

Acaricidal Activity of the Combination of Plant Crude-extracts to Tropical Cattle Ticks

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ABSTRACT

Thirty four ethanol crude-extracts of plant species were studied the acaricidal activity of the two combined crude-extracts to the engorged female tropical cattle tick (*Boophilus microplus*). The concentration of crude-extract was 2.5% in mixed solution of 9 parts of 1% Tween 80® and 1 part of 100% ethanol. The acaricidal activity of the combined crude-extracts were tested by dipping method and observed the corrected mortality of the ticks after dipping 24 h, 48 h and 7 days. The acute acaricidal activity were highly found in the combined crude-extracts as follows; *Aganonerion polymorphum* Pierre ex Spire (Som-lom) with *Calotropis procera* R.Br. (Rak-dok-khaao), *A. polymorphum* with *Anethum graveolens* L. (Phak-chee-lao); *C. procera* with *Pentapetes phoenicia* L. (Po-seng). The delayed acaricidal activity were highly exhibited in the combined crude-extracts of *A. polymorphum* with *Calotropis gigantea* R.Br. (Rak-dok-muang), *A. polymorphum* with *Cryptostegia grandiflora* R.Br. (Baan-buree-muang), *A. polymorphum* with *Ixora nigricans* Wight & Arn. (Lum-phuk), *C. gigantea* with *C. grandiflora*, *C. gigantea* with *P. phoenicia*, *I. nigricans* with *A. graveolens*, and *Annona muricata* L. (Thu-rian-thet) with *Piper nigrum* L. (Phrik-thai-dam).

This results indicated that the practical application of the combination of two crude-extracts of these common plants to control the tropical cattle tick is possible.

Key words: acaricidal activity, combined plant crude-extracts, tropical cattle ticks

INTRODUCTION

The original structure of new acaricidal substances are derived from plants and further synthesized the effective derivatives for their delay degradation. Thus the synthetic acaricides will remain residue in agricultural environment and induce resistant strains of ticks (Drummond, 1977). Therefore, the direct application of the effective plant crude-extracts against the tick is our aims. However, the reports of effective acaricidal activity of plant crude-extracts against ticks have been minimal (Grainge and Ahmed, 1988). Our previous study to the tropical cattle tick (*Boophilus microplus*) had also shown some plant crude-extracts that exhibit the strong acaricidal activity (Chungsamarnyart *et al.*, 1988; 1990 a; 1991 a, b, c; Chungsamarnyart and Jiwajinda, 1992; Chungsamarnyart and Jansawan, 1993). The combination

of two plant crude-extracts were studied to find out the synergistic acaricidal crude-extracts. The present study showed the acaricidal activity of the combination of two ethanol crude-extracts of various kinds of local plants.

MATERIALS AND METHODS

Thirty four plant species were extracted by 95% ethanol and evaporated the ethanol being the crude-extracts. These plants were leaves of *Acacia harmandiana* Gagnep, *Cyperus rotundus* L., *Kalanchoe pinnata* Lamk., *Melia azedarach* L., *Maerua siamensis* Pax., *Premna latifolia* Roxb., *Thunbergia erecta* T. Anders.; the leaves and stems of *Aganonerion polymorphum* Pierre ex Spire, *Anethum graveolens* L., *Calotropis gigantea* R.Br., *Calotropis procera* R.Br., *Ixora nigricans* Wight & Arn., *Pentapetes phoenicea* L., *Spilanthes acmella*

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Murr., *Streblus asper* Lour.; leaves and branches of *Cratogeomys magna* DC., *Polyscias balfouriana* Baill., *Rhinacanthus nasutus* Kurz., *Thunbergia laurifolia* Lindl.; leaves and flowers of *Polygonum tomentosum* Willd.; leaves, stem and flowers of *Mimosa invisa* Mart ex Colla; flowers of *Cryptostegia grandiflora* R.Br., *Malvaviscus pilosus* DC.; seeds of *Annona muricata* L., *Cucurbita moschata* Decne., *Momordica charantia* L., *Piper nigrum* L.; fruits of *Caryota mitis* Lour., *Datura metel* L.; rhizomes of *Alpinia officinarum* Hance., *Homalomena aromatica* Schott., *Rauwolfia serpentina* Benth. ex Kurz; and whole plants of *Dactyloctenium aegyptiacum* Willd., *Lagascea mollis* Cav. Each crude-extract was diluted into 2.5% in mixed solution of 9 parts of 1% Tween 80® and 1 part of 100% ethanol. Two kinds of diluted crude-extracts (2.5%) were equally mixed and tested the acaricidal activity to the engorged female tropical cattle ticks by dipping method. The mortality of the ticks was observed at 24 h, 48 h and 7 days mark after dipping (Chungsamarnyart, *et al.*, 1990 b). At 5-7 days after dipping, the alive ticks were fully lay many eggs. The control group of ticks was dipping into the solution for diluting the crude-extracts. Abbott's formula (Abbott, 1925) was used to calculate the corrected mortality of ticks. This result of the corrected mortality of ticks was the mean (%) of 5 replications (20 adult ticks/replication).

RESULTS

The combination of 2.5% of crude-extracts of *Calotropis procera* (No.19) with *Aganonerion polymorphum* (No.143) (Table 1) and *A. polymorphum* (No.143) with *Anethum graveolens* (No.155) (Table 5) were showed the highest corrected mortality of ticks (71 and 68%, respectively) at 24 h after dipping. At 48 h after dipping, these two combination crude-extracts were exhibited much higher corrected mortality of ticks (83 and 87%, respectively). In addition, the combination of *C. procera* (No.19) and *Pentapetes phoenicea* (No.247) was also showed the high corrected mortality of ticks (89%) at 48h after dipping (Table 1). These high corrected mortality of ticks within 48 h after dipping were classified to be the acute acaricidal activity. The acaricidal activity during on 3-7 days after dipping was classified to be the delayed acaricidal activity.

At 7 days after dipping, the combination of crude-extracts that mentioned above were still exhibiting higher mortality of ticks (Table 1 and 5) as high as the following combination of crude-extracts of *Calotropis gigantea* (No.20) and *Aganonerion polymorphum* (No.143), *C. gigantea* and *Cryptostegia grandiflora* (No. 85), *C. gigantea* and *Pentapetes phoenicea* (No.247) (Table 1); *Cryptostegia grandiflora* and *A. polymorphum* (Table 3); *Ixora nigricans* (No. 139) and *A. polymorphum*, *I. nigricans* and *Anethum graveolens* (No. 155) (Table 5); and *Annona muricata* (No. 163) and *Piper nigrum* (No. 290) (Table 6).

Table 1 Acaricidal effects of 2.5% of *Calotropis procera* R.Br. and *Calotropis gigantea* R.Br. crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
19	<i>Calotropis procera</i> (Rak-dok-muang)	5 fg	12 fghijklm	46 fghi
19+20	<i>C. procera</i> + <i>Calotropis gigantea</i>	0 g	1 mn	78 cde
20	<i>Calotropis gigantea</i> (Rak-dok-khaao)	8 ef	16 efghij	31 jklm
19+44	<i>C. procera</i> + <i>Lagascea mollis</i>	3 fg	12 fghijklm	23 lmnpq
20+44	<i>C. gigantea</i> + <i>Lagascea mollis</i>	0 g	0 n	9 rstu
44	<i>Lagascea mollis</i> Cav. (Yaa-kam-ma-yeei)	1 fg	2 mn	3 stu
19+57	<i>C. procera</i> + <i>Dactyloctenium aegyptiacum</i>	0 g	0 n	0 u
20+57	<i>C. gigantea</i> + <i>Dactyloctenium aegyptiacum</i>	0 g	0 n	16 nopqrs
57	<i>Dactyloctenium aegyptiacum</i> Willd. (Yaa-paak-khwaai)	0 g	0 n	4 stu
19+85	<i>C. procera</i> + <i>Cryptostegia grandiflora</i>	1 fg	3 lmn	3 stu
20+85	<i>C. gigantea</i> + <i>Cryptostegia grandiflora</i>	14 de	77 b	84 bcd
85	<i>Cryptostegia grandiflora</i> R.Br. (Baan-buree-muang)	0 g	5 jklmn	21 lmnpqr
19+104	<i>C. procera</i> + <i>Maerua siamensis</i>	0 g	10 ghijklmn	26 jklmno
20+104	<i>C. gigantea</i> + <i>Maerua siamensis</i>	8 ef	17 efghi	71 de
104	<i>Maerua siamensis</i> Pax. (Jaeng)	1 fg	1 mn	5 stu
19+111	<i>C. procera</i> + <i>Premna latifolia</i>	0 g	0 n	14 opqrst
20+111	<i>C. gigantea</i> + <i>Premna latifolia</i>	0 g	1 mn	5 stu

