JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

REPELLENT AND LARVICIDAL ACTIVITY OF MEDICINAL PLANT EXTRACT AGAINST *RHYZOPERTHA DOMINICA* (F.) (COLEOPTERA: BOSTRICHIDAE)

Pappathi T[1], Dharani P[1], Maria Packiam, S[2], Martin P[1] and Elumalai K[1]*

[1]Entomology Research Unit, Department of Advanced Zoology & Biotechnology, Govt. Arts College for Men (Autonomous), Affiliated to University of Madras, Nandanam, Chennai – 600 035, Tamilnadu, India.
[2]Director, Entomology Research Institute, Assistant Professor, Department of Zoology, Loyola College, Chennai - 600034, Tamilnadu
*Corresponding author professorelumalai@gmail.com

ABSTRACT: Several synthetic pesticides used to control stored pests were applied during the storage period, providing total protection. At the same time, the chemicals' lingering effects have several negative consequences for humans and the environment. To discover an alternate method, the larvicidal and repellent activities of different solvent extracts of *Impatiens balsamina* were investigated in the current study. The results obtained from the experiment showed that the plant extracts offered significant protection. So it can be concluded that the *Impatiens balsamina* will substantially replace the application of chemical pesticides in the near future at the same time, the detailed analyses of the different phytochemicals and their structural elucidation warrants the further exploration of the selected plant species.

KEYWORDS: Solvent extracts, Lesser grain borer, *Rhyzopertha dominica*, *Impatiens balsamina*, Repellent and Insecticidal activity.

1.0 INTRODUCTION

Rhyzopertha dominica (F.) (Coleoptera: Bostrichidae) is a major pest that damages grains in temperate and tropical areas. *R. dominica* is a worldwide insect pest that feeds on stored seeds. Gravid females lay eggs either singly or in groups in the grain quantity, with several eggs observing together, forming a bundle. Larvae producing from eggs (first instars) are 0.78 mm elongated, with a head capsule width of 0.13 mm, and campodeiform in shape. First instars are energetic and can be recognized by a terminal median spine at the dorsal surface of the last abdominal segment. First instars come in kernels and carry on immature improvement within grains. There are a lesser number of studies on the wheat kernel-huge number by *R. dominica* first instars. *R.dominica* first instars can successfully infest an uncontaminated wheat kernel or sound durum kernels (Limonta *et al*., 2011). Thomson (1966) stated that humidity content of 8% or higher is critical for first instars to bore into whole and sound sorghum kernels; the germ is the first point of record on sound kernels (Akmaliyah *et al*., 2013).

Rhyzopertha dominica causes cost-effective losses to stored cereals. The destruction occurs due to weight failing by generating frass from injured grains, bad smells due to insect emissions and decline of nutrient contents. These disagreeable results in cereals make them unfit for human consumption, moderate essential amino acids, and reduce germination capacity. The two stages spent most of their lives inside the kernel, feeding on both the germ and endosperm, openly causing damages and changes in grain physicochemical properties (Perisic *et al*., 2018).

According to WHO (2002), 70–80|% of the equally developed and developing countries population uses traditional treatments, mainly of the plant source, to treat diseases (Ahmad *et al*., 2010; Shrestha and Dhillion, 2003; Usman *et al*., 2020). The use of medicinal plants in nutrition products increases the body's natural immunity against several diseases affecting agents due to the manifestation of the high level of phytochemicals (Conforti *et al*., 2008; Hudaib *et al*., 2008). These phytochemicals have been described to accomplish different biological actions. In addition, they may prevent lipid peroxidation and platelet aggregation and increase capillary permeability and insubstantiality (Smeriglio *et al*., 2019). All over the world, scientists are tiresome to develop plant-based pesticides because commercial pesticides harmfully affect the environment and human health (Tariq *et al*., 2010). Afterwards, with severe obstacles and hazardous effects of chemical pesticides on the living system and the environment, the use of eco-friendly bio-pesticides is acceptance increased (Kumar *et al*.,2011; Odek *et al*., 2017; Mahroof *et al*., 2005; Subramanyam *et al*., 2011; Campolo *et al*., 2013).

