

## Effects of two water-based plant extracts, *Hyptis suaveolens* and *Ricinus communis*, on the developmental stages of *Leptoglossus membranaceus* in Daloa, Côte d'Ivoire

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### Abstract

This study assessed the bioinsecticidal effects of two water-based plant extracts, *Hyptis suaveolens* (L.) and *Ricinus communis* (L.), on the developmental stages of *Leptoglossus membranaceus* Fabricius (1781) (Heteroptera: Coreidae) in Daloa, Côte d'Ivoire. Systemic applications were administered by injection into eggs, larvae, and adults. The *R. communis* extract showed the highest effectiveness on eggs, reducing fertility to  $43.8\% \pm 1.02$  at a concentration of 0.8 g/ml. For first-instar larvae, *H. suaveolens* was most effective at 0.1 g/ml, while *R. communis* performed better across later larval stages at concentrations of 0.2-0.8 g/ml. Concerning adult mortality, *R. communis* achieved a 78.18% kill rate at 1 g/ml, with the lowest lethal doses recorded at 0.7 g/ml for males and 0.8 g/ml for females. Notably, both extracts decreased the fertility of surviving females to 45% at lethal concentrations. These results demonstrate the potential of botanical insecticides for integrated pest management in agroecological systems.

**Keywords:** Botanical insecticides, *Leptoglossus membranaceus*, larval stages, water-based extracts, lethal concentration

### Introduction

The control of insect pest damage through synthetic insecticides has long contributed to improved crop yields. However, these chemical interventions often carry significant ecological costs, including harm to beneficial fauna and disruption of environmental balance (Williamson *et al.*, 2008) <sup>[1]</sup>. In contrast, the use of beneficial insects and plant-based biopesticides offers a more sustainable and environmentally friendly alternative to conventional chemical spraying (Jeffery, 2001) <sup>[2]</sup>. Among these alternatives, applying locally available biopesticidal plants presents a promising strategy for managing *Leptoglossus membranaceus*, a pest of growing concern in tropical agroecosystems. For centuries, human communities have relied on botanical extracts to protect crops and stored products, demonstrating the enduring relevance of traditional ecological knowledge in modern pest management. These products are undoubtedly one of the keys to the sustainable development of agricultural activities worldwide. Recent advances in analytical chemistry and molecular biology techniques have led to a better understanding of the interactions between plants and plant pests or between plants themselves (allelopathy) and the discovery of plant resistance genes (Catherine *et al.*, 2006) <sup>[3]</sup>. The development of insecticidal products was based on the observation that certain plants protect themselves better than others against predators. Laboratory tests have revealed the presence of insect repellent and/or insecticidal properties in certain plants (Foua-Bi, 1993) <sup>[4]</sup>. More than 2,000 plant species with insecticidal properties have been identified (Jacobson, 1989; Philogène *et al.*, 2002) <sup>[5-6]</sup>. Botanical pesticides are generally safer to use and handle than synthetic chemical pesticides (Rother, 2013) <sup>[7]</sup>. They pose minimal risk to the environment and are less harmful to beneficial insect populations, such as pollinators and natural predators (Amoabeng *et al.*, 2013; Mkenda *et al.*, 2015) <sup>[8-9]</sup>. Additionally, their natural origin makes them more difficult to counterfeit, ensuring integrity in field applications. Among the many plants with biopesticidal properties, this

study focuses on two locally available species: *Ricinus communis* L. (Euphorbiaceae) and *Hyptis suaveolens* L. Poit (Lamiaceae). The research was conducted with the overarching goal of improving cucumber yields through sustainable pest management. Specifically, the study aims to

- Evaluate the efficacy of different extract concentrations on the eggs, larvae, and adults of *Leptoglossus membranaceus*;
- Determine the median lethal dose (LD<sub>50</sub>) and assess its impact on the fertility of surviving adult insects

### Materials and Methods

The study was conducted in Daloa (06°52'38" N, 06°27'00" W), a city located in western Côte d'Ivoire. As the capital of the Haut Sassandra region, Daloa is located approximately 331 km from Abidjan, the economic capital, and 135 km from Yamoussoukro, the political capital. According to the 2014 General Population and Housing Census, the city has a population of 26,600 and covers an area of 80 km<sup>2</sup> (Anonymous, 2014) <sup>[10]</sup>. The biological material consists of animal material (*Leptoglossus membranaceus*) and plant material (cucumber, *Ricinus communis* and *Hyptis suaveolens*).

