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Utilization of Tribal Ethnobotanicals for control of mosquito and mosquito borne diseases and Covid herbal mask and sanitizer for the livelihood of Irular tribes Western Ghats, Tamil Nadu, India

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Abstract

The Irular are a Dravidian ethnic group inhabiting the Indian states of Tamil Nadu and they are facing many problems with mosquitoes, which are transmitting Malaria, dengue and filariasis etc. The tribal (Irular) plants, *Phyllanthus emblica* and *Artemisia pallens* from Western Ghats, Tamilnadu, India have been used the preparation of mosquito control agents. An effective mosquito larvicide and bio-mosquito coil has been prepared by use of above herbals to establish a powerful knockdown effect against larvae and adult mosquitoes, when compared with marketed synthetic products. A Mosquito coil (0.6 cm thickness) was prepared manually and shade dried and it has been demonstrated to tribal people. In laboratory conditions, the herbal formulations were found to possess toxicity against young instars (I, II, III, and IV) dengue vector, *Aedes aegypti*. Field trials have been conducted at the breeding sites of mosquitoes at stagnant water bodies and insect pests at the Agricultural forest ecosystem at tribal settlement at Nilgiris and Maruthamalai Hills. Bioassays have also been conducted against non-target organisms such as copepods, *Mesocyclops aspericornis,* Guppy fish, *Poecilia reticulata and earthworm, Eudrilus eugeniae* species. Herbal masks (covid-19) were prepared by infusion of herbal extract through Ayurvastra technique, and it has been demonstrated to the tribal community for their use for the mosquito repellent and as Covid facial masks. Less alcoholic and special herbal covid mask spray have also been made with herbals (neem, ginger, clove, turmeric, tulsi). The nanoformulations of herbal extract showed a potent antiplasmodial activities against CQ-resistant (CQ-r) and CQ-sensitive (CQ-s) strains of *Plasmodium falciparum* and Anti Dengue with moderate cytotoxicity was detected on Vero cells post-treatment. Formulations were tested for antimicrobial activities and it can be used as eco-friendly bioinsecticides and alternate herbal medicine for tribals.

Keywords: Human Health and Well-being, Innovation, Adaptive and Integrated Management, Social Protection, Zoonotic diseases

Introduction, scope and main objectives

Forests are important repositories of medicinal compounds in wild organisms, including some already-common foods, drinks and drugs (e.g. cocoa, cola nut and ginger). Forests are a rich reserve of compounds that can be used as pharmaceuticals and nutraceuticals. Forest trees and other plants contain a wide variety of bioactive compounds with potential as anticancer drugs, antiatherogenic compounds, and antioxidants. Forest species contain alkaloids such as reserpine, quinine, quinidine, ipecac, ephedrine and caffeine, as well as antibacterial and antifertility compounds. Quinine and quindine, which derive from Andean forest trees in the genus Cinchona, have been the world's main defence against malaria for decades, saving countless lives.

The entire Western Ghats, India is known for its biodiversity, richness and endemism of different species. India harbors about 15% (3000 – 3500) out of 20,000 medicinal plants of the world. There are about 2,000 plant species that have been found to possess medicinal value, in all the four systems of indigenous medicine, viz., Ayurveda, Unani, Siddha, and Homeopathy (Hemambara et al., 1996). In this milieu, medicinal herbs are

'Gifted Gods' for healing, supporting and rehabilitating human beings. Irulas are a small tribal community that is part of the Dravidian language group that is spoken in South-Eastern India. The Irulas are the Dravidian inhabitants and one among the 36 sub-tribal communities in Tamil Nadu that hold a population of about 26,000.