Plant extracts and essential oils have long been used to kill or prevent insects in stored goods (Bandeira *et al*., 2013; Fouad *et al*., 2012). Plant extracts of several plants demonstrate significant toxic, fumigant and repellent effects on the adult of *R. dominica* (Arifuzzaman *et al*. 2014; Ishtiaq *et al*. 2016;). Mejri *et al*. (2013) showed that this plant had bioactive compounds such as alkaloids, flavonoids, coumarins, tannins, volatile oil, glycosides and terpenes (Zeeshan Ali and Urooj Mazhar 2018).

Creso and Al-Mallah (2013) also tested the lethal effect of mixtures of oils and insecticides on the larvae of the capillary beetle, and Al-Obaidi (2015) emphasize the need to depend on biological control programs for pests of stored materials, as they are the safest and safest for the environment and for the agricultural ecosystem. In observation of the importance of the insect and allowing for it as a universal spread and infecting grains and foodstuffs, this study was directed with the aim of significant the effect of plant oils on some aspects of live performance, such as the proportion of mortality and the ratio of germination of grains treated with oils to be used as seeds right for cultivation. Botanical insecticides are good choices for chemical insecticides and proved their efficiency in controlling insect pests (Vinuela *et al*., 2000; Isman 2000; Rehman *et al*., 2009). Herbal insecticidal have an antagonistic effect on insect pest physiology and biochemistry. In the effective control of *R. dominica* and other stored-grain pests, with insignificant insecticide use involves an integrated management method related to sanitation, monitoring, and other preventive practices, including the use of pheromone-baited traps. Plant components having insecticidal qualities have been reported to be used all over the world because they are handy, less costly, highly effective, and safer for humans and their surroundings. However, these insecticides are frequently related to hazardous residues for the consumer and the environment (Lamiri *et al.*, 2001). Hence, there is an awareness in finding an alternative way for stored products Plants in the family Lamiaceae are aromatic herbs with vast socio-economic value in flavouring, cosmetics and perfumery, confectionery and medicinal preparations (Magness *et al.*, 2006). With these backgrounds, this present study was aimed to assess the medicinal plant's controlling potential against the pulse beetle, *Rhyzopertha dominica.*

2. 0 MATERIALS AND METHODS

2.1 Collection of plant and Preparation of Plant Extract

The leaves of *Impatiens balsamina* active components were extracted using the cold extraction method (maceration). 200g of leaves were prepared by crushing with the help of an electric blender and sieved to obtain a fine powder. In a sterile conical flask, the fine powder was soaked separately in one litre of hexane, dichloromethane, and ethanol for around 48 hours, stirring periodically. The mixture was then filtered via filter paper (Whatman No. 1). The extract was then filtrated, and the collected filtrates were exposed to air at room temperature to eliminate the solvent.

2.2 Rearing of insects

In plastic jars holding 300g of corn, 200 adult beetles were introduced. To prevent insects from escaping and enable aeration, the plastic jars were then covered with a muslin cloth and rubber bands. The insects were given three weeks to oviposit before being removed. In bioassays, unsexed beetles aged 2-4 weeks were employed.

2.3 **Repellent activity**:

The filter paper strips were exposed to the plant extracts of different concentrations of 100,200,300 and 400 ppm against the *R.dominica*.After the filter paper was kept in the plastic containers into the arms of the olfactometer. Then the control filter paper with Neem Azal was used. After the attachment of all the plastic vials with the arms, ten pairs of newly emerged adults of *R.dominca* were introduced into the olfactometer and EPI values were calculated by using Lawanda's formula of

$$EPI = \frac{Nt - Nc}{Nt + Nc} X\, 100$$

Where EPI = Excess Proportion Index
Nt = the number of insects in the treated sample; Nc = the number of insects in the control sample side.