The breeding equipment consists of square cages (70 cm wide and 160 cm high), made with No. 6 concrete reinforcing bars and white muslin with a 0.50 mm mesh. The material used to prepare the extracts consists of an oven to dry the organs to be used, a blender to reduce the organs to powder and mix the powder with distilled water, Whatman paper (3 mm) used to filter the mixture, and an oven to evaporate the filtrate obtained.

The treatment and protection equipment for applicators consists of a hand sprayer and 10 ml syringes used for contact treatments on *L. membranaceus*. The protective equipment consists of gloves, masks, and goggles.

### Methods

Aqueous extracts were prepared according to the method described by Zirihi *et al.* (2003) <sup>[11]</sup>. The dry residue was

used to prepare five concentrations of aqueous extracts: 0.1 g/ml, 0.2 g/ml, 0.4 g/ml, 0.6 g/ml, and 0.8 g/ml.

The eggs and the five (5) larval stages will be treated with concentrations of each extract. The survival rate or mortality rate of the larvae at 24 hours and then at 72 hours for each concentration of each extract was compared. Data processing was carried out using Excel version 2013, Statistica, Paleontological Past and WinDL software. WinDL software was used in particular to calculate the lethal doses of the extracts. Analysis of variance (ANOVA) and Fisher's LSD test at the 5% threshold were used to analyse and compare the fertility rate of eggs and the mortality rate of larvae and adults.

## Results and Discussion

### Results

#### Effect of aqueous extracts on the fertility of *L. membranaceus* eggs

Aqueous plant extracts had varying effects, depending on

their concentration and the age of the eggs (Table I). For one-day-old eggs, the lowest fertility rate ( $43.8 \pm 1.02\%$  induced by *R. communis* compared to  $54.4 \pm 1.6\%$  for *H. suaveolens*) was obtained at a concentration of 0.8 g/ml. Statistical analysis revealed a significant difference between the fertility rates of one-day-old eggs ( $F = 7.69$ ;  $ddl = 10.56$ ;  $P = 0.002$ ). For 2-day-old eggs, fertility rates were low in *R. communis*. Statistical analysis showed a significant difference between the fertility rates of 2-day-old eggs ( $F = 9.80$ ;  $ddl = 10.05$ ;  $p = 0.001$ ). For 4-day-old eggs, the lowest fertility rate ( $56.4 \pm 1.36\%$ ) induced by *R. communis* was obtained at a concentration of 0.8 g/ml. The other extracts had rates above 80%. According to statistical analyses, there is a significant difference between the fertility rates of 4-day-old eggs ( $F = 3.33$ ;  $ddl = 10.92$ ;  $P = 0.04$ ). Finally, for 6-day-old eggs, fertility rates were above 80% for both extracts and all concentrations combined. Statistical analysis revealed a significant difference between the fertility rates of 1-day-old eggs ( $F = 5.79$ ;  $ddl = 10.48$ ;  $P = 0.008$ )

**Table 1:** Egg fertility after treatment

Aqueous plant extracts	Concentrations (g/ml)	Age of eggs (days)			
		1	2	4	6
<i>Ricinus communis</i> Leaves, bolls and fruits	0,1	73,4± 0,51 e	76,8± 1,28f	84 ±0,70 def	84,6± 0,68 d
	0,2	71,2± 0,86 d	74,2 ± 0,97f	84 ±0,70 def	84,6± 0,68 d
	0,4	57,4± 0,51 c	67± 2,16 de	77±0,70 c	83,2± 0,37 c
	0,6	45,4± 0,51 b	52,8± 0,66b	62±0,54 b	81,8± 0,66 b
	0,8	43,8± 1,02 b	51,8± 0,37ab	56,4±1,36 a	82,2 ±0,58 b
<i>Hyptis suaveolens</i> Leaves and flowers	0,1	80,6± 0,92g	75,5±1,62f	84,2±1,77 def	85,4 ±1,66 g
	0,2	75,6± 2,3ef	70 ±1,58 e	83,16±1,03 def	84 ±1,83 fg
	0,4	78,8±0,58 ef	68,16±3,29e	82± 1,41 de	81,4 ±1,63 ef
	0,6	78,2±0,8 ef	63,2±1,28 c	80,2±0,96 cd	83,6± 1,32 c
	0,8	54,4± 1,6fg	84,2±1,77 cd	85 ±1,41 efg	85,4 ±1,66 eg