Table 1 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
111	<i>Premna latifolia</i> Roxb. (Muu-man)	0 g	20 efgh	46 fghi
19+121	<i>C. procera</i> + <i>Polyscias balfouriana</i>	0 g	1 mn	12 pqrstu
20+121	<i>C. gigantea</i> + <i>Polyscias balfouriana</i>	3 fg	8 ijklmn	28 jklmn
121	<i>Polyscias balfouriana</i> Baill. (Lep-khrut)	6 fg	26 ef	67 e
19+122	<i>C. procera</i> + <i>Thunbergia erecta</i>	0 g	2 mn	25 klmnop
20+122	<i>C. gigantea</i> + <i>Thunbergia erecta</i>	0 g	1 mn	46 fghi
122	<i>Thunbergia erecta</i> T. Anders. (Chong-naang)	0 g	10 ghijklmn	50 fgh
19+139	<i>C. procera</i> + <i>Ixora nigricans</i>	3 fg	4 klmn	8 rstu
20+139	<i>C. gigantea</i> + <i>Ixora nigricans</i>	27 c	54 c	78 cde
139	<i>Ixora nigricans</i> Wight & Arn. (Lum-phuk)	0 g	0 n	0 u
19+140	<i>C. procera</i> + <i>Crateva magna</i>	4 fg	8 ijklmn	29 jklmn
20+140	<i>C. gigantea</i> + <i>Crateva magna</i>	1 fg	3 lm	37 hijk
140	<i>Crateva magna</i> DC. (Kaam)	2 fg	8 ijklmn	20 mnopqr
19+143	<i>C. procera</i> + <i>Aganonerion polymorphum</i>	71 a	83 ab	98 a
20+143	<i>C. gigantea</i> + <i>Aganonerion polymorphum</i>	18 d	58 c	94 ab
143	<i>Aganonerion polymorphum</i> Pierre ex Spire. (Som-lom)	4 fg	21 efg	39 ghij
19+148	<i>C. procera</i> + <i>Streblus asper</i>	0 g	3 lm	9 rstu
20+148	<i>C. gigantea</i> + <i>Streblus asper</i>	0 g	0 n	34 ijkl
148	<i>Streblus asper</i> Lour. (Khoi)	0 g	0 n	4 stu
19+155	<i>C. procera</i> + <i>Anethum graveolens</i>	19 d	23 ef	69 e
20+155	<i>C. gigantea</i> + <i>Anethum graveolens</i>	3 fg	21 efg	52 fg
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 fg	1 mn	31 jklm
19+247	<i>C. procera</i> + <i>Pentapetes phoenicea</i>	55 b	89 a	100 a
20+247	<i>C. gigantea</i> + <i>Pentapetes phoenicea</i>	19 d	72 b	88 abc
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	1 fg	10 ghijklmn	25 klmnop
19+262	<i>C. procera</i> + <i>Alpinia officinarum</i>	0 g	9 ijklmn	53 f
262	<i>Alpinia officinarum</i> Hance (Khaa-taa-daeng)	0 g	2 mn	8 rstu
19+263	<i>C. procera</i> + <i>Cucurbita moschata</i>	1 fg	6 ijklmn	12 pqrstu
20+263	<i>C. gigantea</i> + <i>Cucurbita moschata</i>	4 fg	6 ijklmn	13 opqrstu
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 fg	2 mn	11 qrstu
19+264	<i>C. procera</i> + <i>Momordica charantia</i>	2 fg	2 mn	8 rstu
20+264	<i>C. gigantea</i> + <i>Momordica charantia</i>	0 g	0 n	32 jklm
264	<i>Momordica charantia</i> L. (Ma-ra)	0 g	0 n	5 stu
19+276	<i>C. procera</i> + <i>Malvaviscus pilosus</i>	0 g	0 n	8 rstu
20+276	<i>C. gigantea</i> + <i>Malvaviscus pilosus</i>	4 fg	14 fghijkl	37 hijk
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 fg	2 mn	2 tu
19+279	<i>C. procera</i> + <i>Cyperus rotundus</i>	5 fg	15 fghijk	50 fgh
20+279	<i>C. gigantea</i> + <i>Cyperus rotundus</i>	14 de	27 e	72 de
279	<i>Cyperus rotundus</i> L. (Hao-muu)	0 g	0 n	4 stu
19+287	<i>C. procera</i> + <i>Spilanthes acmella</i>	0 g	9 ijklmn	23 lmnopq
20+287	<i>C. gigantea</i> + <i>Spilanthes acmella</i>	18 d	40 d	71 de
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 g	3 lm	9 rstu
19+288	<i>C. procera</i> + <i>Rauwolfia serpentina</i>	0 g	6 ijklmn	21 lmnopqr
20+288	<i>C. gigantea</i> + <i>Rauwolfia serpentina</i>	0 g	3 lm	39 ghij
288	<i>Rauwolfia serpentina</i> Benth. ex Kurz (Ra-yoam)	3 fg	8 ijklmn	23 lmnopq

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 11.5500; 3 LSD .05 = 7.4925; 4 LSD .05 = 13.3863