2.4 **Insecticidal activity:**

The insecticidal activity was performed on the newly emerged adults against *R.dominica*. The Whatman no.1 filter paper was treated with different concentrations (100, 200, 300 and 400 ppm) of various plant extracts and was allowed to dry for 10 minutes. Then, the filter paper was attached to the cap of the lid internally and in each plastic jar, twenty adults were introduced. Control was treated with Neem Azal. The insecticidal activity was calculated by using Abbott's formula.

$$\mathrm{PO} = \frac{\mathrm{Ts} - \mathrm{Cs}}{\mathrm{Cs}} \mathrm{X100}$$

POD: Percentage of damage. Ts: Number of insects in treated sample. Cs: Number of insects in control.

3.0 RESULT

Repellent activity of different solvent extraction of *Impatiens balsamina*

The repellent activity of hexane extract of *Impatiens balsamina* was tested against the adult beetles of *R.dominica*, and the values of the experiments are shown in figure 1. It was observed that 16.4, 28.7, 46.2, and 70.5% repellent activity in 200, 400, 600, and 800 ppm for 24 hours. Similarly % of repellent activity recorded for 48 hours was 15.7, 30.4, 49.9, and 74.2% at the concentration of 200, 400, 600, and 800 ppm. Finally, the highest activity of 17.7, 30.9, 50.1, and 77.3% were noted for 72 hours at the concentration of 200, 400, 600, and 800 ppm, respectively.

The repellent activity of dichloromethane extract of *Impatiens balsamina* was tested against the adult beetles of *R.dominica* and the values of the experiments are shown in figure 2. It was observed that 17.3, 31.6, 50.5, and 73.1% repellent activity in 200, 400, 600, and 800 ppm for 24 hours. Similarly % of repellent activity recorded for 48 hours was 18.9, 31.0, 56.4, and 80.3% at the concentration of 200, 400, 600, and 800 ppm. Finally, the highest activity of 19.0, 33.8, 65.3, and 80.7% were noted for 72 hours at the concentration of 200, 400, 600, and 800 ppm, respectively.

The repellent activity of ethanol extract of *Impatiens balsamina* was tested against the adult beetles of *R.dominica* and the values pertaining to the experiments are shown in figure 3. It was observed that 18.1, 31.7, 60.5, and 82.8% repellent activity in 200, 400, 600, and 800 ppm for 24 hours. Similarly % of repellent activity recorded for 48 hours was 19.3, 33.8, 62.7, and 89.2% at the concentration of 200, 400, 600, and 800 ppm. Finally, the highest activity of 22.4, 35.6, 67.8, and 94.3% was noted for 72 hours at the concentration of 200, 400, 600, and 800 ppm, respectively.

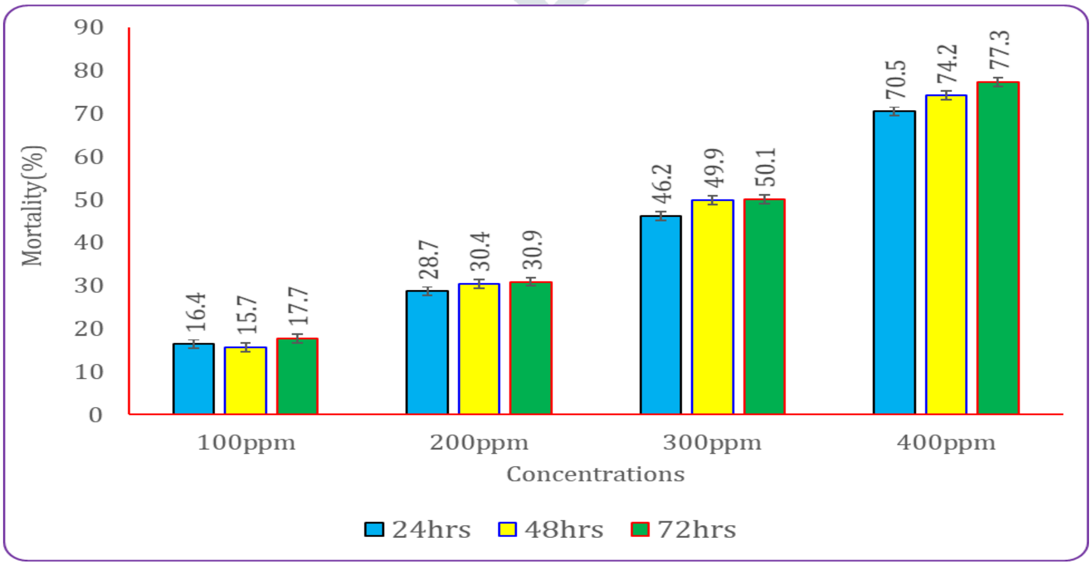

Figure 1: Repellent activity of hexane extract of *Impatiens balsamina* tested against *R.dominica*