1-day-old egg:  $F = 7.69$ ;  $ddl = 10.56$ ;  $P = 0.002$  2-day-old egg:  $F = 9.80$ ;  $ddl = 10.05$ ;  $P = 0.001$

4-day-old egg:  $F = 3.33$ ;  $ddl = 10.92$ ;  $P = 0.04$  6-day-old egg:  $F = 5.79$ ;  $ddl = 10.48$ ;  $P = 0.008$

In the same column, means followed by the same letters are not significantly different.

#### Assessment of the efficiency of aqueous extracts on *L. membranaceus* larvae within 24 hours

The mortality rates of the larvae varied depending on the concentration of the aqueous extracts and the age of the larvae (Table II). The highest mortality rate was  $21.8 \pm 1.38\%$  (*H. suaveolens*) at the lowest concentration (0.1 g/ml). For the other concentrations (0.2 g/ml; 0.4 g/ml; 0.6 g/ml and 0.8 g/ml), *R. communis* had the highest mortality rates with  $57.7 \pm 1.50\%$ ;  $55.7 \pm 1.73\%$ ;  $66 \pm 1.87\%$  and  $73.2 \pm 1.87\%$ , respectively. Statistical analysis revealed no significant difference between the mortality rates of L1 at 24 hours

( $F = 2.77$ ;  $ddl = 11.17$ ;  $P = 0.07$ ). For the other larval stages (L2, L3, L4 and L5), no extract had any effect at concentrations of 0.1 g/ml and 0.2 g/ml. For these larvae, the highest mortality rates were obtained with *R. communis* at a concentration of 0.8 g/ml ( $52.1 \pm 3.88\%$ ;  $48.8 \pm 3.63\%$ ;  $43.2 \pm 2.62\%$  and  $40.2 \pm 3.3\%$ ). Statistical analysis revealed that there was no significant difference between the mortality rates of larvae 2 ( $F = 0.62$ ;  $ddl = 11.07$ ;  $P = 0.68$ ); larvae 3 ( $F = 0.27$ ;  $ddl = 11.11$ ;  $P = 0.91$ ); larvae 4 ( $F = 0.15$ ;  $ddl = 11.15$ ;  $P = 0.97$ ) and larvae 5 ( $F = 0.13$ ;  $ddl = 11.16$ ;  $P = 0.92$ ). However, *R. communis* had the highest mortality rate regardless of concentration.

**Table 2:** Larval mortality rate 24 hours after treatment

Water-based plant extracts	Concentration (g/ml)	Larval Stages				
		Larvae 1	Larvae 2	Larvae 3	Larvae 4	Larvae 5
<i>Ricinus communis</i> Leaves, bolls, and fruits	0,1	16 ± 1,11 ab	0±0 a	0± 0 k	0± 0 j	0± 0 i
	0,2	57,7 ±1,50 kl	0±0 a	0± 0 k	0± 0 j	0± 0 i
	0,4	55,7 ± 1,73 k	37,4± 2,63 ef	29,8± 2,32 de	25,8±1,86 bcd	20,1± 1,47 bc
	0,6	66 ±1,87 m	41,8 ±3,24 fg	37,3±3,36fgh	32,3 ± 2,02efg	31,1± 2,6 e
	0,8	73,2± 1,87n	52,1± 3,88 h	48 ±3,63 j	43,2 ±2,62 hi	40,2± 3,3 g
<i>Hyptis suaveolens</i> Leaves and flowers	0,1	21,8±1,38 bc	0 ± 0 a	0 ± 0 k	0± 0 j	0± 0 i
	0,2	43 ±2,41 gh	0 ± 0 a	0 ± 0 k	0± 0 j	0± 0 i
	0,4	45,7±1,98ghi	37,3 ±2,54 ef	30,5±2,83 def	23,3 ±2,86 bc	21,72±1,89 cd
	0,6	51,4±3,27 ijk	40,3± 1,43 f	37,8 ±2,78 gh	37,8± 1,96 gh	31,63± 2,15 ef
	0,8	62,3±3,36mn	49,2±1,61 h	45,2± 2,99 ij	44,6 ±1,99 i	38,90± 2,01 g

