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Research Article

A STUDY ON INSECTICIDAL POTENTIAL OF *BALANITES AEGYPTIACA (L.)* DELILE SEED KERNEL OIL IN MANAGEMENT OF *HYBLAEA PUERA* (TEAK DEFOLIATOR) ON TEAK IN TAMIL NADU

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ABSTRACT

Balanites aegyptiaca (family: Zygophilaceae) otherwise known as desert dates is a prioritized species of many African, Middle East and South Asian countries due to its wide environmental adaptability, long living nature, easy regeneration from seeds and coppice, etc. Edible fruits, animal feed, firewood, soap, detergent, and high-quality charcoal are among the uses of this crop. It is also reported for ethnomedicinal uses to treat a variety of illnesses including jaundice, asthma, malaria, syphilis, epilepsy, haemorrhoids and more. Most significantly, it manages vector mosquitoes (eg. *Aedes aegypti, Anopheles gambiae, Culex pipiens)*, which are considered as deadliest animals in the world. In present investigation, seed kernel extracted oil was tested for *in-vitro* bioassay against *Hyblaea puera*, a notorious lepidopteran defoliator of the highest valued timber crop *Tectona grandis* (teak) in India. This resulted in 77% mortality with 55% anti-feeding within 24 hours at 1% concentration. During the investigation, top five superior *B. aegyptiaca* populations have been identified based on seed availability and percentage of oil yield obtained by Duncan's Multiple Range Test (DMRT), Analysis of Variance (ANOVA). Of the 21 screened populations in Tamil Nadu, the maximum oil yield was obtained from Kalugumalai, Thoothukudi (63.17 ± 0.91), while the lowest was in Ammathur, Virudhunagar (38.43 ± 1.43). Additionally, a slight positive correlation (r=0.315) between seed area and oil yield percentage was discovered at 0.01 level of significance in 2-tailed Pearson's correlation. Further, methanol extracted the maximum number of phytochemicals with insecticidal potential, such as phenolic compound, tannin and saponin.

Keywords: *Balanites aegyptiaca*, Teak defoliator, *Hyblaea puera*, Pest control, Bioinsecticide.

INTRODUCTION

Balanites aegyptiaca (L.) Delile (family: Zygophilaceae), a no maintenance woody, spiny shrub of arid regions commonly known as desert dates or soapberry is primarily grown in Africa, Middle East, and South Asia. It is highly tolerant of a wide range of weather and geographic conditions, including variations in soil, altitude, temperature, and rainfall. It can reproduce itself successfully by root sucking, coppice shoots, and seeds, and it has a lifespan of over a century. Many nations prioritise *B. aegyptiaca* because of the many advantages of each part of this agroforestry species: the fruit's pulp and fruits are eaten by rural Africans and used as animal feed; the fruit's mesocarp contains saponin, which generally is used as soap, detergent, and insecticide; and the root, bark, and seed oil have medicinal uses. In addition to producing high-quality charcoal, it is frequently used as firewood. Multiple studies reported the efficacy of *B.aegyptiaca* seed oil for the control of storage insect pests namely *Callosobruchus maculatus, Trogoderma granarium, Sitophilus zeamais, Tribolium castaneum* (Feyisola *et al.*, 2022; Vandi and Elias, 2021; Mokhtar and Abdalla, 2013; Mokhtar *et al.*, 2021, etc.) as well as pests of medical importance such as different mosquitoes *Aedes aegypti*, *Culex pipiens, Anopheles gambiae* (Chapagain and Wiesman, 2005; Chapagain *et al.*, 2008; Yonki *et al.*, 2023) but, there is only single report of desert date seed oil controlling lepidopteran pest i.e. *Helicoverpa armigera*

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(Sule *et al.,* 2022). Non-edible tree crop pests are frequently managed using easily accessible synthetic chemical pesticides that are harmful for the environment. Thus, this study concentrated on controlling polyphagous and voracious feeder *H. puera* which completely defoliates planting materials of the highest valued timber crop of the country *Tectona grandis* (Teak) in nurseries and plantations resulting significant loss in economy also feeds on 45 (approx.) other host plants *viz.* different species of mangrove plants (*Avicennia marina, A. officinalis, A. schaueriana), Vitex parviflora* and so on. This investigation also aimed at identifying the superior populations of *B. aegyptiaca* in Tamil Nadu, screening of physico-chemical properties and phytochemicals present in seed kernel oil and evaluating the efficacy of seed kernel oil extract against *H. puera* in *in-vitro* bioassay.