Phyllanthus emblica L. can be grown successfully in variable habitat and agro climatic conditions. Aonla (Amla) has been raised from seeds for a long time. Seeds attain full maturity by February in north India and October in western India. Of the various methods of vegetative propagation, budding has been found most efficient and successful. Though Aonla is classified as subtropical fruit, its cultivation in tropical, arid and in rain fed semi-arid conditions are quite successful. It is a tropical plant. Annual rainfall of 630-800 mm is ideal for its growth. The young plant up to the age of 3 years should be protected from hot wind during may-June. Young plants require watering during summer months at a 15 days interval till they are fully established. Watering of bearing plants is advised during summer months at bi-weekly intervals. Amla tree does not require regular pruning but in early years for getting proper shape and development. During summer, the crop should be mulched with paddy straw or wheat straw at the base of the tree up to 15-20 cm from the trunk. Inter crops like green gram, black gram, cow pea and horse gram can be grown up to 8 years. The Amla tree starts bearing fruit after about 4-5 years of planting. Aonla fruits are harvested after attaining maturity. The fruits are harvested during February when they become dull greenish yellow from light green. During harvesting, individual fruit is picked and put in lined baskets carefully to avoid bruising and to avoid spoilage loss. The mature fruits are hard and they do not fall gently and therefore vigorous shaking is required.

Artemisia pallens Roxb. is widely distributed in the cool temperate and subtropical regions of the world and found to grow on all types of soil. The leaves and flowers of *A. pallens* yields an essential oil known as 'Oil of Davana' used in high grade perfume. An ideal soil for the plant is fertile, well drained, sandy loam soil and rich in organic matter. Plant is mainly propagated by seeds. The good quality seeds are always filled up and have a shape. The seeds can be stored for an average period of 4 months. Due to small seed size, direct sowing in the main field does not give good results. Hence, seedlings are first raised in nursery beds and then transplanted to the main field. The field is to be irrigated frequently from transplanting to establishment of the crop. Seedlings are watered manually after transplantation. Seeds can be sown in nursery during September-October for the late rainy season crop and during November - December for the summer crop. November - December planted crop is reported to give maximum oil yield.

The two herbal plants need intensive cultivation and its yield can utilized for various therapeutic purposes. Hence, in the present study address on the use of herbal plants for the health and wealth of tribal people in Western Ghats, Maruthamalai and Adjacent Area of Western Ghats, Coimbatore, Tamil Nadu, India with following objectives: (i) Use of tribal plants as a bioinsecticide to control Crop Insects and Mosquito larvae at their settlement. (ii) Use of tribal plant extracts in nanoformulations as antimalarial and anti-dengue agents and (iii) use of tribal plant for the fabrications of herbal masks, sprayer through essential oil of herbals, and further less alcoholic hand sanitizer.

Methodology

Plant collection & Insect Culture

Phyllanthus emblica and Artemisia pallens were collected from the Irulas settlement in Maruthamalai Hills (Western Ghats), Southern India. The malarial vector *An. stephensi* and dengue vector *Ae. aegypti* (Murugan et al., 2015) larvae were collected from National Communicable Disease Centre, Mettupalayam and forest insect pest, *Hyblaea puera* (Senthilnathan and Sehoon, 2006) were collected from Western Ghats, Siruvani hills, Coimbatore, Tamilnadu, India, cultures were maintained at standard experimental protocol at the well-maintained laboratory, Department of Zoology, Bharathiar University, Coimbatore-641046, India.

Preparation of plant extracts:

The both leaves were washed with tap water, shade-dried at room temperature (28±2°C) for 5 to 10 days. Since certain compounds get denatured in sunlight, it is dried under shade to avoid decomposition. 250 g of

fresh, both mature leaves were rinsed with distilled water and dried under shade. The dried leaves were put in a Soxhlet apparatus and extract were prepared by methanol. The yield extract was 100g and was evaporated to dryness in rotary vacuum evaporator and the dried residues obtained were stored in airtight bottles in a refrigerator for further use.

Bioassay in standard laboratory condition

Different larval instars viz., third instar and pupae of 25 numbers *An. stephensi* and *Ae. aegypti* were taken in 250ml of water with various concentrations of *P. emblica* and *A. pallens* extract with five replicates and plain water is taken as control. The percentage of larval instars death (Mortality) was estimated according the standard method (Rajaganesh et al., 2016).

Field Trial

P. emblica and *A. pallens* ethanol leaf extract were applied in the breeding sites of malaria and dengue at a clean and stored water system, using a knapsack sprayer. Percentage reduction of the larval density was calculated using the formula in different time intervals (24h, 48h, and 72h): Percentage reduction: (C−T) /C × 100; where C is the total number of mosquitoes in the control and T is the total number of mosquitoes in the treatment (Panneerselvam et al., 2016).