Larvae 1:  $F = 2.77$ ;  $ddl = 11.17$ ;  $P = 0.07$  Larvae 2:  $F = 0.62$ ;  $ddl = 11.17$ ;  $P = 0.68$

Larvae 3:  $F = 0.27$ ;  $ddl = 11.11$ ;  $P = 0.91$  Larvae 4:  $F = 0.15$ ;  $ddl = 11.15$ ;  $P = 0.97$

Larvae 5:  $F = 0.13$ ;  $ddl = 11.16$ ;  $P = 0.92$

In the same column, means followed by the same letters are not significantly different.

**Evaluation of the effectiveness of aqueous extracts on *L. membranaceus* larvae 72 hours after treatment**

72 hours after treatment, mortality rates for each extract increased compared to those at 24 hours (Table III). As in the case of 24 hours, aqueous extracts caused varying mortality rates depending on their concentrations and the age of the larvae. The highest mortality rate with the lowest concentration (0.1 g/ml) was  $24.7 \pm 1.03\%$  (*H. suaveolens*). For the other concentrations (0.2 g/ml; 0.4 g/ml; 0.6 g/ml and 0.8 g/ml), *R. communis* had the highest mortality rates with  $61 \pm 1.74\%$ ;  $62.7 \pm 1.93\%$ ;  $69.2 \pm 1.83\%$  and  $75.3 \pm 2.24\%$ , respectively. Statistical analysis revealed no significant difference between the mortality rates of stage 1

larvae ( $F= 2.59$ ;  $ddl= 11.18$ ;  $P= 0.08$ ). For the other larval stages (L2, L3, L4 and L5), no extract was effective at concentrations of 0.1 g/ml and 0.2 g/ml. For these larvae, the highest mortality rates were obtained with *R. communis* at a concentration of 0.8 g/ml ( $56.1 \pm 3.98\%$ ;  $51.1 \pm 3.97\%$ ;  $47.2 \pm 2.72\%$  and  $40.7 \pm 4.65\%$ ). Statistical analysis revealed that there was no significant difference between the mortality rates of larvae 2 ( $F= 0.66$ ;  $ddl= 11.07$ ;  $P= 0.66$ ); larvae 3 ( $F= 0.84$ ;  $ddl= 10.98$ ;  $P= 0.54$ ); larvae 4 ( $F= 0.61$ ;  $ddl= 11.08$ ;  $P= 0.69$ ) and larvae 5 ( $F= 1.51$ ;  $ddl= 10.02$ ;  $P= 0.26$ ). As in the case of 24 hours after treatment, *R. communis* had the highest mortality rate regardless of concentration.

**Table 3:** Larval mortality rate 72 hours after treatment

Water-based plant extracts	Concentration (g/ml)	Larval Stages				
		Larvae 1	Larvae 2	Larvae 3	Larvae 4	Larvae 5
<i>Ricinus communis</i> Leaves, bolls, and fruits	0,1	17,3 ±1,23 a	0±0 k	0±0 k	0±0 m	0±0 h
	0,2	61 ±1,74 jk	0±0 k	0±0 k	0±0 m	0±0 h
	0,4	62,7± 1,93 jk	42,5 ±2,88 efg	32,8± 2,31def	28,8±2,26cdef	25,7± 2,03 c
	0,6	69,2± 1,83 l	47,6± 3,38 ghi	43,4± 3,54 h	37,2±2,37 ghi	36,1± 3,31 ef
	0,8	75,3± 2,24 l	56 ±3,98 j	51,1± 3,97 i	47,2± 2,72 j	40,7 ±4,65 fg
<i>Hyptis suaveolens</i> Leaves and flowers	0,1	24,7± 1,03bc	0±0 k	0±0 k	0±0 m	0±0 h
	0,2	48 ±2,50 gh	0±0 k	0±0 k	0±0 m	0±0 h
	0,4	49 ±2,40 gh	40,2± 1,85 def	34,5±1,85 efg	31,6± 1,4 ef	28,81± 1,47 cd
	0,6	58,8± 3,33 k	45,4 ±1,25 fgh	41 ±3,16g h	40,8± 2,08 i	34 ±2,45 de
	0,8	66,1± 3,40 k	51,6± 1,50 ij	50,5± 3,25 i	47,7 ±1,89 j	43,27 ±2,10 g