MATERIALS AND METHODS

An extensive field survey was conducted in all the districts of Tamil Nadu to identify the populations of *B. aegyptiaca*. Total 250 trees of 21 identified populations from 6 districts namely Coimbatore, Erode, Madurai, Theni, Thoothukudi and Virudhunagar were surveyed (Table-1). Matured fruits were obtained from 15 populations out of 21 surveyed populations during different seasons. Seeds were weighed, scanned in image analyser for total area measurement and correlated with the oil yield using SPSS software (version 17.0). Seed kernels or the endocarps were extracted from matured fruits, powdered, and processed. 10 grams of each powdered sample collected from 15 selected populations in 5 replications were taken to the laboratory for oil extraction using 300ml of various organic solvents (namely, Methanol, n-hexane, and petroleum ether) in Soxhlet apparatus. Screening of physico-chemical properties, evaluation of phytochemicals, Gas chromatography-mass spectrometry (GC-MS), and Fourier Transform Infrared (FT-IR) analysis (Outsourced from CSIR-Indian Institute of Petroleum, Dehradun) of *B. aegyptiaca* seed kernel extract was performed to examine the oil using standard protocols (Murthy *et al.,* 2021; Sadasivam and Manickam, 2007; Mehedi *et al.*, 2023). Oil yield percentages were calculated using the following formula (Xiao, 2022) and assessed against different solvents and to identify the superior population and best solvent.

$$\text{Oil yield (\%)} = \frac{\text{Mass of oil extract (g)}}{\text{Mass of seed material (g)}} X100$$

Figure1. Extraction of *B. aegyptiaca* seed kernel oil and *H. puera in-vitro* bioassay.

Superior populations of *B. aegyptiaca* were ranked by Duncan's Multiple Range Test (DMRT). Furthermore, larval stages of *H. puera* were collected from *Tectona grandis* teak from different locations of Tamil Nadu (Karamadai, Thadagam road, Sadivayal, Thondamuthur, IFGTB research nurseries) and Kerala (Walayar, Panampally field research station). Field collected larvae of *H. puera* were separately arranged in culture jar based on larval stages for *in-vitro* multiplication and fed with fresh teak leaves daily. The healthy larval batch were obtained after the completion of one life cycle (Figure-1). This process reduced the risk of parasite induced mortality of *H. puera* and produced enough numbers of larvae required for the bioassay. Laboratory reared healthy 3rd and 4th larval instars larvae of *H. puera,* 10 numbers each in 3 replications were employed for the bioassay study using 0.5% and 1% concentrations of selected superior *B. aegyptiaca* oil extract. Further, the mortality was assessed between 24-96 hours after foliar application to check the efficacy of *B. aegyptiaca* seed kernel oil also the antifeedant activity were calculated using the following formula (Isman, 1990).

$$\text{Antifeedant Index (\%)} = \frac{\text{Control} - \text{Treatment}}{\text{Control} + \text{Treatment}} X100$$

Table 1. Surveyed populations of *B. aegyptiaca* in Tamil Nadu.

S. No	Locations	Population	Geo coordinates	Altitude in meter	No. of Trees
1	Bannari, Satyamangalam Tiger Reserve (STR), Erode	I	11°32’58” N 77°09’13” E	317	16
2	Dhimbam, (STR), Erode	I	11°34’43” N 77°07’58” E	410	19
3	Talamalai, (STR), Erode	I	11°41’57” N 77°07’22” E	893	10
4	Thalavadi, (STR),Erode	I	11°33’53” N 77°08’05” E	368	26
5	Hasanur, (STR), Erode	I	11°40'40.8"N 77°07'36.0"E	915	10
6	Palavanatham, Virudhunagar	I	09°32’39” N 78°01’33” E	101	12
7	Alagapuri, Virudhunagar	I	09°34’26” N 77°51’38” E	110	10
8	Ammathur, Virudhunagar	I	09°34'16.9"N 77°52'54.9"E	121	6
9	Deivaseyalpuram, Thoothukudi	I	08°44’07” N 77°55’32” E	38	30
10	Vallanadu, Thoothukudi	I	09°05’43” N 78°00’44” E	59	10
11	Kalugumalai, Thoothukudi	I	09°08'52.6"N 77°43'50.0"E	112	12
12	Chinnar, Anamalai Tiger Reserve (ATR), Coimbatore	I	10°22’10” N 77°13’13” E	484	7
13	Theni	I	09°47'58.7"N 77°25'57.6"E	434	17
14	Chinnakattalai, Madurai	I	09°51'34.6"N 77°47'49.8"E	155	6
		II	09°51'34.6"N 77°47'49.4"E	155	14
15	Sedapatti, Madurai	I	09°48'43.9"N 77°48'01.1"E	173	11
16	Forest Campus, Coimbatore	I	11°01’01” N 76°56’56” E	437	6
17	Samichettypalayam, Coimbatore	I	11°09’56” N 76°56’03” E	422	1
18	Onnapalayam, Coimbatore	I	11°00'48.4"N 76°52'26.5"E	456	11
19	Kurumbapalayam, Coimbatore	I	11°00'31.5"N 76°53'25.8"E	442	9
20	Naickenpalayam, Coimbatore	I	11°09'18.8"N 76°55'27.0"E	435	7
	Total	21			250