Bio-mosquito Coil and Smoke toxicity test:

Bio-coil has been prepared with *P. emblica* and *A. pallens* powder the method of Saini et al. (1986) the protection given by the smoke from plant samples against the biting of *An. stephensi* and *Ae. aegypti* was calculated in terms of percentage of unfed mosquitoes after the treatment (Rajaganesh et al., 2016).

Predatory efficiency of fish and Copepods against mosquitoes

Predatory efficiency *P. reticulata* (Murugan et al., 2021) and *M. aspericornis* (Murugan et al., 2016) was calculated using the formula: Predatory efficiency= [(Number of consumed mosquitoes/Number of predators)/Total number of mosquitoes] ×100.

In vitro antiplasmodial bioassay:

CQ-sensitive strain 3D7 and CQ-resistant strain INDO of *P. falciparum* were used in in vitro blood stage culture and to test the antimalarial efficacy of *Phyllanthus emblica* and *Artemisia pallens extracts* as described method (Trager and Jensen, 1976).

Antibacterial inhibitory assay:

Antibacterial activity over *P. emblica* and *A. pallens* extract was tested towards the selected Gram-positive and Gram negative bacteria (*B. subtilis, E.coli, K. pneumonia* yet *S. aureus*) using the disk diffusion method (Bauer et al., 1966).

Artificial soil test:

OECD 78 guidelines were followed in artificial soil for the period of 14-day toxicity test for earthworm, *Eudrilus Eugenia* (De Silva and van Gestel, 2009).

Herbal Mask from the plant materials:

To fabricate herbal mask the dry the fabric in direct sunlight and then apply a gumming substance, containing plants like *Aloe vera* (Xanthorrhoeaceae) and then dip it into a concoction called kashaya that contains up to ginger, medicinal plants such as *P. emblica* (Indian gooseberry-Amla), *A. pallens*, *Azadirachta indica* (neem), *Ocimum sanctum* (tulsi) and *Syzygium aromaticum* (clove) etc., The gumming substances help the kashaya take hold, giving the fabrics their colors. The fabric is left to dry for 3 days and then kept in a room for 15 days for "seasoning," a period of time that allows the fabric to dry completely and the kashaya to settle into the fabric. It is then washed, dried in the shade, and seasoned for another 15 days. It is ready to fabricate herbal masks. The dried mask was tested for its shape and stitching quality and finally packing as per the requirements of the tribal community.

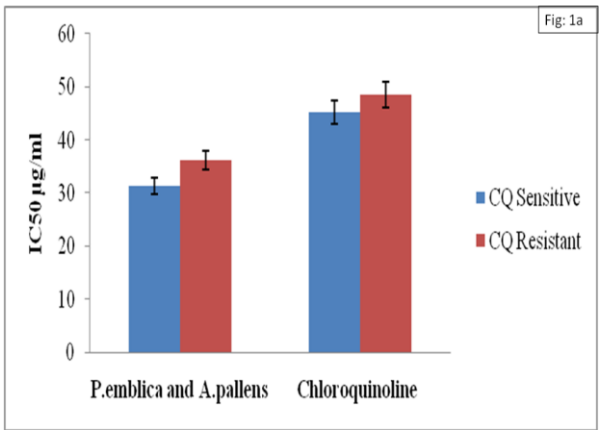
Herbal Sanitizer and sprayer:
Two parts isopropyl alcohol or ethanol (91–99 percent alcohol) m^1 part *Aloe vera* gel and a few drops of Amla, and Artemisia essential oil. Mostly hand washing reduces the germs in our hand. Similarly, the essential oil of *Amla* and *Artemisia* has been used as Sprayer for the mask.

Data analysis
The average mosquito mortality data were subjected to probit analysis. LC_{50} and LC_{90} were calculated using the method by Finney (1971). Data were analyzed using the SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). A probability level of $P < 0.05$ was used for the significance of differences between values. Copepod predation data were analyzed by JMP 7 (SAS, 1999) using a weighted generalized linear model with two fixed factors: $y = X\beta + \varepsilon$ where y is the vector of the observations (the number of consumed preys), X is the incidence matrix, ß is the vector of 263 fixed effect (the targeted mosquito instar and species) and ε is the vector of the random residual effect. A probability level of $P < 0.05$ was used for the significance of differences between values.