Larvae 1:  $F= 2.59$ ;  $ddl= 11.18$ ;  $P= 0.08$  Larvae 2:  $F= 0.66$ ;  $ddl= 11.07$ ;  $P= 0.66$

Larvae 3:  $F= 0.84$ ;  $ddl= 10.98$ ;  $P= 0.54$  Larvae 4:  $F= 0.61$ ;  $ddl= 11.08$ ;  $P= 0.69$

Larvae 5:  $F= 1.51$ ;  $ddl= 10.02$ ;  $P= 0.26$

In the same column, means followed by the same letters are not significantly different.

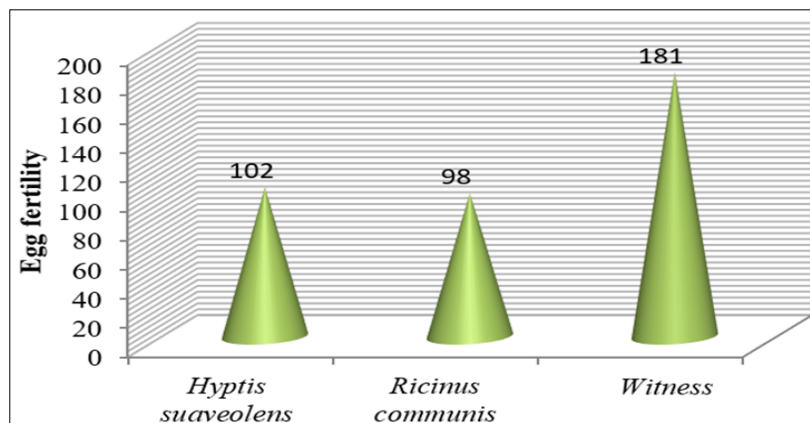
**Median lethal concentration (LC50 or LD50) of aqueous extracts**

The median lethal dose ( $LD_{50}$ ) was determined using the linear regression function  $Y = aX + b$ , where  $Y$  represents probit values and  $X$  the logarithm of applied doses. Regression lines were plotted to evaluate the toxicity of each extract on the tested insects. Among the extracts, *Ricinus communis* proved to be the most effective, exhibiting the lowest  $LD_{50}$  values: 1.26 g/ml for females and 1.17 g/ml for males. Although males appeared slightly more sensitive, statistical analysis revealed no significant difference between sexes

( $F = 1.909$ ;  $df = 7.998$ ;  $P = 0.20$ ). Similarly, no significant difference was found between the toxicities of the various aqueous extracts ( $F = 4.033$ ;  $df = 2.478$ ;  $P = 0.17$ ), despite the superior performance of *R. communis*. To achieve a 90% mortality rate, *R. communis* remained the most potent, requiring a concentration of 2.34 g/ml. These findings suggest that while *R. communis* demonstrates enhanced toxicological efficacy, the observed variations between extracts and sexes are not statistically significant. This highlights the need for a complementary approach that integrates biological, ecological, and economic criteria when selecting botanical biopesticides.