RESULTS AND DISCUSSION

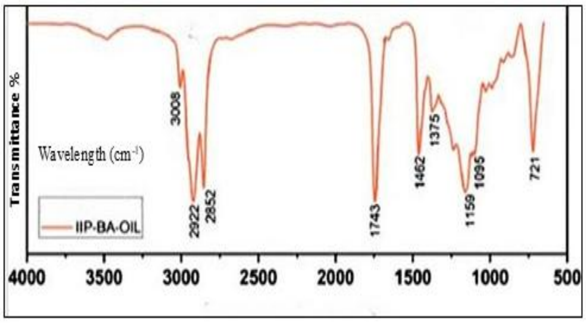
B. aegyptiaca seed kernel oil is light yellow in colour with a viscosity 38.88 centistokes at 40ºC, acid value 4.5, Sulphur content 26 ppm (Table-2a). The mid-IR range of FI-TR spectra revealed the peaks at 2852 cm^{-1} and 2922 cm^{-1} indicates -C-H (CH3) and -C-H (CH2) vibrations, transmittance at 1743 cm^{-1} denotes the presence of ester group and another C-H stretching vibration at 3008 cm^{-1} indicates unsaturated fatty acid olefinic hydrocarbon, all other vibrations have been given below in Table-2b. During the screening of phytochemicals solvent methanol extracted maximum number of phytochemicals from *B. aegyptiaca* seed kernel oil, such as saponin, phenolic compounds, tannins, etc., (Table-2c). However, Petroleum ether managed to provide maximum oil yield i.e. 36% higher than methanol and least in n-hexane (22%). On the other hand, GC-MS result showed the presence of four major bioactive compounds such as 2,4-Decadienal (15.8%), 2,4-Nonadienal, (E, E)- (22.6%), l -(+)-Ascorbic acid 2,6-dihexadecanoate (57.3%) and Hexadecanoic acid, ethyl ester (4.1%) (Table-2d).

Table 2. Physico-chemical assessment and Phytochemical Screening of *B. aegyptiaca* Seed Kernel Oil:

a)

Physico-chemical Properties of *B. aegyptiaca* kernel oil	Values
Cloud Point, °C	0
Kinematics Viscosity@40°C, cSt	38.88
Density at 15°C, g/cc	0.9179
Pour Point, °C	+3
Acid Value	4.5
Sulphur by XRF, ppm	26.0

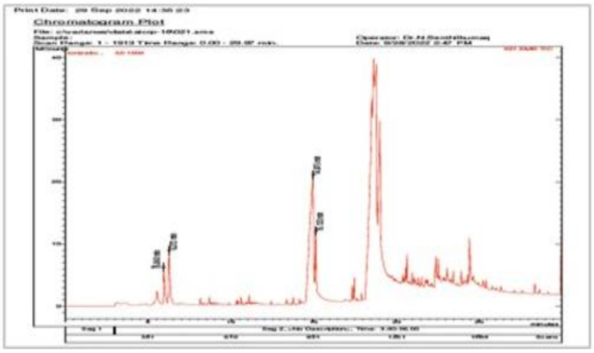
b)



c)

Phytochemicals	Methanol	n-hexane	Petroleum ether
Carbohydrate	+	-	-
Protein	+	+	+
Steroid	+	+	+
Alkaloids	+	+	+
Flavonoids	-	-	-
Phenol	+	+	-
Glycosides	+	-	+
Saponin	+	-	-
Tannin	+	-	-

d)



The seed area measured by image analysis showed weak positive correlation (r=0.315) with oil yield % (Table-3).