Results

There was a considerable larval and pupal toxicity was noticed against mosquito vectors and crop pests (Table 1). Field evaluations at the breeding sites of malarial and dengue vectors also showed considerable reduction of larval populations at 24 hrs and 48 hrs and led to the complete elimination of larval populations of *An. stephensi* and *Ae. aegypti* after 72 h (Table 2). Table 3 summarizes the results of smoke toxicity experiments conducted using *P. emblica and A. pallens* coils against the *An. stephensi* and *Ae. aegypti*. After the treatment with the leaf based coils, the mean percentages of unfed mosquitoes were 60 % and 58%, respectively. Mortality was slightly higher in the positive control and had higher adult mortality and surviving adults had less fecundity, hatchability and further reduction in the progeny production during F_1 generations. There was considerable predatory potential of fish and copepods against larvae of mosquito vectors in normal situations also herbal extract contaminated environment (Table 4 & Table 5). Earthworm survivability also does not affect (Table 6). Herbal extracts treatment showed greater antimalarial activity with a good percentage of inhibition effect against the *Plasmodium falciparum* (Fig 1a), and also found that, the inhibitory effect against vero cell viability (Fig 1b). The antibacterial activity of *Phyllanthus emblica* and *Artemisia pallens* had been examined against *B. subtilis, E.coli, K. pneumonia* and *S. aureus* and its activity was measured as zone of inhibition. The *Phyllanthus emblica* and *Artemisia pallens* were observed to remain more efficient interms' of efficiency rather than the medicinal plants alone (Fig. 2).

Figure 1: Effect of *P. emblica* and *A. pallens* extract against malarial parasites and Vero cells



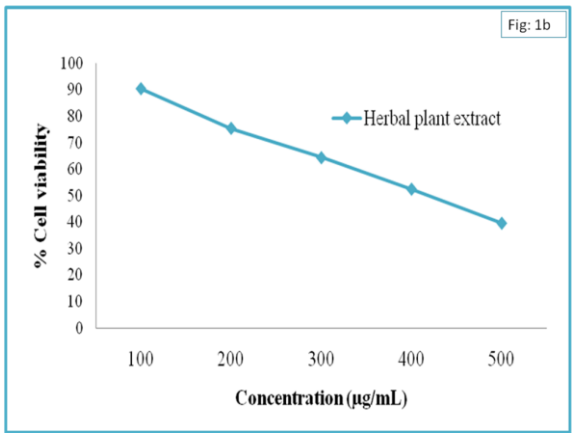


Table 1: Toxicity effect of *P. emblica* and *A. pallens* extract against *An. stephensi* and *Ae. aegypti* and forest pest *Hyblaea puera* larvae and pupae

Target species	Target instars	LC_{50} (LC_{90}) (ppm)	95% Confidential Limit LC_{50} (LC_{90}) ppm		Regression equation	χ^2 (*df*=4)
			LCL	UCL		
Anopheles stephensi	III	267.262 (568.345)	191.475 (467.555)	330.744 (813.848)	*y*=-1.138+ 0.004*x*	5.538 n.s
	Pupa	367.409 (753.093)	332.293 (658.407)	410.360 (908.361)	*y*=-1.221+ 0.003*x*	0.655 n.s
Aedes aegypti	III	289.991 (591.976)	261.449 (535.713)	317.901 (674.252)	*y*=-1.231+ 0.004x	4.535 n.s
	Pupa	399.476 (772.273)	363.550 (676.362)	446.407 (928.544)	*y*=-1.373+ 0.003x	1.275 n.s
Hyblaea puera	III	295.259 (561.320)	269.931 (514.291)	320.296 (627.145)	*y*=-1.422+ 0.005*x*	0.569 n.s
	Pupa	499.211 (920.307)	446.453 (781.788)	584.038 (1169.343)	*y*=-1.519+ 0.003*x*	2.628 n.s

No mortality was observed in the control; LC_{50} =lethal concentration that kills 50% of the exposed organisms; LC_{90} = lethal concentration that kills 50% of the exposed organisms; χ^2 = chi-square value; *d.f.* = degrees of freedom; *n.s* = non significant (α =0.05)

