THE EFFECT OF ESSENTIAL OIL FORMULAS ON MORTALITY AND OVIPOSITION DETERRENT OF *Helopeltis antonii*

Pengaruh Formula Minyak Atsiri terhadap Mortalitas dan Penghambatan Peneluran Helopeltis antonii

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INFO ARTIKEL

Article history:
Diterima: 5 Desember 2017
Direvisi : 22 Desember 2017
Disetujui: 12 Januari 2018

Key words:
Helopeltis antonii; essential oils; mortality; oviposition deterrent

Kata kunci:
Helopeltis antonii*; minyak atsiri; mortalitas; penghambatan peneluran*

ABSTRACT/ABSTRAK

Citronella, clove and lemongrass oils are known to be toxic and repel certain pests. Mixing different essential oils (EOs) in the form of formula is expected to increase the insecticidal properties. The experiments aimed to examine the effect of EOs mixture formulas on mortality and oviposition deterrent of *Helopeltis antonii*. The study was conducted at the green house of Indonesian Spices and Medicinal Crops Research Institute. A mixture of two EOs citronella + clove (1:1), lemongrass + clove (1:1), individual EO formulas, and their inert solution (mixture of tween 80, turpentine, and teepol) were tested on *H. antonii* at 5 and 10 ml.l^{-1} concentrations. Parameters observed were the number of eggs laid, mortality of adults and nymphs of *H. antonii*. The citronella + clove and lemongrass + clove formula at 10 ml.l^{-1} deterred the oviposition of *H. antonii* by 60.18 % and 46.56 % respectively. These formulas also caused adults mortality at 79.17 % and 62.50 %, as well as the nymphs mortality at 87.50 % and 82.50 % respectively. The citronella + clove and lemongrass + clove formulas tested had the same effectiveness compared to the commercial citronella oil formula. Therefore, these two formulas were potential to be tested in field to control *H. antonii*.

Minyak seraiwangi, cengkeh, dan serai dapur bersifat toksik dan repelen terhadap hama tertentu. Pencampuran dua macam minyak atsiri (MA) dapat meningkatkan daya kerja sifat insektisidanya. Penelitian yang bertujuan untuk mengetahui pengaruh campuran MA terhadap penghambatan peneluran, mortalitas imago dan nimfa Helopeltis antonii *telah dilakukan di rumah kaca Balai Penelitian Tanaman Rempah dan Obat. Formula campuran dua macam minyak atsiri, yaitu minyak seraiwangi + cengkeh (1:1), minyak serai dapur + cengkeh (1:1), minyak atsiri tunggal, dan bahan penyusun (campuran tween 80, terpentin, dan teepol) diuji terhadap* H. antonii *pada konsentrasi 5 dan 10 ml.l^{-1}. Parameter yang diamati adalah jumlah telur yang diletakkan, mortalitas imago dan nimfa* H. antonii. *Formula seraiwangi + cengkeh dan serai dapur + cengkeh pada konsentrasi 10 ml.l^{-1} menghambat peneluran* H. antonii *berturut-turut 60,18 % dan 46,56 %. Kedua formula tersebut juga menyebabkan mortalitas imago berturut-turut 79,17 % dan 62,50 %, dan mortalitas nimfa berturut-turut 87,50 % dan 82,50 %. Formula seraiwangi + cengkeh dan serai dapur + cengkeh yang diuji mempunyai efektivitas yang sama dengan formula seraiwangi komersial. Oleh karena itu, kedua formula tersebut berpotensi untuk diuji di lapang dalam mengendalikan* H. antonii.