Table 2 Acaricidal effects of 2.5% of *Lagascea mollis* Cav., *Dactyloctenium aegyptiacum* Willd. and *Polygonum tomentosum* W. crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
44	<i>Lagascea mollis</i> Cav. (Yaa-kam-ma-yeei)	1 de	2 ij	3 pqr
44+57	<i>L. mollis</i> + <i>Dactyloctenium aegyptiacum</i>	0 e	1 ij	8 mnopqr
57	<i>Dactyloctenium aegyptiacum</i> Willd. (Yaa-paak-khwaai)	0 e	0 j	4 pqr
44+74	<i>L. mollis</i> + <i>Polygonum tomentosum</i>	0 e	3 hij	23 ghij
74	<i>Polygonum tomentosum</i> W. (Oueang-pet-maa)	0 e	0 j	22 hijk
44+85	<i>L. mollis</i> + <i>Cryptostegia grandiflora</i>	0 e	1 ij	7 nopqr
57+85	<i>D. aegyptiacum</i> + <i>Cryptostegia grandiflora</i>	0 e	0 j	6 nopqr
74+85	<i>P. tomentosum</i> + <i>Cryptostegia grandiflora</i>	3 cd	21 bc	53 c
85	<i>Cryptostegia grandiflora</i> R.Br. (Baan-buree-muang)	0 e	5 ghij	21 hijkl
44+99	<i>L. mollis</i> + <i>Melia azedarach</i>	2 cde	11 efg	18 ijklmn
99	<i>Melia azedarach</i> L. (Lian)	0 e	0 j	4 pqr
44+104	<i>L. mollis</i> + <i>Maerua siamensis</i>	0 e	2 ij	21 hijkl
57+104	<i>D. aegyptiacum</i> + <i>Maerua siamensis</i>	1 de	6 fghij	46 cde
104	<i>Maerua siamensis</i> Pax. (Jaeng)	1 de	1 ij	5 opqr
44+111	<i>L. mollis</i> + <i>Premna latifolia</i>	0 d	4 ghij	16 ijklmnop
57+111	<i>D. aegyptiacum</i> + <i>Premna latifolia</i>	0 e	1 ij	16 ijklmnop
111	<i>Premna latifolia</i> Roxb. (Muu-man)	0 e	20 bcd	46 cde
44+121	<i>L. mollis</i> + <i>Polyscias balfouriana</i>	0 e	7 fghij	25 ghi
57+121	<i>D. aegyptiacum</i> + <i>Polyscias balfouriana</i>	0 e	3 hij	25 ghi
121	<i>Polyscias balfouriana</i> Baill. (Lep-khrut)	6 b	26 ab	67 ab
44+122	<i>L. mollis</i> + <i>Thunbergia erecta</i>	1 de	7 fghij	32 fgh
57+122	<i>D. aegyptiacum</i> + <i>Thunbergia erecta</i>	3 cd	11 efg	72 a
122	<i>Thunbergia erecta</i> T. Anders. (Chong-naang)	0 e	10 efgh	50 cd
44+139	<i>L. mollis</i> + <i>Ixora nigricans</i>	0 e	0 j	17 ijklmno
139	<i>Ixora nigricans</i> Wight & Arn. (Lum-phuk)	0 e	0 j	0 r
44+140	<i>L. mollis</i> + <i>Crateva magna</i>	0 e	1 ij	8 mnopqr
57+140	<i>D. aegyptiacum</i> + <i>Crateva magna</i>	1 de	8 fghi	35 efg
140	<i>Crateva magna</i> DC. (Kaam)	2 cde	8 fghi	20 hijklm
44+143	<i>L. mollis</i> + <i>Aganonerion polymorphum</i>	0 e	0 j	6 nopqr
143	<i>Aganonerion polymorphum</i> Pierr ex Spire. (Som-lom)	4 bc	21 bc	39 def
44+144	<i>L. mollis</i> + <i>Thunbergia laurifolia</i>	0 e	0 j	11 jklmnopqr
144	<i>Thunbergia laurifolia</i> Lindl. (Raang-juet)	0 e	6 fghij	8 mnopqr
44+148	<i>L. mollis</i> + <i>Streblus asper</i>	0 e	1 ij	9 lmnopqr
57+148	<i>D. aegyptiacum</i> + <i>Streblus asper</i>	0 e	1 ij	5 opqr
148	<i>Streblus asper</i> Lour. (Khoi)	0 e	0 j	4 pqr
44+155	<i>L. mollis</i> + <i>Anethum graveolens</i>	0 e	1 ij	12 jklmnopqr
57+155	<i>D. aegyptiacum</i> + <i>Anethum graveolens</i>	0 d	0 j	16 ijklmnop
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 de	1 ij	31 fgh
44+161	<i>L. mollis</i> + <i>Rhinacanthus nasutus</i>	0 e	2 ij	15 ijklmnop
161	<i>Rhinacanthus nasutus</i> Kurz. (Thong-pan-chang)	0 e	0 j	9 lmnopqr
44+163	<i>L. mollis</i> + <i>Annona muricata</i>	2 cde	13 def	49 cd
163	<i>Annona muricata</i> L. (Thu-rian-thet)	6 b	16 cde	53 c
44+247	<i>L. mollis</i> + <i>Pentapetes phoenicea</i>	11 a	31 a	56 bc
57+247	<i>D. aegyptiacum</i> + <i>Pentapetes phoenicea</i>	0 e	5 ghij	18 ijklmn
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	0 e	10 efgh	25 ghi
44+262	<i>L. mollis</i> + <i>Alpinia officinarum</i>	0 e	0 j	11 ijklmnopqr
57+262	<i>D. aegyptiacum</i> + <i>Alpinia officinarum</i>	0 e	1 ij	14 ijklmnopq

Table 2 Cont

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
262	<i>Alpinia officinarum</i> Hance (Khaa-taa-daeng)	0 e	2 ij	8 mnopqr
44+263	<i>L. mollis</i> + <i>Cucurbita moschata</i>	0 e	0 j	8 mnopqr
57+263	<i>D. aegyptiacum</i> + <i>Cucurbita moschata</i>	0 e	0 j	14 ijklmnopq
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 cde	2 ij	11 jklmnopqr
44+264	<i>L. mollis</i> + <i>Momordica charantia</i>	1 de	5 ghij	17 ijklmno
57+264	<i>D. aegyptiacum</i> + <i>Momordica charantia</i>	1 de	6 fghij	16 ijklmnop
264	<i>Momordica charantia</i> L. (Ma-ra)	0 e	0 j	5 opqr
44+276	<i>L. mollis</i> + <i>Malvaviscus pilosus</i>	0 e	1 ij	12 jklmnopqr
57+276	<i>D. aegyptiacum</i> + <i>Malvaviscus pilosus</i>	2 cde	11 efg	35 efg
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 cde	2 ij	2 qr
44+279	<i>L. mollis</i> + <i>Cyperus rotundus</i>	0 e	0 j	0 r
57+279	<i>D. aegyptiacum</i> + <i>Cyperus rotundus</i>	0 e	0 j	9 lmnopqr
279	<i>Cyperus rotundus</i> L. (Hao-muu)	0 e	0 j	4 pqr
44+287	<i>L. mollis</i> + <i>Spilanthes acmella</i>	1 de	2 ij	16 ijklmnop
57+287	<i>D. aegyptiacum</i> + <i>Spilanthes acmella</i>	0 e	0 j	1 r
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 e	3 hij	9 lmnopqr
44+288	<i>L. mollis</i> + <i>Rauwolfia serpentina</i>	0 e	1 ij	9 lmnopqr
57+288	<i>D. aegyptiacum</i> + <i>Rauwolfia serpentina</i>	1 de	1 ij	10 klmnopqr
288	<i>Rauwolfia serpentina</i> Benth. ex Kurz (Ra-yoam)	3 cd	8 fghij	23 ghij
44+290	<i>L. mollis</i> + <i>Piper nigrum</i>	2 cde	17 cde	35 efg
290	<i>Piper nigrum</i> L. (Phrik-thai-dam)	0 e	0 j	7 nopqr

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 2.8916; 3 LSD .05 = 7.1543; 4 LSD .05 = 12.3253

Table 3 Acaricidal effects of 2.5% plant crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
64	<i>Datura metel</i> L. (Lam-phong)	0 f	6 mnopq	17 pqrstuvw
64+85	<i>C. grandiflora</i> + <i>Datura metel</i>	0 f	2 opq	13 rstuvwxy
64+161	<i>D. metel</i> + <i>Rhinacanthus nasutus</i>	1 ef	5 mnopq	21 nopqrstu
64+247	<i>D. metel</i> + <i>Pentapetes phoenicea</i>	0 f	6 mnopq	20 opqrstu
74	<i>Polygonum tomentosum</i> Willd. (Oueang-pet-maa)	0 f	0 q	22 mnopqrst
74+85	<i>C. grandiflora</i> + <i>Polygonum tomentosum</i>	3 def	22 defg	53 efg
74+161	<i>P. tomentosum</i> + <i>Rhinacanthus nasutus</i>	0 f	15 ghijkl	31 klmno
74+163	<i>P. tomentosum</i> + <i>Annona muricata</i>	4 def	31 c	58 defg
74+247	<i>P. tomentosum</i> + <i>Pentapetes phoenicea</i>	0 f	19 efghi	28 klmnopq
74+291	<i>P. tomentosum</i> + <i>Homalomena aromatica</i>	2 ef	12 hijklm	39 hijk
85	<i>Cryptostegia grandiflora</i> R.Br. (Baan-buree-muang)	0 f	5 mnopq	21 nopqrstu
85+91	<i>C. grandiflora</i> + <i>Caryota mitis</i>	10 bc	30 cd	62 cdef
91	<i>Caryota mitis</i> Lour. (Tao-raang-daeng)	0 f	0 q	5 wxy
85+99	<i>C. grandiflora</i> + <i>Melia azedarach</i>	0 f	4 mnopq	32 klmno
99	<i>Melia azedarach</i> L. (Lian)	0 f	0 q	4 wxy
85+104	<i>C. grandiflora</i> + <i>Maerua siamensis</i>	0 f	3 nopq	53 efg
104	<i>Maerua siamensis</i> Pax. (Jaeng)	1 ef	1 pq	5 wxy
85+111	<i>C. grandiflora</i> + <i>Premna latifolia</i>	0 f	12 hijklm	15 qrstuvw
111	<i>Premna latifolia</i> Roxb. (Muu-man)	0 f	20 efgh	46 ghij