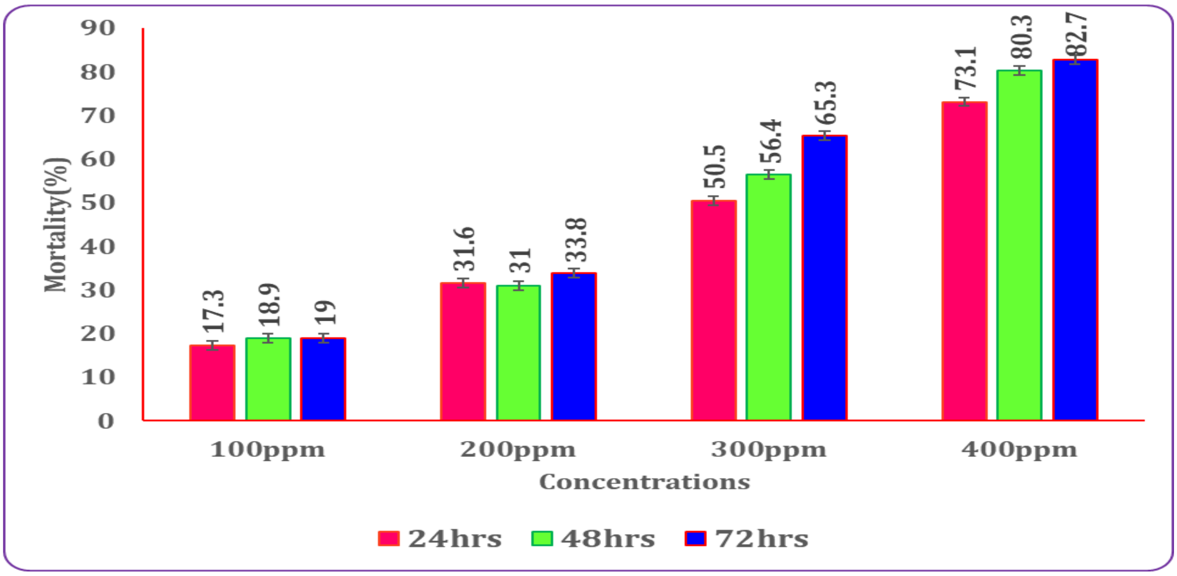

Figure 2: Repellent activity of dichloromethane extract of Impatiens balsamina tested against R.dominica