INTRODUCTION

Helopeltis antonii (Hemiptera: Miridae) is the most important pest of cashew. Damage caused by *H. antonii* attack could reach 60 %. The loss will be higher if its attack followed by plant pathogen infection. Injures as a result of *H. antonii* punctures will simplify the infection of

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DOI : http://dx.doi.org/10.21082/bullittro.v28n2.2017.171-180
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Accreditation Number : 778/Akred/P2MI-LIPI/08/2017

Pestalotiopsis sp. fungi (Karmawati and Mardiningsih 2005). However, the lack of food sources for the insects in the cashew plantation area during the dry season, would decrease and eliminate *H. antonii* population (Siswanto *et al*. 2008).

Aromatic plants produce many compounds which could repel insect or alter insect feeding behavior, growth and development, ecdysis (molting), behavior during mating and oviposition (Khater 2012). Essential oils (EOs) such as lemongrass, eucalyptus, rosemary, vetiver, clove, citronella, and thyme are known to have pest control properties (Koul *et al.* 2008). Citronella oil applied on chili reduced egg laying and hatchability of *Helicoverpa armigera* in the laboratory. Moreover, it also decreased fruit damaged and raised fruit quality in the field (Setiawati *et al*. 2011). Furthermore, the application of 5 $ml.l^{-1}$ citronella oil on black pepper plantation in Bangka could decrease the level of *Dasynus piperis* attack and the yield loss of pepper was equivalent to synthetic organophosphate insecticide treatment (Rohimatun and Laba 2013). Citronella, lemongrass, ageratum, java turmeric, and neem oils caused mortality and oviposition deterrent to *Crocidolomia pavonana* (Balfas and Mardiningsih 2016).

Lemongrass oil at 0.1, 1.0, and 10 $ml.l^{-1}$ exhibited repellent activity to *Tribolium castaneum* 84, 100, 100 %, respectively at 4 hours after application. It was lethal for the insect at 1.0, and 10 $ml.l^{-1}$ concentration and the contact toxicity increased following dosage and time (Olivero-Verbel *et al*. 2010). Moreover, lemongrass oil also had larvicidal activity. Spraying 1 ml of the oil to the diet of *Musca domestica* larvae at 140.28 $\mu g.cm^2$ indicated mortality rate of 67. Pupicidal activity also was shown at 28.05 $\mu g.cm^2$ by spraying 0.2 ml lemongrass oil to pupae placed on filter paper, showed 95 % inhibition rate (Kumar *et al*. 2011).

Akhtar *et al*. (2008) reported the application of clove oil to *Trichoplusia ni* (cabbage semi-looper) and *Pseudaletia unipuncta*. Clove oil could inhibit the growth of *T. ni* at EC_{50} 400 ppm (EC_{50} = concentration inhibiting larval growth by 50 % relative to control). It also caused toxicity (by feeding) to *P. unipuncta* at LC_{50} 4.900 ppm and *T. ni* mortality (by spraying) at $LC_{50} = 6.3 \times 10^4$ ppm after 24 hours and 5.4×10^4 ppm after 7 days (LC_{50} = concentration causing 50 % mortality compared with the control). Clove oil had medium range feeding deterrent for *T. ni* at DC_{50} 217.4 ppm and for *P. unipuncta* at DC_{50} 206.2 ppm (DC_{50} = concentration causing 50 % feeding deterrence compared with the control). Most plant essential oils are chemically complex, which enhances their efficacy. For crop protection, essential oils can be used in rotation or in combination with other insecticides, potentially lessening the overall quantities applied and possibly mitigating or delaying the development of resistance in pest populations (Isman *et al*. 2011).

The use of botanical pesticide to control *Helopeltis* spp. were easy to be applied by farmers and environmentally friendly (Karmawati 2010). Treatments of neem oil and citronella oil + clove oil + jatropha oil significantly reduced damage intensity of *Helopeltis* sp. (Willis *et al*. 2013). Extracts of citronella, garlic, and *Tithonia diversivolia* at concentration of 5 % caused mortality of *H. antonii* nymphs 65.8, 65, and 63.8 %, consecutively (Sulistyowati *et al*. 2014).