Table 3 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
85+121	<i>C. grandiflora</i> + <i>Polyscias balfouriana</i>	0 f	0 g	30 klmnop
121	<i>Polyscias balfouriana</i> Baill (Lep-krut)	6 bcde	26 cdef	67 bcd
85+122	<i>C. grandiflora</i> + <i>Thunbergia erecta</i>	0 f	7 lmnopq	33 jklmno
122	<i>Thunbergia erecta</i> T. Anders. (Chong-naang)	0 f	10 jklmno	50 fgh
85+139	<i>C. grandiflora</i> + <i>Ixora nigricans</i>	0 f	4 mnopq	30 klmnop
139	<i>Ixora nigricans</i> Wight & Arn. (Lum-phuk)	0 f	0 q	0 y
85+140	<i>C. grandiflora</i> + <i>Crateva magna</i>	0 f	4 mnopq	35 ijklm
140	<i>Crateva magna</i> DC. (Kaam)	2 ef	8 klmnopq	20 opqrstuv
85+143	<i>C. grandiflora</i> + <i>Aganonerion polymorphum</i>	54 a	67 a	92 a
143	<i>Aganonerion polymorphum</i> Pierr ex Spire (Som-lom)	4 def	21 efg	39 hijk
85+144	<i>C. grandiflora</i> + <i>Thunbergia laurifolia</i>	0 f	5 mnopq	27 klmnopq
144	<i>Thunbergia laurifolia</i> Lindl. (Raang-juet)	0 f	6 mnopq	8 uvwxy
85+148	<i>C. grandiflora</i> + <i>Streblus asper</i>	0 f	0 q	9 tuvwxxy
148	<i>Streblus asper</i> Lour. (Khoi)	0 f	0 q	4 wxy
85+155	<i>C. grandiflora</i> + <i>Anethum graveolens</i>	0 f	0 q	11 stuvwxxy
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 ef	1 pq	31 klmno
85+161	<i>C. grandiflora</i> + <i>Rhinacanthus nasutus</i>	0 f	12 hijklm	34 ijklmn
161	<i>Rhinacanthus nasutus</i> Kurz. (Thong-phan-chang)	0 f	0 q	9 tuvwxxy
85+163	<i>C. grandiflora</i> + <i>Annona muricata</i>	1 ef	5 mnopq	17 pqrstuvw
163	<i>Annona muricata</i> L. (Thu-rian-thet)	6 bcde	16 ghijk	53 efg
85+247	<i>C. grandiflora</i> + <i>Pentapetes phoenicea</i>	11 b	40 b	77 b
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	0 f	10 jklmno	25 lmnopqr
85+262	<i>C. grandiflora</i> + <i>Alpinia officinarum</i>	0 f	0 q	12 rstuvwxxy
262	<i>Alpinia officinarum</i> Hance (Khaa-taa-daeng)	0 f	2 opq	8 uvwxy
85+263	<i>C. grandiflora</i> + <i>Cucurbita moschata</i>	0 f	2 opq	25 lmnopqr
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 ef	2 opq	11 stuvwxxy
85+264	<i>C. grandiflora</i> + <i>Momordica charantia</i>	1 ef	3 nopq	6 wxy
264	<i>Momordica charantia</i> L. (Ma-ra)	0 f	0 q	5 wxy
85+272	<i>C. grandiflora</i> + <i>Acacia harmandiana</i>	2 ef	6 mnopq	16 qrstuvw
272	<i>Acacia harmandiana</i> Gagnep. (Kra-thin-phi-maan)	2 ef	10 jklmno	47 ghi
85+276	<i>C. grandiflora</i> + <i>Malvaviscus pilosus</i>	5 cdef	18 fghij	72 bc
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 ef	2 opq	2 xy
85+279	<i>C. grandiflora</i> + <i>Cyperus rotundus</i>	5 cdef	9 klmnop	37 hijkl
279	<i>Cyperus rotundus</i> L. (Haeo-muu)	0 f	0 q	4 wxy
85+287	<i>C. grandiflora</i> + <i>Spilanthes acmella</i>	0 f	11 ijklmn	31 klmno
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 f	3 nopq	9 tuvwxxy
85+288	<i>C. grandiflora</i> + <i>Rauwolfia serpentina</i>	1 ef	4 mnopq	5 wxy
288	<i>Rauwolfia serpentina</i> Benth. ex Kurz (Ra-yoam)	3 def	8 klmnopq	23 mnopqrs
85+290	<i>C. grandiflora</i> + <i>Piper nigrum</i>	0 f	3 nopq	4 wxy
290	<i>Piper nigrum</i> L. (Phrik-thai-dam)	0 f	0 q	7 vwxy
85+291	<i>C. grandiflora</i> + <i>Homalomena aromatica</i>	2 ef	9 klmnop	21 nopqrstu
291	<i>Homalomena aromatica</i> Schott. (Tao-kiat)	5 edef	27 cde	64 bcde
91+272	<i>C. mitis</i> + <i>Acacia harmandiana</i>	1 ef	2 opq	25 lmnopqr
91+290	<i>C. mitis</i> + <i>Piper nigrum</i>	1 ef	6 mnopq	16 qrstuvw
91+296	<i>C. mitis</i> + <i>Mimosa invisa</i>	1 ef	3 nopq	9 tuvwxxy
99+161	<i>M. azedarach</i> + <i>Rhinacanthus nasutus</i>	0 f	0 q	25 lmnopqr
99+272	<i>M. azedarach</i> + <i>Acacia harmandiana</i>	3 def	6 mnopq	9 tuvwxxy
99+296	<i>M. azedarach</i> + <i>Mimosa invisa</i>	0 f	2 opq	17 pqrstuvw
296	<i>Mimosa invisa</i> Mart ex Colla (Mai-ya-raap-rai-naam)	8 bcd	12 hijklm	39 hijk

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 5.7636; 3 LSD .05 = 8.7460; 4 LSD .05 = 13.6540

