and the environment in Malaysia and other countries where *S. tora* is considered a significant problem.

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