Previous study revealed that mixtures of citronella + clove oils, lemongrass + clove oils, ageratum + clove oils in various ratios were two to three times more toxic and had higher oviposition deterrent effect than individual EOs on *Crocidolomia pavonana* and *H. antonii*. Citronella + clove oils and lemongrass + clove oils at the ratio of 1:1 showed the lowest number of eggs laid by *C. pavonana* and *H. antonii* (Mardiningsih and Balfas 2017). Those mixtures are in Emulsifiable Concentrate (EC) formulation.

Currently, there were no information about the effect of citronella + clove oils and lemongrass + clove oils on the mortality and oviposition deterrent of *H. antonii*. Citronella + clove oils and lemongrass + clove oils were formulated to provide practical usage for some important pests. However, the evaluation of the formula is required. Commercial citronella oil has been used to control plant pest but its inert solution has not been tested.

Therefore, this study was aimed to evaluate the mixtures of EOs formulas (citronella, clove, and lemongrass) at the ratio of 1:1 to mortality and oviposition deterrent of *H. antonii* in the green house and their effectiveness compared to commercial citronella oil formula.

MATERIALS AND METHODS

Preparation of insects testing

Nymphs and adults of *H. antonii* were collected from tea plantation of PTP VIII, Gedeh, Cianjur, West Java ($6^o50'$ S and $107^o13'$ E). The insects were mass-reared at the green house of Indonesian Spices and Medicinal Crops Research Institute (ISMCRI). Fresh cucumber fruits used as alternative host, were bought from a local market in Bogor. The fruits were washed, drained, then put into plastic containers. The collected *H. antonii* nymphs and adults were transferred and fed cucumber fruit in the containers. The cucumbers were replaced with the fresh ones every two days. The third instar nymphs of *H. antonii* were used for mortality tests, whereas the three-day old adults for oviposition deterrent and mortality test.

Essential oil formulation

The EOs used in this experiment were citronella, clove, and lemongrass oils. The EOs obtained by steam distillation (Rusli 2002) were from various places. Citronella oil was distilled from citronella leaves at Manoko Research Installation, Lembang, Bandung; clove oil from clove leaves distilled by a private company in Leuwiliang and re-distilled in the laboratory of ISMCRI, Bogor; whereas lemongrass oil was distilled from lemongrass stem by a private supplier in Cianjur. The chemical contents of the EOs were analyzed using GC-MS at health laboratory in Jakarta.

Two emulsifiable concentrates (EC) of EOs formulas were mixture of citronella + clove oils (1:1) and lemongrass + clove oils (1:1), were prepared using solvent and surfactant/emulsifier, such as tween 80, turpentine, and teepol. Each single of EOs was also formulated using the same carrier as mentioned above. The formula contained 30 % of EOs.

Oviposition deterrent

The experiment of oviposition deterrent was arranged in a randomized complete block design, 13 treatments and repeated four times. The treatments were six EOs formulations (two mixture and three single formulations) at two concentrations (5 $ml.l^{-1}$ and 10 $ml.l^{-1}$ water) and control.

Newly emerged *H. antonii* adults were paired in plastic box container (14 cm in diameter and 13 cm in height). Fresh cucumbers were sprayed with the tested formula using plastic hand sprayer (8 cm in height and 2.3 cm in diameter) then air-dried. One treated cucumber was placed in the box as feeding for three pairs of three-day-old *H. antonii* adults. The boxes were covered with a perforated cloth. Two days later, mortality of the adults was observed and the old treated cucumber was replaced with a new treated one. Number of eggs laid on the cucumber, indicated by the appearance of threads, were counted visually (Figure 1). The same procedures as previously described were repeated for 6 days and the total number of eggs laid was counted.

Figure 1. Observation on *H. antonii's* egg on cucumber was shown by the existence of the stalk of *H. antonii's egg*.