Table 4 Acaricidal effects of 2.5% of *Maerua siamensis* Pax., *Premna latifolia* Roxb., *Polyscias balfouriana* Baill. and *Thunbergia erecta* T. Anders. crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
104	<i>Maerua siamensis</i> Pax. (Jaeng)	1 ef	1 gh	5 yzABC
104 + 111	<i>M. siamensis</i> + <i>Premna latifolia</i>	0 f	1 gh	19 lmnopqrstuvwxyz
111	<i>Premna latifolia</i> Roxb. (Muu-man)	0 f	20 abc	46 bcd
104 + 121	<i>M. siamensis</i> + <i>Polyscias balfouriana</i>	7 a	18 bc	32 efghijkl
111 + 121	<i>P. latifolia</i> + <i>Polyscias balfouriana</i>	0 f	4 efgh	36 cdefgh
121	<i>Polyscias balfouriana</i> Baill. (Lep-krut)	6 ab	26 a	67 a
104 + 122	<i>M. siamensis</i> + <i>Thunbergia erecta</i>	0 f	2 fgh	22 ijklmnopqrstu
111 + 122	<i>P. latifolia</i> + <i>Thunbergia erecta</i>	2 def	10 de	24 ghijklmnopqrs
121 + 122	<i>P. balfouriana</i> + <i>Thunbergia erecta</i>	1 ef	4 efgh	29 efghijklmno
122	<i>Thunbergia erecta</i> (Chong-naang)	0 f	10 de	50 b
104 + 139	<i>M. siamensis</i> + <i>Ixora nigricans</i>	0 f	2 fgh	7 wxyzABC
111 + 139	<i>P. latifolia</i> + <i>Ixora nigricans</i>	0 f	0 h	26 efghijklmnopq
121 + 139	<i>P. balfouriana</i> + <i>Ixora nigricans</i>	0 f	1 gh	16 opqrstuvwxyzA
122 + 139	<i>T. erecta</i> + <i>Ixora nigricans</i>	0 f	2 fgh	28 efghijklmnop
139	<i>Ixora nigricans</i> Wight & Arn. (Lum-phuk)	0 f	0 h	0 C
104 + 140	<i>M. siamensis</i> + <i>Crateva magna</i>	0 f	2 fgh	18 mnopqrstuvwxyz
111 + 140	<i>P. latifolia</i> + <i>Crateva magna</i>	0 f	3 efgh	30 efghijklmn
121 + 140	<i>P. balfouriana</i> + <i>Crateva magna</i>	0 f	0 h	16 opqrstuvwxyzA
122 + 140	<i>T. erecta</i> + <i>Crateva magna</i>	0 f	0 h	10 tuvxyzABC
140	<i>Crateva magna</i> DC. (Kaam)	2 def	8 defg	20 klmnopqrstuvwxyz
104 + 143	<i>M. siamensis</i> + <i>Aganonerion polymorphum</i>	1 ef	3 efgh	6 xyzABC
111 + 143	<i>P. latifolia</i> + <i>Aganonerion polymorphum</i>	2 def	5 efgh	17 nopqrstuvwxyz
121 + 143	<i>P. balfouriana</i> + <i>Aganonerion polymorphum</i>	0 f	0 h	2 BC
122 + 143	<i>T. erecta</i> + <i>Aganonerion polymorphum</i>	1 ef	4 efgh	21 jklmnopqrstuv
143	<i>Aganonerion polymorphum</i> Pierre ex Spire (Som-lom)	4 bcd	21 ab	39 bcde
111 + 144	<i>P. latifolia</i> + <i>Thunbergia laurifolia</i>	0 f	6 defgh	27 efghijklmnop
121 + 144	<i>P. balfouriana</i> + <i>Thunbergia laurifolia</i>	0 f	7 defgh	22 ijklmnopqrstu
122 + 144	<i>T. erecta</i> + <i>Thunbergia laurifolia</i>	0 f	3 efgh	9 uvxyzABC
144	<i>Thunbergia laurifolia</i> Lindl. (Rang-juet)	0 f	6 defgh	8 wxyzABC
104 + 148	<i>M. siamensis</i> + <i>Streblus asper</i>	2 def	4 efgh	24 ghijklmnopqrs
111 + 148	<i>P. latifolia</i> + <i>Streblus asper</i>	0 f	2 fgh	13 rstuvwxyzABC
121 + 148	<i>P. balfouriana</i> + <i>Streblus asper</i>	0 f	4 efgh	16 opqrstuvwxyzA
122 + 148	<i>T. erecta</i> + <i>Streblus asper</i>	1 ef	6 defgh	37 bcdefg
148	<i>Streblus asper</i> Lour. (Khoi)	0 f	0 h	4 zABC
104 + 155	<i>M. siamensis</i> + <i>Anethum graveolens</i>	2 def	10 de	30 efghijklmn
111 + 155	<i>P. latifolia</i> + <i>Anethum graveolens</i>	1 ef	7 defgh	29 efghijklmno
121 + 155	<i>P. balfouriana</i> + <i>Anethum graveolens</i>	0 f	1 gh	20 klmnopqrstuvwxyz
122 + 155	<i>T. erecta</i> + <i>Anethum graveolens</i>	0 f	3 efgh	26 efghijklmnopq
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 ef	1 gh	31 efghijklm
104 + 247	<i>M. siamensis</i> + <i>Pentapetes phoenicea</i>	0 f	5 efgh	36 cdefgh
111 + 247	<i>P. latifolia</i> + <i>Pentapetes phoenicea</i>	1 ef	5 efgh	23 hijklmnopqrst
121 + 247	<i>P. balfouriana</i> + <i>Pentapetes phoenicea</i>	0 f	4 efgh	12 rstuvwxyzABC
122 + 247	<i>T. erecta</i> + <i>Pentapetes phoenicea</i>	1 ef	9 def	50 b
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	0 f	10 de	25 fghijklmnopqr
104 + 262	<i>M. siamensis</i> + <i>Alpinia officinarum</i>	0 f	0 h	3 ABC
111 + 262	<i>P. latifolia</i> + <i>Alpinia officinarum</i>	0 f	0 h	23 hijklmnopqrst
121 + 262	<i>P. balfouriana</i> + <i>Alpinia officinarum</i>	0 f	2 fgh	9 uvxyzABC

Table 4 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
122+262	<i>T. erecta</i> + <i>Alpinia officinarum</i>	0 f	0 h	38 bcdef
262	<i>Alpinia officinarum</i> Hance (Khao-taa-daeng)	0 f	2 fgh	8 vwxyzABC
104+263	<i>M. siamensis</i> + <i>Cucurbita moschata</i>	0 f	0 h	13 qrstuvwxyzABC
111+263	<i>P. latifolia</i> + <i>Cucurbita moschata</i>	1 ef	4 efgh	17 nopqrstuvwxyz
121+263	<i>P. balfouriana</i> + <i>Cucurbita moschata</i>	0 f	4 efgh	11 stuvwxyzABC
122+263	<i>T. erecta</i> + <i>Cucurbita moschata</i>	3 cde	13 cd	33 defghijk
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 def	2 fgh	11 stuvwxyzABC
111+264	<i>P. latifolia</i> + <i>Momordica charantia</i>	3 cde	7 defgh	20 klmnopqrstuvwxyz
121+264	<i>P. balfouriana</i> + <i>Momordica charantia</i>	3 cde	22 ab	47 bc
122+264	<i>T. erecta</i> + <i>Momordica charantia</i>	5 abc	10 de	34 cdefghij
264	<i>Momordica charantia</i> L. (Ma-ra)	0 f	0 h	5 yzABC
104+276	<i>M. siamensis</i> + <i>Malvaviscus pilosus</i>	0 f	3 efgh	36 cdefgh
111+276	<i>P. latifolia</i> + <i>Malvaviscus pilosus</i>	0 f	6 defgh	17 nopqrstuvwxyz
121+276	<i>P. balfouriana</i> + <i>Malvaviscus pilosus</i>	0 f	3 efgh	10 tuvxyzABC
122+276	<i>T. erecta</i> + <i>Malvaviscus pilosus</i>	0 f	0 h	15 pqrstuvwxyzAB
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 def	2 fgh	2 BC
111+279	<i>P. latifolia</i> + <i>Cyperus rotundus</i>	0 f	6 defgh	17 nopqrstuvwxyz
121+279	<i>P. balfouriana</i> + <i>Cyperus rotundus</i>	2 f	2 fgh	34 cdefghij
122+279	<i>T. erecta</i> + <i>Cyperus rotundus</i>	0 f	7 defgh	28 efghijklmnop
279	<i>Cyperus rotundus</i> L. (Hao-muu)	0 f	0 h	4 zABC
104+287	<i>M. siamensis</i> + <i>Spilanthes acmella</i>	1 ef	6 defgh	18 mnopqrstuvwxyz
111+287	<i>P. latifolia</i> + <i>Spilanthes acmella</i>	3 cde	13 cd	35 cdefghi
121+287	<i>P. balfouriana</i> + <i>Spilanthes acmella</i>	0 f	2 fgh	18 mnopqrstuvwxyz
122+287	<i>T. erecta</i> + <i>Spilanthes acmella</i>	0 f	4 efgh	19 lmnopqrstuvw
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 f	3 efgh	9 uvxyzABC
104+288	<i>M. siamensis</i> + <i>Rauwolfia serpentina</i>	0 f	2 fgh	15 pqrstuvwxyzAB
111+288	<i>P. latifolia</i> + <i>Rauwolfia serpentina</i>	0 f	4 efgh	15 pqrstuvwxyzAB
121+288	<i>P. balfouriana</i> + <i>Rauwolfia serpentina</i>	0 f	3 efgh	13 qrstuvwxyzABC
122+288	<i>T. erecta</i> + <i>Rauwolfia serpentina</i>	0 f	1 gh	12 rstuvwxyzABC
288	<i>Rauwolfia serpentina</i> Benth. ex Kurz (Ra-yoam)	3 cde	8 defg	23 hijklmnopqrst