Table 2: Field evaluation of herbal extract against the larval populations of *A. stephensi* and *A. aegypti*

	Target Species	*Phyllanthus emblica* and *Artemisia pallens* extract (10xLD_{50})			
		Before treatment	24 hours	48 hours	72 hours
Larval density	*An. stephensi*	119.8±7.04	81.6±3.84	40.6±2.70	0.00±0.00
	Ae. aegypti	103.6± 6.34	73.6± 4.03	31.8± 3.42	0.00±0.00

Means ± SD followed by different letter(s) are significantly different (ANOVA, Tukey's HSD, P b 0.05).

Table 3: Smoke toxicity effect of against *Anopheles stephensi* and *Aedes aegypti*

Target species	Herbal plants	No. of mosquitoes used	Fed mosquitoes	Unfed mosquitoes		Total	% unfed over control 1
				Alive	Dead		
Anopheles stephensi	*P.emblica* & *A.pallens*	100	20	14	66	80	60
	Control I	100	80	20	0	20	0
	Control II	100	11	35	54	89	69
Aedes aegypti	*P.emblica* & *A.pallens*	100	19	15	66	81	58
	Control I	100	77	23	0	23	0
	Control II	100	8	33	59	92	69

Within a column means followed by the same letter(s) are not significantly different at 5% level by DMRT. Control I*= Negative control – blank without plant material; Control II*= Positive control – mortein coil.

Table 4. Predation efficiency of *Poecilia reticulata* against the larvae of *An. stephensi* and *Ae. aegypti*

	Mosquito species	Target instars	Predation (%)		Total Predation (Nos.)	Mean predation (%)
			Daylight time	Night time		
Under lab condition (Distilled water)	***Anopheles stephensi***	Larva I	46.9±1.1	41.8±1.4	88.7	44.3
		Larva II	62.7±0.6	58.6±1.0	121.3	60.6
	Aedes aegypti	Larva I	55.9±1.0	50.3±1.4	106.2	53.1
		Larva II	68.1±0.2	62.1±1.8	130.2	65.1
Plant extract	***Anopheles stephensi***	Larva I	58.2±2.1	52.6±1.8	110.8	55.4
		Larva II	86.4±0.9	79.2±2.1	165.6	82.8
	Aedes aegypti	Larva I	69.5±0.6	55.4±2.0	124.9	62.4
		Larva II	93.1±0.9	85.6±0.7	178.7	89.3

Predation rates are means ± SD of five replicates (1 predator vs. 200 both larvae per replicate); Control was clean water, without mosquito predators; within each column, values followed by different letter(s) are significantly different (generalized linear model, P<0.05)

Table 5. Predation efficiency of the copepod *M. aspericornis* against larvae of *An. stephensi* and *Ae. aegypti*.

	Targeted species	Targeted instars	Number of Consumed prays					Total Predation (n)	Consumed preys per copepod per day
			Day 1	Day 2	Day 3	Day 4	Day 5		
Under lab condition (Distilled water)	*Anopheles stephensi*	Larva I	36.6±2.6	37.2±1.0	35.6±1.5	33.6±3.5	30.5±1.2	173.5	3.47
		Larva II	22.8±0.5	20.8±0.8	19.2±0.8	18.9±2.1	20.4±1.6	102.1	2.04
	Aedes aegypti	Larva I	60.3±1.8	58.1±2.8	55.4±1.0	57.9±0.7	56.1±2.4	287.8	5.75
		Larva II	49.2±1.4	47.6±2.4	45.2±0.9	47.8±2.4	47.1±1.8	236.9	4.73
Plant extract	*Anopheles stephensi*	Larva I	49.7±1.5	50.4±1.8	49.5±2.5	47.9±1.5	48.6±3.1	246.1	4.92
		Larva II	30.2±0.9	27.6±1.6	29.2±3.1	31.4±2.7	30.7±2.1	149.1	2.98
	Aedes aegypti	Larva I	72.3±1.5	70.4±0.7	73.1±0.9	70.5±0.5	71.9±2.1	358.2	7.16
		Larva II	59.1±1.9	62.7±1.8	59.0±1.4	57.9±1.4	60.1±1.0	298.8	5.97