Gambar 1. Observasi terhadap keberadaan telur H. antonii *pada timun, ditandai dengan adanya tangkai telur.*

The data were analyzed using SAS Program. The comparison of means was calculated using Duncan's Multiple Range Test (DMRT) at 0.05 level. The effective repellency for each EOs was determined using the following formula (Setiawati *et al*. 2011):

$$ER\ (\%) = \frac{NC - NT}{NC} \times 100\%$$

Note :
= effective repellency percentage.
= number of eggs in the control treatment (inert formula).
= number of eggs in the treatment.

Keterangan :
ER = *persentase efektivitas repelensi.*
NC = *jumlah telur pada kontrol.*
NT = *jumlah telur pada perlakuan.*

Mortality of *H. antonii* nymphs

The mortality experiment was arranged in randomized complete block designs with 13 treatments and repeated four times. Ten nymphs of *H. antonii* third instar were sprayed with EOs formula at 5 $ml.l^{-1}$ and 10 $ml.l^{-1}$. The control treatment was sprayed with inert solution at the same concentrations as EOs formula. The treated nymphs were then placed in the box containing one cucumber, covered with a perforated cloth. The mortality of the nymphs were recorded daily until four days after treatment (Figure 2).

Figure 2. Observation on the mortality of *H. antonii's* adult.
Gambar 2. Pengamatan kematian serangga dewasa (imago) *H. antonii.*

Oviposition deterrent and mortality of *H. antonii* adults of the EOs mixture in comparison with commercial citronella oil

The experiment was arranged in randomized complete block designs, 9 treatments and repeated four times. The treatments were two concentration (5 $ml.l^{-1}$ and 10 $ml.l^{-1}$ water) and four formulations (1) formulation of citronella + clove oil (1:1); (2) commercial citronella oil formula containing 30 % citronellal; (3) inert solution of the formula containing tween 80, turpentine, and teepol; (4) inert solution of the commercial citronella oil formula (provided by the supplier) and control (water).

The method to evaluate EOs effect on oviposition deterrent used the same procedure as mentioned in oviposition deterrent experiment. Data were analyzed with analysis of variance (ANOVA) using SAS Program and analyze further with DMRT at 0.05 level. The effective repellency (ER) for each EOs was calculated with formula as mentioned above.

RESULTS AND DISCUSSION

Chemical compositions of the tested essential oils

The major components of the EOs oil used were presented on Table 1. The content of total geraniol in citronella oil (citronellal, citronellol and geraniol) was 87.26 %, fulfilled Indonesian National Standards (minimum total geraniol 85 %) (BSN 1995). Citronellal and citronellol content from this study was higher than previously reported by Setiawati *et al.* (2011), which was 35.97 % for citronellal and 10.03% for citronellol.

The main component of clove oil in this study was eugenol (82.68 %), also fulfilled Indonesian National Standards (minimum 78 %) (BSN 2006). This result was higher than previous study 74.3 % (Bhuiyan *et al.* 2010) and 77.54 % (Mardiningsih and Balfas 2017).

Table 1. Main chemical compositions of three essential oils used in the experiment.
Tabel 1. Kandungan kimia utama dari tiga jenis minyak atsiri yang digunakan dalam penelitian.

Essential oils	The chemical components
Citronella	Citronellal (57.51 %), citronellol (15.18 %), geraniol (nerol) (14.57 %), linalool (1.29 %), isopulegol (1.94 %), limonene (4.05 %), citronelil acetat (3.23 %), geraniol acetat (1.29 %).
Clove	Eugenol (82.68 %), beta-caryophyllene (17.31 %).
Lemongrass	Myrcene (11.06 %), methyl heptenon (3.62 %), citronellal (3.72 %), trans citral (25.78 %), cis-citral (40.14 %), linalool (1.36 %), geranil acetat (1.68 %), citronelol (3.45 %), trans geraniol (7.15 %)