Table 3. Correlations between the Seed area and oil yield%.

		Area	Oil Yield %
Area	Pearson Correlation	1	.268
	Sig. (2-tailed)		**.315**
	N	16	16
Oil Yield %	N	16	16
	Pearson Correlation	.268	1
	Sig. (2-tailed)	**.315**	
	N	16	16

B. aegyptiaca populations were found distributed in the western and southern districts of Tamil Nadu (Figure 2a). Top five superior populations selected based on high oil yield are highlighted and oil yield obtained from different locations are presented (Figure-3b). Kalugumalai, Thoothukudi showed the highest oil yield (63.17 ± 0.91[a]) followed by Alagapuri, Virudhunagar (47.57 ± 1.68[b]) out of 15 seed bearing populations whereas, least oil was obtained from Ammathur, Virudhunagar (38.43 ± 1.43[f]) population. In laboratory bioassay of *H. puera*,0.5% concentration of *B. aegyptiaca* seed kernel oil showed 20-40% larval mortality within 24-72 hours whereas, 1% concentration achieved 77% and 100 % of larval mortality within 24 and 72 hours respectively (Figure-3). Similarly, while screening the antifeeding against the treatment, 0.5% concentration recorded 46.7% antifeeding and 1% showed 55% of antifeeding in average (Figure- 4). Major components present in *B. aegyptiaca* seed kernel extract were ester, unsaturated fatty acids, olefinic hydrogen, a normal range of sulphur content which were the generally observed in an oil (Hassabo *et al*, 2018; Volha *et al.*, 2014; He *et al.*, 2010; Soon-Mo *et al.*, 2015). The presence of esters, olefins, saponin, tannin, phenolic compounds additionally, bioactive compounds namely, 2,4-Decadienal, Hexadecanoic acid, ethyl ester in the oil indicated its potential as a biopesticide (Viswakethu *et al.*, 2025; Muhammad *et al.*, 2020; Varsha *et al.*, 2023; El-Aswad *et al.*, 2022). Unlike other edible oils the acid value of *B. aegyptiaca* oil was found slightly high and the kinematic viscosity resembles the sunflower oil at same temperature (Elena & Yakov, 2005; Sharma & Jain, 2015; Chiplunkar & Pratap 2016; Rafeal *et al.*, 2024). Population distribution map of *B. aegyptiaca* prepared during the study revealed that the availability of this species limited to the southern and western districts of the state Tamil Nadu. Most of the sampling locations fell under rain shadow area or the dried parts of the states according to Nathan's report (1998) though in recent rainfall report by IMD 2024 described the selected locations under normal rainfall zone which differs from the global distribution of the species (eg. Pan-African regions, north to south in the Middle East indicates the wide environment adaptability of the species in arid habitat).