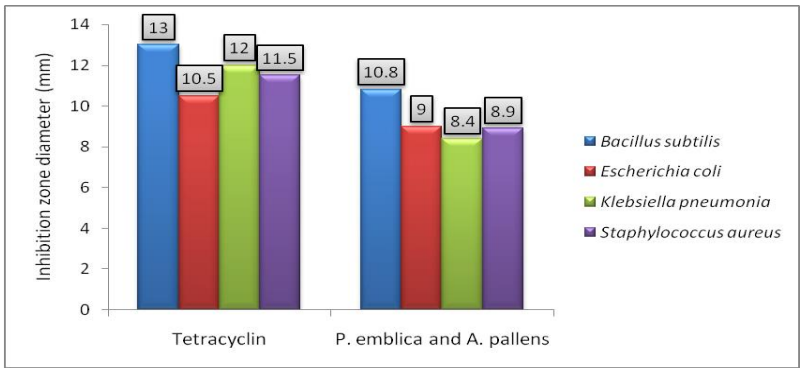
Predation rates are means ± SD of five replicates (10 predator vs. 200 both larvae per replicate); Control was clean water, without mosquito predators; within each column, values followed by different letter(s) are significantly different (generalized linear model, P<0.05)

Table 6: Toxicity effect of plant extracts against non-target organism, earthworm

Treatment		Mean Weight Per Earthworm (mg)				
		Concentration (ppm)				
		100ppm	200ppm	300ppm	400ppm	500ppm
P.emblica* and *A. pallens	Day 1	NC	NC	NC	NC	NC
	Day 7	0.13 ±0.02	0.14 ±0.02	0.13 ±0.01	0.15 ±0.03	0.16 ±0.03
	Day 14	0.30 ±0.02	0.28±0.01	0.27±0.03	0.30±0.04	0.32±0.03

NC*- No change; Means ± SD followed by different letter(s) are significantly different (ANOVA, Tukey's HSD, P b 0.05).

Figure 2: Inhibitory effect of *P. emblica* and *A. pallens* against bacterial pathogens



Discussion

The results presented in our research showed that *P. emblica and A. pallens* were extremely toxic to young larvae of *An. stephensi* and *Ae.aegypti* (Tables 1). Recent evidence underlined that green biopesticides can represent an important tool to boost the efficacy against mosquito control programs (Jaganathan et al., 2016; Subramanian et al., 2016). Therefore, the toxicity results achieved by *P. emblica and A. pallens. P. emblica and A. pallens* extract treatment on teak plantations and had considerable mortality as well as potent percentage of reduction teak defoliator, *Hyblaea puera.* The present investigation clearly exhibited that both *P. emblica and A. pallens* could serve as a potential larvicidal agent. Since, in the field, the treatment at water storage tanks (breeding sites of malarial filarial vector) had considerable populations during 72hrs of herbal extract applications. Therefore, this study provides the first report on mosquito larvicidal activity. Suresh et al. (2015) reported that the field application of *P. niruri* extract (10×LC_{50}) lead to *Ae. aegypti* larval reduction of 39.9, 69.2, and 100 %, after 24, 48, and 72 h, respectively. *P. emblica and A.*

pallens extract showed antimalarial activity against *P. falciparum* IC_{50} calculated were 83.32 µg ml^{-1} (CQ-s) and 87.47 µg ml^{-1} (CQ-r). Similarly, our previous study to determine the antimalarial activity of the ethanol leaf extract of *Carica papaya* showed promising inhibitory activity against blood stages of CQ-sensitive and CQ resistant strains of *Plasmodium falciparum* with (IC_{50}) and in CQ resistant (IC_{50}) values against *P. falciparum* (Kovendan et al., 2012) (Fig. 1). They have been also reported as growth inhibitors against dengue virus (serotype DEN-2), with moderate cytotoxicity on mammalian cells. The present research reported moderate cytotoxicity rates on Vero cells exposed to combined treatment of PE&AP extract at concentrations lower than 4 µg ml^{-1} (Fig. 2) Sujitha et al. 2015. *P. emblica and A. pallens* contaminated environment, predatory efficiency quite normal (Table 4 & 5). Similar findings combining *M. aspericornis* biocontrol agents with other control tools contributed to the eradication of *A. aegypti* larval populations (Murugan et al., 2016). There was no significant effect of *P. emblica and A. pallens* extract on earthworm *Eudrilus eugeniae* with filter paper tests. Survival was 100% in all treatments after the 14days exposure, and it does not have toxicity to soil organisms like earthworm. Antibacterial properties of *P. emblica and A. pallens* were evaluated against *Bacillus subtilis*, *Klebsiella pneumoniae*, and *Salmonella typhi* using the agar disk diffusion and minimum inhibitory concentration protocol (Dinesh et al., 2015).