The main components of lemongrass oil was citral content (Tajidin *et al*. 2012). The citral content (cis and trans citral) of the lemongrass oil from this study was 65.92 %. However, it did not fulfil EOA Specification and Standards Oil of Lemongrass (minimum 75 %) (USA EO Association 1970). The composition of EOs varies depending on isolation method. Distillation may influence the composition of the oil isolated, because isomerization, saponification, and other reaction may occur under distillation conditions (Tripathi *et al*. 2009). In addition, the chemical profile of plant species can vary naturally depending on geographic, genetic, climatic, and annual or seasonal factors (Koul *et al*. 2008). The variation of chemical composition of EOs may influence their biological activities. Therefore, EOs application may give different response to insects.

Oviposition deterrent and mortality of *H. antonii* adults

Up to 6 days after treatment, citronella + clove oil at 10 ml.l^{-1} suppressed number of laid egg higher than lemongrass + clove oil at 10 ml.l^{-1} and significantly different than other treatments. It also indicated the highest effective repellency (60.18 %) (Table 2). The mixture of citronella oil + clove oil EC increased the activity of oviposition deterrent of *H. antonii*. Meanwhile, the inert solution signified no effect on oviposition deterrent as indicated by the numbers of eggs laid which were not significant from control. Mardiningsih and Balfas (2017) also reported the highest effective repellency (63.30 %) of citronella and clove oils mixture in alkyl glycerol ftalat to *H. antonii*.

Citronella + clove oil at 10 ml.l^{-1} caused higher mortality of *H. antonii* adults at 6 days after treatment. However, the mortality percentage was not significantly different from lemongrass + clove oil at 10 ml.l^{-1} and citronella + clove oil at 5 ml.l^{-1} (Table 3).

Mortality of *H. antonii* nymphs

Citronella + clove oil increased mortality of *H. antonii* nymphs significantly up to 4 days after treatment compared to inert solution and control. However, the effect was insignificant compared to other mixture formulas (Table 4).

Oviposition deterrent and mortality of *H. antonii* adults of the EOs mixture treatment in comparison with commercial citronella

Citronella + clove oil and commercial citronella oil at 10 ml.l^{-1} repressed the number of laid egg up to 6 days after treatment significantly than other treatments (Table 5). However, the effect citronella + clove oil and commercial citronella oil at 10 ml.l^{-1} to mortality of *H. antonii* adults was insignificant compared to other treatments (Table 6).

Mortality of *H. antonii nymphs* of the EOs mixture treatment in comparison with commercial citronella oil

Up to 3 days after treatment, citronella + clove oil and commercial citronella oil formula at both concentrations enhanced *H. antonii* nymphs mortality significantly in the green house compared to inert solution and control (Table 7).

Table 2. The average number of egg laid by *H. antonii* adults after formula application.
Tabel 2. Rata-rata jumlah telur yang diletakkan imago H. antonii *setelah aplikasi formula.*

Treatments	Concentrations ($ml.l^{-1}$)	The average number of laid egg, days after treatment#			ER *
		2	4	6	
Citronella + clove oil EC	10	8.75 f	41.50 e	68.00 d	60.18
	5	17.75 def	63.25 cde	101.75 bcd	42.76
Lemongrass + clove oil EC	10	12.25 ef	57.25 de	91.25 cd	46.56
	5	28.25 cdef	67.25 cde	104.50 bcd	41.21
Citronella oil EC	10	37.00 abcd	96.75 abcd	151.75 abc	11.13
	5	41.75 abcd	103.25 abcd	156.25 abc	12.09
Lemongrass oil EC	10	38.50 abcd	105.50 abc	161.50 abc	5.42
	5	45.25 abcd	126.00 ab	187.00 ab	-5.20
Clove oil EC	10	29.25 cde	90.75 bcd	148.00 abc	13.32
	5	39.00 abcd	98.75 abcd	158.00 abc	11.11
Inert solution	10	47.25 abc	106.50 abc	170.75 ab	
	5	57.00 ab	113.75 abc	177.75 ab	
Control (water)		73.75 a	162.25 a	215.00 a	
CV (%)		11.23	7.66	8.81	