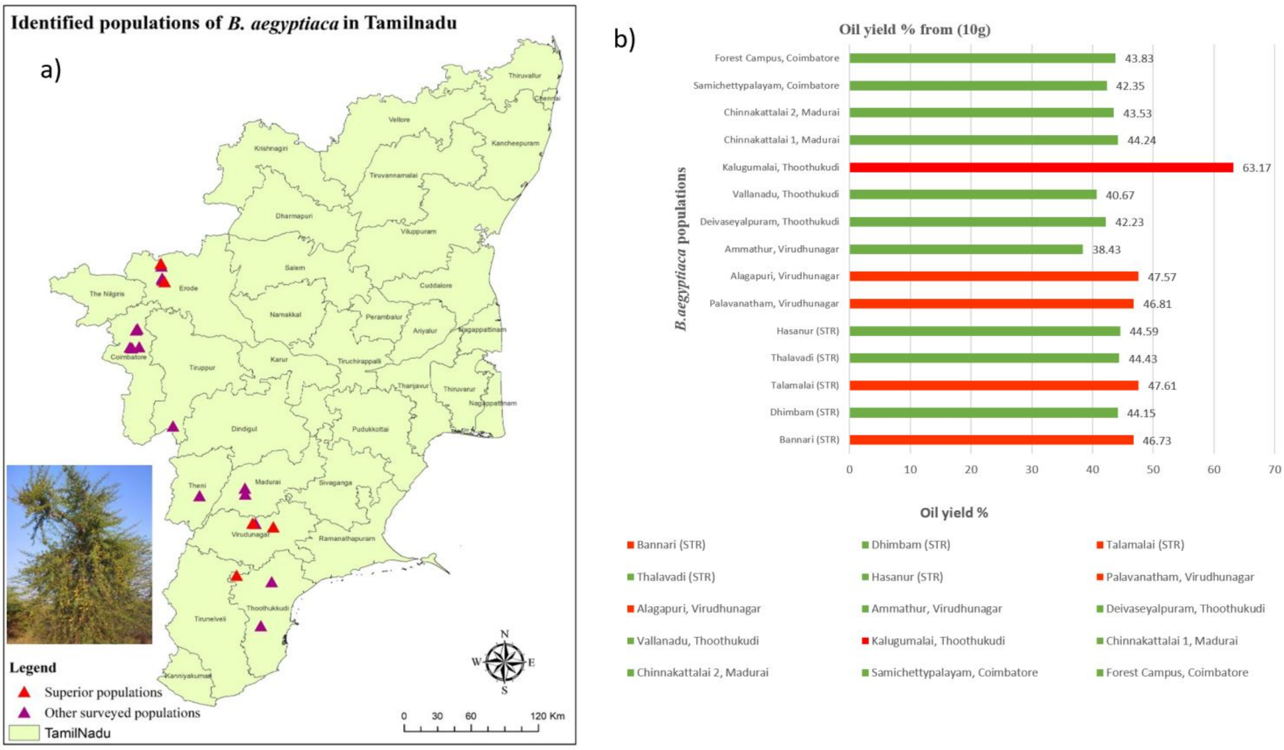


Figure 2. a). *B. aegyptiaca* surveyed sites, b). Oil yield % from surveyed populations in Tamil Nadu.

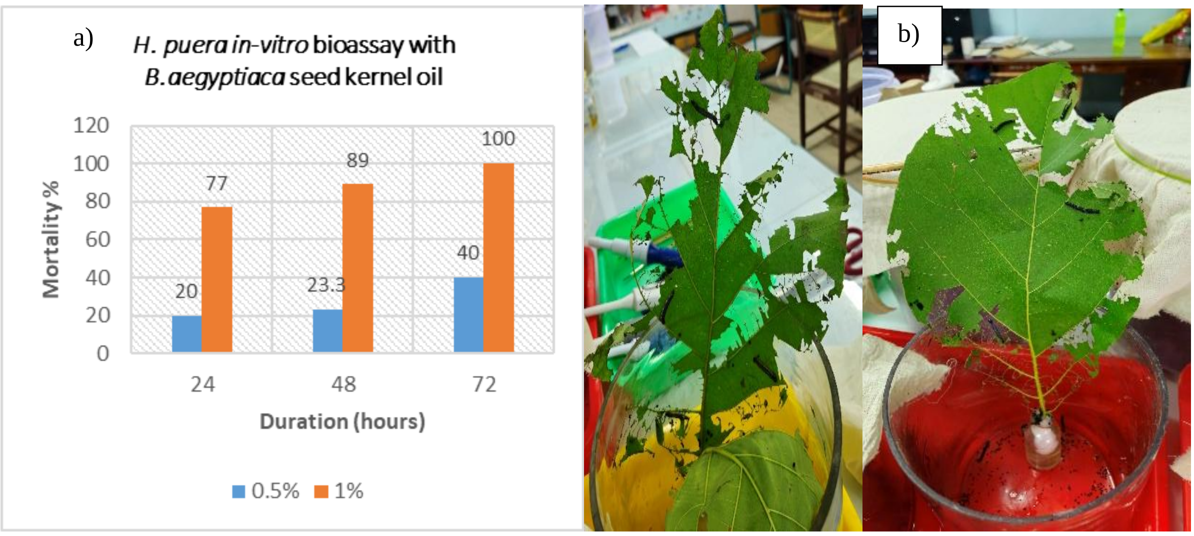


Figure 3. a) *H. puera* larval bioassay mortality graph, b) in-vitro bioassay: Control (Left), 1% *B. aegyptiaca* seed kernel oil treatment (Right).