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 2.9379; 3 LSD .05 = 7.5084; 4 LSD .05 = 13.4612

Table 5 Acaricidal effects of 2.5% of *Ixora nigricans* Wight & Arn., *Crateva magna* DC., *Aganonerion polymorphum* Pierre ex Spire, *Thunbergia laurifolia* Lindl. and *Streblus asper* Lour. crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
139	<i>Ixora nigricans</i> Wight & Arn. (Lum-phuk)	0 e	0 l	0 v
139+140	<i>I. nigricans</i> + <i>Crateva magna</i>	0 e	0 l	32 fghi
140	<i>Crateva magna</i> DC. (Kaam)	2 de	8 fghijk	20 jklmno
140+148	<i>C. magna</i> + <i>Streblus asper</i>	4 cde	8 fghijk	64 d
139+143	<i>I. nigricans</i> + <i>Aganonerion polymorphum</i>	7 bc	15 def	84 ab
143	<i>Aganonerion polymorphum</i> Pierre ex Spire (Som-lom)	4 cde	21 cde	39 efg
144	<i>Thunbergia laurifolia</i> Lindl. (Rang-juet)	0 e	6 ghijkl	8 pqrstuv
139+148	<i>I. nigricans</i> + <i>Streblus asper</i>	6 bcd	6 ghijkl	19 klmnop

Table 5 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
143+148	<i>A. polymorphum</i> + <i>Streblus asper</i>	0 e	14 ef	47 e
144+148	<i>T. laurifolia</i> + <i>Streblus asper</i>	4 cde	5 ghijkl	8 pqrstuv
148	<i>Streblus asper</i> Lour. (Khoi)	0 e	0 l	4 stuv
139+155	<i>I. nigricans</i> + <i>Anethum graveolens</i>	2 de	10 fghi	88 a
140+155	<i>C. magna</i> + <i>Anethum graveolens</i>	0 e	3 ijkl	48 e
143+155	<i>A. polymorphum</i> + <i>Anethum graveolens</i>	68 a	87 a	95 a
144+155	<i>T. laurifolia</i> + <i>Anethum graveolens</i>	0 e	3 ijkl	7 qrstuv
148+155	<i>S. asper</i> + <i>Anethum graveolens</i>	1 e	8 fghijk	16 lmnopqr
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 e	1 kl	31 fghij
139+247	<i>I. nigricans</i> + <i>Pentapetes phoenicea</i>	2 de	12 fg	27 hijkl
140+247	<i>C. magna</i> + <i>Pentapetes phoenicea</i>	2 de	21 cde	72 cd
143+247	<i>A. polymorphum</i> + <i>Pentapetes phoenicea</i>	6 bcd	24 bc	71 cd
144+247	<i>T. laurifolia</i> + <i>Pentapetes phoenicea</i>	3 cde	11 fgh	27 hijkl
148+247	<i>S. asper</i> + <i>Pentapetes phoenicea</i>	9 b	22 cd	62 d
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	0 e	10 fghi	25 ijklm
139+262	<i>I. nigricans</i> + <i>Alpinia officinarum</i>	0 e	0 l	17 klmnopq
140+262	<i>C. magna</i> + <i>Alpinia officinarum</i>	4 cde	9 fghij	32 fghi
143+262	<i>A. polymorphum</i> + <i>Alpinia officinarum</i>	1 e	8 fghijk	42 ef
144+262	<i>T. laurifolia</i> + <i>Alpinia officinarum</i>	0 e	5 ghijkl	11 opqrstuv
148+262	<i>S. asper</i> + <i>Alpinia officinarum</i>	0 e	0 l	9 opqrstuv
262	<i>Alpinia officinarum</i> Hance (Khaa-taa-daeng)	0 e	2 jkl	8 pqrstuv
139+263	<i>I. nigricans</i> + <i>Cucurbita moschata</i>	1 e	6 ghijkl	14 mnpqrst
140+263	<i>C. magna</i> + <i>Cucurbita moschata</i>	0 e	0 l	37 efgh
143+263	<i>A. polymorphum</i> + <i>Cucurbita moschata</i>	0 e	14 ef	69 cd
144+263	<i>T. laurifolia</i> + <i>Cucurbita moschata</i>	6 bcd	12 fg	25 ijklm
148+263	<i>S. asper</i> + <i>Cucurbita moschata</i>	0 e	0 l	4 stuv
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 de	2 jkl	11 opqrstuv
139+264	<i>I. nigricans</i> + <i>Momordica charantia</i>	0 e	0 l	12 nopqrstu
140+264	<i>C. magna</i> + <i>Momordica charantia</i>	7 bc	22 cd	42 ef
143+264	<i>A. polymorphum</i> + <i>Momordica charantia</i>	2 de	30 b	72 cd
144+264	<i>T. laurifolia</i> + <i>Momordica charantia</i>	0 e	0 l	12 nopqrstu
148+264	<i>S. asper</i> + <i>Momordica charantia</i>	0 e	3 ijkl	24 ijklm
264	<i>Momordica charantia</i> L. (Ma-ra)	0 e	0 l	5 rstuv
139+276	<i>I. nigricans</i> + <i>Malvaviscus pilosus</i>	0 e	3 ijkl	8 pqrstuv
140+276	<i>C. magna</i> + <i>Malvaviscus pilosus</i>	1 e	2 jkl	20 jklmno
143+276	<i>A. polymorphum</i> + <i>Malvaviscus pilosus</i>	0 e	3 ijkl	16 lmnopqr
148+276	<i>S. asper</i> + <i>Malvaviscus pilosus</i>	2 de	4 hijkl	14 mnpqrst
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 de	2 jkl	2 uv
139+279	<i>I. nigricans</i> + <i>Cyperus rotundus</i>	0 e	0 l	15 mnpqrs
140+279	<i>C. magna</i> + <i>Cyperus rotundus</i>	0 e	4 hijkl	41 ef
143+279	<i>A. polymorphum</i> + <i>Cyperus rotundus</i>	0 e	20 cde	76 bc
144+279	<i>T. laurifolia</i> + <i>Cyperus rotundus</i>	2 de	3 ijkl	15 mnpqrs
148+279	<i>S. asper</i> + <i>Cyperus rotundus</i>	3 cde	4 hijkl	4 stuv
279	<i>Cyperus rotundus</i> L. (Hao-muu)	0 e	0 l	4 stuv
139+287	<i>I. nigricans</i> + <i>Spilanthes acmella</i>	0 e	0 l	0 v
140+287	<i>C. magna</i> + <i>Spilanthes acmella</i>	0 e	0 l	0 v
143+287	<i>A. polymorphum</i> + <i>Spilanthes acmella</i>	0 e	8 fghijk	28 ghijk
144+287	<i>T. laurifolia</i> + <i>Spilanthes acmella</i>	0 e	3 ijkl	7 qrstuv
148+287	<i>S. asper</i> + <i>Spilanthes acmella</i>	4 cde	9 fghij	27 hijkl
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 e	3 ijkl	9 opqrstuv