**Table 4:** Lethal doses and regression equations

Extracts	Sex	LD 50 (g/ml)	Regression equations
<i>Ricinus communis</i>	Females	1,26	$Y= 4,48218x - 0,45596$
	Males	1,17	$Y= 4,57711x - 0,31980$
<i>Hyptis suaveolens</i>	Females	1,44	$Y= 4,63381x - 0,73997$
	Males	1,26	$Y= 3,71882x - 0,37580$



**Fig 1:** Fertility rate of female *L. membranaceus* surviving LD50

### Effect of aqueous extracts on the fertility of female survivors of lethal concentration

For both extracts, the fertility of females that survived the lethal dose decreased compared to the control. *Hyptis suaveolens* has less of an effect on female fertility. Statistical analysis indicated a significant difference between the number of eggs laid after the lethal dose ( $F=37.5$ ,  $ddl=24.24$ ,  $P<0.001$ ) (Figure)

### Discussion

The application of aqueous plant extracts to *Leptoglossus membranaceus* eggs produced variable outcomes depending on egg age and extract concentration. The lowest fertility rate ( $43.8\% \pm 1.02$ ) was recorded with *Ricinus communis* at 0.8 g/ml, applied to day-old eggs. Fertility rates were even lower in younger eggs, suggesting heightened sensitivity during early embryonic development. The ovicidal effect is hypothesized to result from the disruption of embryogenesis, caused by the penetration of bioactive compounds through the egg's respiratory structures. This mechanism has been previously documented by Tano (2012) [12], Ketoh *et al.* (2005) [13], and Papachristos & Stamopoulos (2002) [14]. These compounds appear to act independently, as demonstrated by Seljåsen & Meadow (2006) [15] in their study on azadirachtin A's impact on *Mamestra brassicae* eggs (*Lepidoptera: Noctuidae*). Similar conclusions were drawn by Alzouma & Boubacar (1987) [16], who reported that plant-derived ovicides exert their effect prior to first-instar larval emergence. Regarding larval susceptibility, the effectiveness of the extracts increased over time. Mortality rates rose significantly between 24 and 72 hours, indicating a progressive toxic impact and potential for delayed action in pest control strategies. These results align with those reported by Vijaykumar *et al.* (2015) [17], who confirmed the insecticidal properties of various spice-derived extracts against adult *Tribolium castaneum*. Their study demonstrated that mortality generally increases proportionally with exposure duration, reinforcing the time-dependent efficacy observed in the present research. Larval sensitivity to botanical extracts varies according to larval age, extract type, and concentration. Notably, only high-concentration formulations yielded significant larvicidal effects, consistent with findings from Aouinty *et al.* (2006) [18], who reported 100% mortality in *Culex pipiens* larvae at a 1% concentration of *Ricinus communis* leaf extract. Regarding *Hyptis suaveolens*, Kossou *et al.* (2007) [19] demonstrated its broad-spectrum efficacy against several key pests, including cowpea aphids (*Aphis craccivora*), thrips (*Megalurothrips sjostedti*), and *Callosobruchus maculatus*. These findings corroborate the ovicidal and larvicidal potential of *H. suaveolens* observed in the current study, particularly when applied at early developmental stages. Together, these comparative studies reinforce the relevance of plant-based biopesticides in integrated pest management (IPM), especially when optimized for concentration, timing, and target species. Larval stages 1 and 2 of *Leptoglossus membranaceus* appear to be the most sensitive to botanical treatments. This heightened susceptibility is likely linked to the greater permeability of the cuticle in young larvae, which are still in the pterygote phase. Such permeability facilitates the direct penetration of active compounds into the organism. This hypothesis is supported by Islam *et al.* (2007) [20], who demonstrated that azadirachtin inhibits the production of ecdysone, a hormone

responsible for initiating larval moulting in the presence of juvenile hormone, whose developmental effects it modulates. The result is a disruption of the moulting process, ultimately leading to larval death. In contrast, larvae in stages 3, 4, and 5 exhibited lower sensitivity to the extracts, likely due to increased cuticular rigidity and enhanced physiological tolerance to chemical stressors. Among the tested extracts, *Ricinus communis* consistently induced the highest mortality rates, corroborating findings by Tano (2012) [12] on *C. lameensis*. The potent insecticidal activity of *R. communis* is attributed to ricin, one of its principal bioactive compounds. Ricin's mode of action has been well documented by Olsnes (2004) [21], Roberts & Smith (2004) [22], and Parikh *et al.* (2008) [23], who reported that it causes irreversible inhibition of protein synthesis in insect cells by inactivating ribosomes, ultimately leading to cell death. The insecticidal potential of *Ricinus communis* was previously highlighted by Adabie-Gomez *et al.* (2006) [24], who reported that leaf powder at a concentration of 0.2 g/ml, when applied to maize kernels, inhibited adult emergence at rates of 96.08% for *Callosobruchus maculatus* and 60% for *Sitophilus zeamais*. The efficacy of *R. communis* capsules was further confirmed by their lowest recorded LD<sub>50</sub> values, indicating high toxicity. Notably, LD<sub>50</sub> values varied according to the sex of the insect, suggesting differential physiological responses between males and females of the same age group.