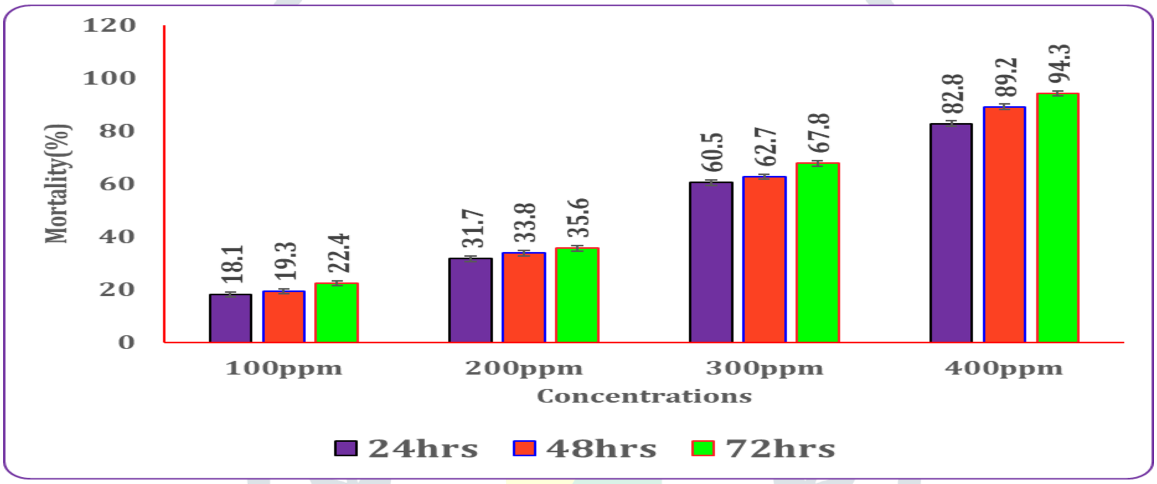

Figure 3: Repellent activity of ethanol extract of Impatiens balsamina tested against R.dominica

The hexane extract was studied for its insecticidal activity against stored grain pest *R.dominica* and data counted are shown in table 1. The filter paper was treated with100, 200,300,400ppm concentrated and it was found that for 24hrs, the insecticidal activity was13.3, 27.8, 38.2and 51.6. Likewise, 48hrs 14.2, 23.6, 32.0 and 50.3 dead insects were recorded. Finally, 16.4, 27.9, 40.5 and 54.7 of mortality of insects were verified. Dichloromethane extract was studied for its insecticidal activity against stored grain pest *R.dominica* and data counted are shown in table 2. The filter paper was treated with 100,200,300,400ppm concentrated and it was found that for 24hrs the insecticidal activity was13.1, 20.6, 44.2and 52.6. Likewise, 48hrs 14.7, 24.4, 47.0 and 53.7 dead insects were recorded. Finally, 15.8, 30.5, 49.5 and 55.3 of mortality of insects were verified. The ethanol extract was studied for its insecticidal activity against stored grain pest *R.dominica* and data counted are shown in table 4.6. The filter paper was treated with 100,200,300,400ppm concentrated, and it was found that for 24 hrs the insecticidal activity was12.6, 23.2, 31.8and 48.3. Likewise 48hrs 14.8, 27.0, 37.6 and 51.1 dead insects were recorded. Finally, 15.3, 30.6, 43.7and 59.4 of mortality of insects were verified.

Table 1: Insecticidal activity of hexane extract of *Impatiens balsamina* tested against *R.dominica*

Concentrations tested (ppm)	Exposure periods (in Hrs)		
	24 Hrs	48Hrs	72Hrs
100	13.3± 1.20^{a}	14.2±0.15^{a}	16.4±0.47^{a}
200	27.8±0.76^{b}	23.6±1.44^{a}	27.9±0.93^{b}
300	38.2±1.04^{b}	32.0±0.89^{a}	40.5±0.22^{c}
400	51.6±0.30^{c}	50.3±0.24^{b}	54.7±0.17^{c}
Neem azal	100.0±0.00 ^{d}	100.0±0.00 ^{d}	100.0±0.00 ^{d}

The values are mean mortality ± S.D. of five replications. At the *p<0.01*% level, values with distinct alphabets demonstrate statistical significance (DMRT).

Table 2: Insecticidal of dichloromethane extract of *Impatiens balsamina* tested against *R.dominica*

Concentrations tested (ppm)	Exposure periods (in Hrs)		
	24 Hrs	48Hrs	72Hrs
100	13.1± 0.62^{a}	14.7±1.21^{a}	15.8±0.34^{a}
200	20.6±1.40^{b}	24.4±0.79^{a}	30.5±1.15^{b}
300	44.2±1.17^{b}	47.0±1.28^{a}	49.5±1.09^{c}
400	52.6±0.98^{c}	53.7±0.75^{b}	55.3±0.11^{c}
Neem azal	100.0±0.00 ^{d}	100.0±0.00 ^{d}	100.0±0.00 ^{d}

The values are mean mortality ± S.D. of five replications. At the *p<0.01*% level, values with distinct alphabets demonstrate statistical significance (DMRT).