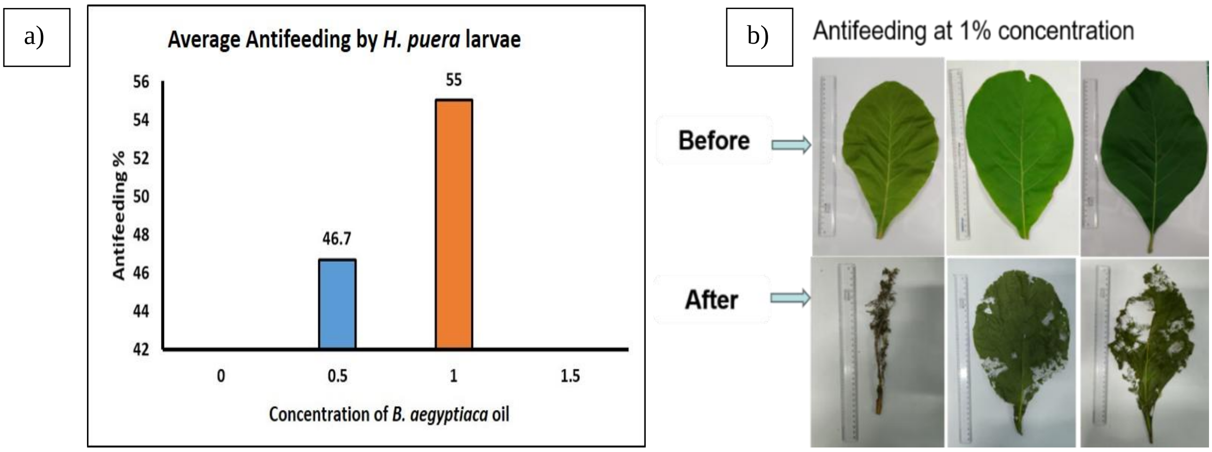


Figure 4. a) *H.puera* larval antifeeding in different concentrations (0.5% and 1%), b) Antifeeding in different replications of 1% *B. aegyptiaca* seed kernel oil treatment

However, this slow growing species takes around 8 years for fruiting and lives more than 100 years therefore, it is difficult to comprehend the suitable weather conditions required to gain maximum oil yield from this species and there are three varieties of the species available worldwide hence, which gives maximum oil yield can be checked further (Hall, 1992; Sagna *et al.*, 2014). Furthermore, a good amount of *B. aegyptiaca* oil yield up to 63.17 ± 0.91[a] % was obtained in the present study from 10g of seeds which is much higher than that of neem oil 52.5% from 950 g of neem seed cake (Sheela *et al.*, 2019). As seen in past researches the oil yield varied depending on factors such as locations, solvents, temperatures etc. (Keneni *et al*, 2021; Xiao *et al*,2022) in current study maximum the oil yield obtained from petroleum ether. The target pest *H. puera* has been utilized in ample number of researches in the past to evaluate pesticide efficacy where nucleopolyhedro virus (NPV) reduced the survival of larvae 20-40%, 0.5 % of *Erythrina indica* seed extract exhibited 92% of larval mortality, seed extract of *Melia azedarach* successfully deterred 94% larvae from feeding (Sudheendrakumar *et al.*, 2011; Deepa and Ramadevi, 2017; Nathan and Sehoon,2006) similarly, in present investigation 100% mortality obtained within 72 hours at 1% concentration. In past researches seed powder, seed oil, leaf and fruit mesocarp extracts of *B. aegyptiaca* were employed to control pests of different orders viz. *Helicoverpa armigera*, *Callosobruchus maculatus, Trogoderma granarium, Sitophilus zeamais, Tribolium castaneum, Aedes aegypti, Anopheles gambiae, Culex pipens*etc. (Feyisola *et al.*, 2022; Chapagain *et al.*, 2005; Yonki *et al.*, 2023; Tigamba and Nukenine, 2021; Mokhtar *et al.*, 2013; Sule *et al.*, 2022).

CONCLUSION

The present study showcased the distribution of *B. aegyptiaca* in Tamil Nadu and assessed its insecticidal potential, oil yield by screening physico-chemical and phytochemicals properties. Furthermore, the successful management of polyphagous devastating teak defoliator *H. puera* during *in-vitro* bioassay indicates that in upcoming days *B. aegyptiaca* could replace synthetic pesticides by managing various pests.

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CONFLICT OF INTERESTS

The authors declare no conflict of interest

ETHICS APPROVAL

Not applicable

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