Beyond acute toxicity, aqueous plant extracts also demonstrated significant reproductive effects. In *Leptoglossus membranaceus* females that survived LD<sub>50</sub> exposure, a marked reduction in fecundity was observed. The average number of eggs laid decreased by 50% with *R. communis* treatment and by 39% with *Hyptis suaveolens*, indicating sub-lethal impacts on reproductive capacity. The observed reduction in the average number of eggs laid by *Leptoglossus membranaceus* females, compared to control groups, may be attributed to the disruptive effects of aqueous plant extracts on gametogenesis. This hypothesis is supported by several studies reporting similar outcomes across diverse insect species. Bruce *et al.* (2004) [25] demonstrated that the application of 0.075 ml of *Azadirachta indica* oil per maize plant significantly reduced oviposition in *Eldana saccharina* Walker, 1865 (*Lepidoptera: Pyralidae*) and *Sesamia calamistis* Hampson, 1910 (*Lepidoptera: Noctuidae*) by 49% and 88%, respectively, compared to untreated controls. Likewise, Séri-Kouassi (2004) [26] and Aboua *et al.* (2010) [27] reported decreased egg-laying in *Callosobruchus maculatus* females exposed to essential oils from *Ageratum conyzoides*, *Citrus aurantifolia* (Christm.) Swingle, 1913, and *Melaleuca quinquenervia* (Cav.) Blake, 1958. Tounou *et al.* (2011) [28] further observed that *Plutella xylostella* females laid fewer eggs on cabbage plants treated with castor oil (*Ricinus communis*) than on untreated plants. These findings collectively suggest that botanical extracts, particularly those rich in bioactive compounds, can exert sub-lethal effects on insect reproduction, potentially by interfering with hormonal regulation or gamete development. The disruptive effects of botanical extracts on oviposition and larval development have been confirmed across multiple insect orders. Trematerra and Lanzotti (1999) [29] and Auger *et al.* (2013) [30] demonstrated that aqueous plant extracts exert ovicidal, larvicidal, and adulticidal actions, highlighting their broad-spectrum efficacy. These findings

are consistent with those of Tano (2012) [12], who reported that aqueous extracts of *Zingiber officinale* and *Ricinus communis* significantly affect larval viability and reduce the average number of eggs laid by female *Coelaenomenodera lamensis*. Such results reinforce the potential of plant, based biopesticides as eco-friendly alternatives for integrated pest management, particularly in agroecological systems aiming to minimize chemical inputs while preserving reproductive control.

### Conclusion

To sustainably manage populations of *Leptoglossus membranaceus*, a major pest of cucumber crops, the use of botanical extracts was explored as an eco-friendly alternative to synthetic insecticides. The study involved rearing the pest to determine its most vulnerable developmental stages and conducting control trials by injecting systemic extracts into eggs, larvae, and adults. Among the tested botanicals, *Ricinus communis* proved most effective on eggs, reducing fertility rates to  $43.8\% \pm 1.02$  at a concentration of 0.8 g/ml compared to natural fertility rates of 91.97% during the rainy season and 96.09% in the dry season. *Hyptis suaveolens* showed highest efficacy on first-instar larvae, while *R. communis* remained dominant across later larval stages. All extracts demonstrated peak effectiveness 72 hours post-treatment. In terms of lethal dose (LD<sub>50</sub>), *R. communis* required the lowest concentrations: 0.7 g/ml for males and 0.8 g/ml for females. On adult insects, *R. communis* again showed superior performance, achieving a mortality rate of 78.18% at 1 g/ml. These findings underscore the potential of *R. communis* and *H. suaveolens* as potent, environmentally responsible agents for integrated pest management in agroecological systems.

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