Table 5 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
139+288	<i>I. nigricans</i> + <i>Rauwolfia serpentina</i>	0 e	0 l	4 stuv
140+288	<i>C. magna</i> + <i>Rauwolfia serpentina</i>	0 e	0 l	9 opqrstuv
143+288	<i>A. polymorphum</i> + <i>Rauwolfia serpentina</i>	2 de	11 fgh	31 fghij
144+288	<i>T. laurifolia</i> + <i>Rauwolfia serpentina</i>	0 e	0 l	5 rstuv
148+288	<i>S. asper</i> + <i>Rauwolfia serpentina</i>	0	1 kl	3 tuv
288	<i>Rauwolfia serpentina</i> Benth. ex kurz (Ra-yoam)	3 cde	3 ijkl	23 ijklmn

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 4.6227; 3 LSD .05 = 7.3826; 4 LSD .05 = 11.6883

Table 6 Acaricidal effects of 2.5% plant crude-extracts and their combinations against the engorged female tropical cattle ticks.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
155	<i>Anethum graveolens</i> L. (Phak-chee-lao)	1 e	1 jk	31 hijklm
155+247	<i>A. graveolens</i> + <i>Pentapetes phoenicea</i>	0 e	6 fghijk	15 opqrstuvw
161	<i>Rhinacanthus nasutus</i> Kurz (Thong-phan-chang)	0 e	0 k	9 tuvw
161+247	<i>R. nasutus</i> + <i>Pentapetes phoenicea</i>	2 de	5 fghijk	12 qrstuvw
247	<i>Pentapetes phoenicea</i> L. (Po-seng)	0 e	10 defgh	25 klmnop
155+262	<i>A. graveolens</i> + <i>Alpinia officinarum</i>	0 e	1 jk	19 mnopqrstu
247+262	<i>P. phoenicea</i> + <i>Alpinia officinarum</i>	0 e	1 jk	13 pqrstuvw
262	<i>Alpinia officinarum</i> Hance (Kha-taa-daeng)	0 e	2 ijk	8 uvwx
155+263	<i>A. graveolens</i> + <i>Cucurbita moschata</i>	1 e	2 ijk	35 ghijkl
262+263	<i>A. officinarum</i> + <i>Cucurbita moschata</i>	0 e	2 ijk	5 vw
247+263	<i>P. phoenicea</i> + <i>Cucurbita moschata</i>	2 de	2 ijk	40 fghijk
263	<i>Cucurbita moschata</i> Decne. (Fak-thong)	2 de	2 ijk	11 rstuvw
155+264	<i>A. graveolens</i> + <i>Momordica charantia</i>	1 e	3 hijk	10 stuvw
247+264	<i>P. phoenicea</i> + <i>Momordica charantia</i>	0 e	15 de	47 efg
262+264	<i>A. officinarum</i> + <i>Momordica charantia</i>	0 e	3 hijk	7 uvwx
263+264	<i>C. moschata</i> + <i>Momordica charantia</i>	3 cde	4 ghijk	26 klmno
264	<i>Momordica charantia</i> L. (Ma-ra)	0 e	0 k	5 vw
247+272	<i>P. phoenicea</i> + <i>Acacia harmandiana</i>	0 e	4 ghijk	36 ghijk
272	<i>Acacia harmandiana</i> Gagnep. (Kra-thin-phi-maan)	2 de	10 defgh	47 efg
155+276	<i>A. graveolens</i> + <i>Malvaviscus pilosus</i>	1 e	4 ghijk	14 opqrstuvw
247+276	<i>P. phoenicea</i> + <i>Malvaviscus pilosus</i>	0 e	3 hijk	45 efg
262+276	<i>A. officinarum</i> + <i>Malvaviscus pilosus</i>	2 de	4 ghijk	21 mnopqrst
263+276	<i>C. moschata</i> + <i>Malvaviscus pilosus</i>	0 e	2 ijk	22 mnopqrs
276	<i>Malvaviscus pilosus</i> DC. (Cha-baa-nuu)	2 de	2 ijk	2 x
155+279	<i>A. graveolens</i> + <i>Cyperus rotundus</i>	0 e	0 k	7 uvwx
247+279	<i>P. phoenicea</i> + <i>Cyperus rotundus</i>	0 e	3 hijk	5 vw
262+279	<i>A. officinarum</i> + <i>Cyperus rotundus</i>	0 e	4 ghijk	22 mnopqrs
263+279	<i>C. moschata</i> + <i>Cyperus rotundus</i>	0 e	2 ijk	30 ijklm
264+279	<i>M. charantia</i> + <i>Cyperus rotundus</i>	1 e	2 ijk	10 stuvw
276+279	<i>M. pilosus</i> + <i>Cyperus rotundus</i>	0 e	3 hijk	43 efg
279	<i>Cyperus rotundus</i> L. (Hao-muu)	0 e	0 k	4 vw
155+287	<i>A. graveolens</i> + <i>Spilanthes acmella</i>	1 e	1 jk	9 tuvw
247+287	<i>P. phoenicea</i> + <i>Spilanthes acmella</i>	1 e	4 ghijk	42 efghi
262+287	<i>A. officinarum</i> + <i>Spilanthes acmella</i>	2 de	3 hijk	10 stuvw

Table 6 Cont.

Serial No.	Scientific Name (Local name)	Corrected Mortality (Mean, %) ¹		
		24 h ²	48 h ³	7 Days ⁴
263+287	<i>C. moschata</i> + <i>Spilanthes acmella</i>	6 bc	11 defg	28 jklmn
264+287	<i>M. charantia</i> + <i>Spilanthes acmella</i>	0 e	6 fghijk	23 lmnopqr
276+287	<i>M. pilosus</i> + <i>Spilanthes acmella</i> Murr.	0 e	0 k	3 wx
279+287	<i>C. rotundus</i> + <i>Spilanthes acmella</i> Murr.	0 e	9 defghi	16 nopqrstuv
287	<i>Spilanthes acmella</i> Murr. (Phak-kraat-hua-waen)	0 e	3 hijk	9 tuvwx
155+288	<i>A. graveolens</i> + <i>Rauwolfia serpentina</i>	1 e	3 hijk	11 rstuvw
247+288	<i>P. phoenicea</i> L. + <i>Rauwolfia serpentina</i>	2 de	16 d	52 def
262+288	<i>A. officinarum</i> Hance + <i>Rauwolfia serpentina</i>	3 cde	6 fghijk	15 opqrstuvw
263+288	<i>C. moschata</i> + <i>Rauwolfia serpentina</i>	0 e	0 k	8 uvwx
264+288	<i>M. charantia</i> + <i>Rauwolfia serpentina</i>	0 e	0 k	5 vwx
276+288	<i>M. pilosus</i> + <i>Rauwolfia serpentina</i>	0 e	3 hijk	6 vwx
279+288	<i>C. rotundus</i> + <i>Rauwolfia serpentina</i>	1 e	12 def	70 bc
279+288	<i>C. rotundus</i> + <i>Rauwolfia serpentina</i>	1 e	12 def	70 bc
287+288	<i>S. acmella</i> + <i>Rauwolfia serpentina</i>	0 e	1 jk	8 uvw
288	<i>Rauwolfia serpentina</i> Benth. ex Kurz (Ra-yoam)	3 cde	8 efghij	23 lmnopqr
161+290	<i>R. nasutus</i> + <i>Piper nigrum</i>	2 de	3 hijk	10 stuvw
163+290	<i>A. muricata</i> + <i>Piper nigrum</i>	2 de	63 a	99 a
290	<i>Piper nigrum</i> L. (Phrik-thai-dam)	0 e	0 k	7 uvwx
161+291	<i>R. nasutus</i> + <i>Homalomena aromatica</i> Schott.	2 de	5 fghijk	16 nopqrstuv
163	<i>Annona muricata</i> L. (Thu-rian-thet)	6 bc	16 d	53 de
163+291	<i>A. muricata</i> + <i>Homalomena aromatica</i>	6 bc	33 c	75 bc
247+291	<i>P. phoenicea</i> + <i>Homalomena aromatica</i>	0 e	2 ijk	22 mnopqrs
290+291	<i>P. nigrum</i> + <i>Homalomena aromatica</i>	0 e	3 hijk	9 tuvwx
291	<i>Homalomena aromatica</i> Schott. (Tao-kiat)	5 bcd	27 c	64 cd
161+296	<i>R. nasutus</i> + <i>Mimosa invisa</i>	0 e	8 efghij	24 klmnopq
247+296	<i>P. phoenicea</i> + <i>Mimosa invisa</i>	16 a	52 b	79 b
296	<i>Mimosa invisa</i> Mart ex Colla (Mai-ya-raap-rai-naam)	8 b	12 def	39 ghij