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5 %/*Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5 %*.
EC = Emulsifiable concentrate/*kepekatan teremulsi.*
ER = Effective repellency percentage/*persentasi repelensi efektif*.
# = 3 pairs of adults/*3 pasang serangga dewasa.*

Table 3**.** The average mortality of *H. antonii* adult after formula application.
Tabel 3. Rata-rata mortalitas imago H. antonii *setelah aplikasi formula.*

Treatments	Concentrations ($ml.l^{-1}$)	Mortality of adults (%), days after treatment		
		2*	4*	6*
Citronella + clove oil EC	10	41.67 a	54.17 a	79.17 a
	5	20.83 a	33.33 abc	58,33 ab
Lemongrass + clove oil EC	10	41.67 a	50.00 ab	62.50 ab
	5	20.83 a	33.33 abc	41.67 b
Citronella oil EC	10	16.67 a	25.00 abcd	50.00 ab
	5	12.50 a	20,83 abcd	41.67 b
Lemongrass oil EC	10	16.67 a	25.00 abcd	45.83 ab
	5	8.33 a	20.83 bcd	45.83 ab
Clove oil EC	10	20.83 a	29.17 abc	54.17 ab
	5	8.33 a	16.67 cd	33.33 bc
Inert solution	10	8.33 a	16.67 cd	33.33 bc
	5	0.00 a	12.50 cd	29.17 bc
Control (water)		0.00 a	0.00 d	8.33 c
CV (%)		5.06	3.87	3.89

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5 %/*Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5 %.*
EC = eMulsifiable concentrate/*kepekatan teremulsi.*
* = data were transformed by $\sqrt{x+1}$/*data ditransformasi dengan* $\sqrt{x+1}$.

Table 4. The average mortality of *H. antonii* nymphs after formula application.
Tabel 4. Rata-rata mortalitas imago H. antonii setelah aplikasi formula.

Treatments	Concentrations (ml.l^{-1})	Mortality of nymphs (%), days after treatment			
		1	2	3	4
Citronella + clove oil EC	10	72.50 f	72.50 f	72.50 f	72.50 f
	5	47.50 def	47.50 def	47.50 def	47.50 def
Lemongrass + clove oil EC	10	57.50 ef	60.00 ef	60.00 ef	60.00 ef
	5	42.50 cdef	42.50 cdef	42.50 cdef	42.50 cdef
Citronella oil EC	10	25.00 bcdef	27.50 bcdef	27.50 bcdef	27.50 bcdef
	5	12.50 abc	15.00 abcd	15.00 abcd	15.00 abcd
Lemongrass oil EC	10	12.50 abc	22.50 abcd	22.50 abcd	22.50 abcd
	5	2.50 ab	10.00 abc	10.00 abc	10.00 abc
Clove oil EC	10	17.50 abcde	17.50 abcde	17.50 abcde	20.00 abcde
	5	2.50 ab	5.00 ab	5.00 ab	5.00 ab
Inert solution	10	0.00 a	0.00 a	0.00 a	0.00 a
	5	0.00 a	0.00 a	0.00 a	0.00 a
Control (water)		0.0 a	0.00 a	0.00 a	0.00 a
CV (%)		2.29	3.41	3.37	3.37

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5 %/ *Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5%.*
EC = emulsifiable concentrate/*kepekatan teremulsi.*

Table 5. The average number of egg laid by *H. antonii* adults after formula application.
Tabel 5. Rata-rata jumlah telur yang diletakkan imago H. antonii *setelah aplikasi formula.*