Herbs are used to create different colors depending on the plants or herbs used for various health benefits. The herbal properties of the clothing provided keep the users in a safe zone by creating a barrier to the external environmental toxins. In the present study herbal mask has been prepared through the infusion of plant extracts from *P. emblica and A. pallens.* World Health Organisations (WHO, 2021) already recognized that traditional, complementary and alternative medicine has many benefits and Africa has a long history of traditional medicine and practitioners that play an important role in providing care to populations. Medicinal plants such as *Artemisia annua* are being considered as possible treatments for COVID-19 and should be tested for efficacy and adverse side effects.

Conclusion

The development of novel mosquito control tools is a key prerequisite to build effective and reliable Integrated Vector Management strategies. So, it can be concluded that these *P. emblica and A. pallens* are most effective in controlling the targeted mosquitoes at the tribal settlement. Moreover, employment of bioinsecticides and biocoil was shown as one of the vector control measures and further indirectly decreased disease transmission and this way assisted to manage diseases at the tribal community and societal level of larger populations. This sort of eco-friendly botanical insecticide package will further decrease poverty and nuisance in mosquito endemic countries by killing mosquitoes and prevent disease transmission in a harmonious way and this it ensures good health for the tribal communities. We have proposed a novel method using tribal plants as a resource toxic to young instars of the malaria vector Anopheles stephensi, chloroquine (CQ)-resistant malaria parasites *P. falciparum* and dengue vector *Ae. aegypti* and vero cells toxicity and microbial pathogens. The findings clearly reveal that both the leaf extract of *P. emblica and A. pallens* plant extract could serve as a potential larvicidal agent against the dengue vector *A. aegypti.* It has demonstrated a synergist act too. This approach could not only improve the bio-efficacy of plant extracts and also substantially reduce the possibilities of physiological resistance development in the mosquito population. Therefore, the present strategy should be promoted in the malaria and dengue vector control program. Further, low doses of the *P. emblica and A. pallens* plant inhibited the growth of *Bacillus subtilis, Klebsiella pneumoniae*, and *Salmonella typhi*, using the agar disk diffusion and minimum inhibitory concentration protocol. Overall, these plant extracts and its metabolites may be potential candidates to develop novel and effective tools in the fight against Plasmodium parasites and their mosquito vectors. The employment of ultra-low doses of herbals in synergy with cyclopoid crustaceans and predatory fishes seems a promising green route for effective mosquito control programs. The present study is a contribution towards scientific knowledge about the use of herbal extracts and their active substance present in it in entomology and parasitology, allowing us to propose the combined plant extracts as a rapid and reliable strategy for mosquito control as well as for the development of drugs to combat dengue and other arboviral diseases. Information are required for traditional medicines and

developing new therapies in the search for potential treatments for COVID-19. At , this juncture, fabrication of herbal mask and hand sanitizer from herbal plants further enhance the integration of Indian Traditional Tribal medicine into the western-based national healthcare structure are also another option for the potential herb-drug interaction are research outlook for future research in research institutions in India. Hence, we conclude that the extracts of *P. emblica and A. pallens* could be used as a multipurpose agent as mosquitocidal, antimicrobial and antiviral and antiplasmodial and this will provide societal benefit in the field of biomedical applications in pursuit of sustainable development. The conservation and sustainable use of medicinal plants have been studied extensively. Various sets of recommendations have been compiled regarding their conservation, including the establishment of systems for species inventorying and status monitoring, and the need for coordinated conservation practices based on both in situ and ex situ strategies. For medicinal plants with increasingly limited supplies, sustainable use of wild resources can be an effective conservation alternative.

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