1 Mean (%) of corrected mortality of 5 replications (20 ticks/rep.); values with different letters in the same column are statistically significantly different.

2 LSD .05 = 3.7188; 3 LSD .05 = 7.4549; 4 LSD .05 = 12.4425

DISCUSSION

The results showed the existence of synergistic acaricidal activity of plant crude-extracts, since the combined crude-extract of two plant species exhibited much higher corrected mortality of ticks than each non-combined crude-extract. The following combined crude-extracts showed highly acute acaricidal activity within 48 h after dipping; *Calotropis procera* (No.19) and *Aganonerion polymorphum* (No.143), *C. procera* (No.19) and *Pentapetes phoenicea* (No.247) (Table 1); and *A. polymorphum* (No.143) + *Anethum graveolens* (No.155) (Table 5). These plant crude-extracts had been shown the acute or delayed acaricidal activities in our previous report (Chungsamarnyart, *et al.*, 1991 b) but their concentration (10%) were four times higher than this experiment. Thus the effective acaricidal activity of the combined of low concentration crude-extracts is more

useful than high concentration. The 10% concentration crude-extract of *A. polymorphum* and *C. procera* exhibited high delayed acaricidal activity while the *P. phoenicea* and *A. graveolens* showed moderate activity (Chungsamarnyart, *et al.*, 1991 b). The *A. graveolens* has been reported only its antitick property to the *Dermacentor marginatus*, *Haemaphysalis punctata*, *Ixodes redikorzevi* and *Rhipicephalus rossicus* (Grainge and Ahmed, 1988). Therefore, the combination of 2.5% of these plant crude-extracts exhibited high effective acaricidal activity against tropical cattle ticks which no report has been done.

The high delayed acaricidal activity which found in the combination of two crude-extracts (2.5%) of the following plants has also not been previously reported; *Aganonerion polymorphum* (No.143) with *Calotropis gigantea* (No.20), *A. polymorphum* (No.143) with *Cryptostegia grandiflora* (No. 85), *A. polymorphum*

(No.143) with *Ixora nigricans* (No. 139); *C. gigantea* (No.20) with *Cryptostegia grandiflora* (No. 85), and *C. gigantea* (No.20) with *Pentapetes phoenicea* L. (No.247); *I. nigricans* (No. 139) with *Anethum graveolens* (No.155); and *Annona muricata* (No. 163) with *Piper nigrum* (No. 290). Some of these plants; *A. polymorphum*, *C. gigantea* and *A. muricata* were showed the high delayed acaricidal activity of their 10% concentration (Chungsamarnyart, et al., 1991 b). The other plants showed low to moderate delayed acaricidal activity. The present work demonstrated that the combination of lower concentration (2.5%) of these plants exhibited highly increase their delayed acaricidal activity. The delayed acaricidal activity might be low toxicity to the human being. Thus these plants showed the possibility of being new original plant crude-extract acaricides. The combination of the simple crude extraction of these plants for practical use should be further studied.

CONCLUSION

Ten plant crude-extracts from 34 plants species were highly increased the acaricidal activities when combined two of each 2.5% concentration. These combination crude-extracts were *Aganonerion polymorphum* (Som-lom) with *Calotropis procera* (Rak-dok-khaao), *A. polymorphum* with *Calotropis gigantea* (Rak-dok-muang), *A. polymorphum* with *Cryptostegia grandiflora* (Baan-buree-muang), *A. polymorphum* with *Ixora nigricans* (Lum-phak) and *A. polymorphum* with *Anethum graveolens* (Phak-chee-lao), *C. procera* with *Pentapetes phoenicea* (Po-seng), *C. gigantea* with *C. grandiflora*, *C. gigantea* with *P. phoenicea*, *Ixora nigricans* with *A. graveolens*, and *Annona muricata* (Thu-rian-thet) with *Piper nigrum* (Phrik-thai-dam). Especially, the *A. polymorphum*, *C. procera* and *C. gigantea* showed more suitableness to combine with many other plants, and they are common local plants. The simple extraction and combination of them for practical applications, as well as the mode of synergistic acaricidal activity should be further studied.

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LITERATURE CITED

- Abbott, W.S. 1925. A method of computing the effectiveness of an insecticide. *J. Econ. Ent.* 18, 265-267.
- Chungsamarnyart, N., S. Jiwajinda, W. Jansawan, U. Kaewsuan and P. Buranasilpin. 1988. Effective plant crude-extracts on the ticks (*Boophilus microplus*). I. Larvicidal Action. *Kasetsart J. (Nat. Sci. Suppl.)* 22: 37-41.
- Chungsamarnyart, N., S. Jiwajinda, W. Jansawan. 1990 a. Effects of plant crude-extracts on the cattle tick (*Boophilus microplus*). Insecticidal action I. *Kasetsart J. (Nat. Sci. Suppl.)* 24, 28-31.
- Chungsamarnyart, N., and W. Jansawan. 1990 b. Bioassay techniques of insecticidal plant-extracts on tropical cattle ticks *Boophilus microplus*. *Kasetsart J. (Nat. Sci. Suppl.)* 24, 24-27.
- Chungsamarnyart, N., S. Jiwajinda, W. Jansawan. 1991 a. Larvicidal effect of plant crude-extracts on the tropical cattle tick (*Boophilus microplus*). *Kasetsart J. (Nat. Sci. Suppl.)* 25, 80-89.
- Chungsamarnyart, N., S. Jiwajinda, W. Jansawan. 1991 b. Acaricidal effect of plant crude-extracts on tropical cattle ticks (*Boophilus microplus*). *Kasetsart J. (Nat. Sci. Suppl.)* 25, 90-100.
- Chungsamarnyart, N., S. Jiwajinda, C. Rattanakreetakul and W. Jansawan. 1991 c. Practical extraction of sugar apple seeds against tropical cattle ticks. *Kasetsart J. (Nat. Sci. Suppl.)* 25, 101-105.
- Chungsamarnyart, N. and S. Jiwajinda. 1992. Acaricidal activity of volatile oil from lemon and citronella grasses on tropical cattle ticks. *Kasetsart J. (Nat. Sci. Suppl.)* 26, 46-51.
- Chungsamarnyart, N. and W. Jansawan. 1993. Activities of plant crude-extracts in accordance with their extraction procedures. (*Nat. Sci. Suppl.*) 27, 1-8.
- Drummond, R.O. 1977. Resistance in ticks and insects of veterinary importance. In *Pesticide management and insecticide resistance* (D.L. Watson and A.W.A. Brown, ed.) pp. 303-317. Academic press, New York, San Francisco, London.
- Grainge, M. and S. Ahmed. 1988. Handbook of plants with pest-control properties. p. 368. Wiley-Interscience Publication, John Wiley & Sons. New York, Chichester, Brisbane, Toronto, Singapore.