Treatments	Concentrations (ml.l^{-1})	The average number of egg laid, days after treatment#			ER*
		2	4	6	
Citronella + clove oil EC	10	8.50 c	43.25 d	89.75 e	41.44
	5	10.75 c	57.00 cd	104.00 de	40.49
Commercial citronella oil EC	10	7.00 c	43.25 d	91 e	33.94
	5	15.75 bc	55.75 cd	113.75 cde	23.79
Inert solution of citronella + clove oil	10	41.00 ab	99.00 ab	153.25 bc	
	5	46.50 ab	113.00 ab	174.75 ab	
Inert solution of commercial citronella oil	10	21.00 bc	80.25 bc	137.75 bcd	
	5	34.00 ab	90.25 bc	149.25 bc	
Control (water)		81.50 a	158.25 a	215.50 a	
CV (%)		15.72	6.89	4.18	

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5 %/*Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5 %.*
EC = emulsifiable concentrate/*kepekatan teremulsi*
ER = effective repellency percentage/*persentasi repelensi efektif*
\# = 3 pairs of adults/*3 pasang serangga dewasa*

Table 6. The average mortality of *H. antonii* adults after formula application.
Tabel 6. Rata-rata mortalitas imago H. antonii *setelah aplikasi formula.*

Treatments	Concentrations ($ml.l^{-1}$)	Mortality of adults (%), days after treatment		
		2*	4*	6*
Citronella + clove oil EC	10	20.83 a	25.00 a	37.50 a
	5	12.50 a	12.50 a	20.83 a
Commercial citronella oil EC	10	16.67 a	20.83 a	37.50 a
	5	12.50 a	12.50 a	20.83 a
Inert solution of citronella + clove oil	10	4.17 a	8.33 a	16.67 a
	5	4.17 a	4.17 a	12.50 a
Inert solution of commercial citronella oil	10	16.67 a	16.67 a	25.00 a
	5	8.33 a	12.50 a	16.67 a
Control (water)		0.00 a	0.00 a	4.17 a
CV (%)		3.05	3.57	4.46

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5 %/*Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5 %.*
EC = emulsifiable concentrate/*kepekatan teremulsi*
* = data were transformed by $\sqrt{x+1}$/*data ditransformasi dengan* $\sqrt{x+1}$

Table 7. The average mortality of *H. antonii* nymphs after formula application.
Tabel 7. Rata-rata mortalitas imago H. antonii *setelah aplikasi formula.*

Treatments	Concentrations ($ml.l^{-1}$)	Mortality of nymphs (%), days after treatment		
		1	2	3
Citronella + clove oil EC	10	87.50 c	87.50 d	87.50 d
	5	42.50 bc	55.00 bcd	55.00 bcd
Commercial citronella oil EC	10	75.00 c	82.50 cd	82.50 cd
	5	35.00 bc	35.00 bcd	35.00 bcd
Inert solution of citronella + clove oil	10	10.00 ab	10.00 ab	10.00 ab
	5	0.00 a	0.00 a	0.00 a
Inert solution of commercial citronella oil	10	17.50 ab	20.00 abc	20.00 abc
	5	10.00 ab	10.00 ab	10.00 ab
Control (water)		0.00 a	0.00 a	0.00 a
CV (%)		3.43	3.93	3.93

Note/*Keterangan* : Numbers followed by the same letters in the same column were not significantly different at DMRT 5%./*Angka-angka yang diikuti oleh huruf yang sama pada kolom yang sama tidak berbeda nyata pada taraf DMRT 5%.*
EC = emulsifiable concentrate/*kepekatan teremulsi*

CONCLUSION

The emulsifiable formula of citronella + clove and lemongrass + clove were effective to enhance oviposition deterrent and mortality of *H. antonii* nymphs and adult. The formula of citronella + clove oil was as effective as the commercial citronella oil formula. The field trial of these formulas is required to validate their effectiveness to control *H. antonii* in the field.

ACKNOWLEDGMENTS

The authors acknowledged Ir. Rodiah Balfas, M.Sc. for her ideas and suggestions, Sondang Suriati, Ahyar and Endang Sugandi for technical assistance during this study.

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