Table 3: Insecticidal activity of ethanol extract of *Impatiens balsamina* tested against *R.dominica*

Concentrations tested (ppm)	Exposure periods (in Hrs)		
	24 Hrs	48Hrs	72Hrs
100	12.6± 0.66^{a}	14.8±1.19^{a}	15.3±0.42^{a}
200	23.2±0.93^{b}	27.0±0.24^{a}	30.6±1.69^{b}
300	31.8±1.12^{b}	37.6±1.13^{a}	43.7±1.17^{c}
400	48.3±1.01^{c}	51.1±0.74^{b}	59.4±0.25^{c}
Neem azal	100.0±0.00 ^{d}	100.0±0.00 ^{d}	100.0±0.00 ^{d}

The values are mean mortality ± S.D. of five replications. At the *p<0.01*% level, values with distinct alphabets demonstrate statistical significance (DMRT).

4.0 DISCUSSION

Rhyzopertha dominica is a dynamic pest that attacks various stored grains, rice, wheat, sorghum, and tubers. They cause quantity losses, also deteriorating the quality during storage due to their feeding activities. The goal of this study was to assess the degree of exposure to the pest *R. dominica* and the damage it produced to cereals during the storage period.The breakfast cereal used in the learning were sorghum, wheat, corn, rice grain, white rice, black glutinous rice, and white glutinous rice. The technique used in this investigation was a no-choice bioassay with variables observed: the amount of F1 progeny, median improvement time and damage cereals. According to the findings, sensitive cereals should not be stored for long periods to avoid grain weight loss (Hendrival *et al*., 2019). Gvozdenac S *et al*., (2018) reported that aqueous extract of *S. montana* caused mortality of adults and the level of this mortality depending on different concentrations and exposure period of the experiment. At the same time, Hampton *et al*., (2019) study indicate that Infrared radiation is a drying process that kills insects and microbiological pests. Internal offspring and feeding damage were analyzed using X-ray technology since *R. dominica* grows inside. To support the present findings, several authors have earlier reported that the plant extracts have potential to mitigate the infestation rate of pests on various stored grains. For example, Ishtiaq Ahmad *et al., (*2016) have studied and observed maximum mortality in *P. nigrum*. Likewise Tahir Bad Shah *et al*., (2015) were analyzed that the five indigenous medicinal plants extracts were tested at different concentrations of repellency effect against *Rhyzopertha dominica* during 10 days of the exposure period.

Valdeany Núbia De Souza *et al*., (2016) were were reported that the fumigant toxicity of *O. basilicum* essential oil against *R. dominica* was high. However, all oils estimated the fumigating property to promote the control of *R. dominica* and confirmed potential use in the management. The present findings are also attributed to the findings of Joshi Rashmi and Gaur Neeta (2018) and Lixia *et al*., (2019). Finally, it can be concluded that the natural plant extracts can verify the best alternatives to chemical repellentsm (Fajarwati *et al*., 2019). Similarly, the oil of *Aloe vera* was produced significant fumigant toxicity to *Aphis nerii* (Ebadollahi and Setzer, 2020). Jinan Malik Kalaf (2021) have reported that essential oils with all their phytoconstituents greately reduced the pest infestation and notably increased the germination potential. Further, Herbal preparation was initiate to be extremely toxic to assorted age cultures of all three major stored grain insect pests was verified as 100% mortality achieved at a dose of 200 µg/L in 72 h exposure, correspondingly (Jacobs Mobolade Adesina *et al*., 2019). Khan *et al*., (2020) have reported that the decreasing order of antixenosis percentage of botanicals such as, D. *stramonium*, *A. indica* and *M. oleifera*, respectively. Hence it concluded that the deltamethrin and cypermethrin prompted maximum antibiosis against *R. dominica* compared to botanicals and control treatment. Muhammad *Imran et al*., (2021) were investigated the insecticidal and cytotoxic potential of *Ajuga bracteosa against Rhyzopertha dominica*, *Trogoderma granarium*, *Tribolium castaneum*, *Sitophilus oryze*, and *Callosobruchus analis*. The maximum mortality rate of insecticidal activity was recorded by n-hexane followed by ethyl acetate extract.

The amount of adult insects (male and female) present, the quantity of females present, and the percentage of weight loss were the experimental variables for the free-choice test conducted by Ludji Pantja Astuti *et al*., (2021). The no-choice examination revealed that as the initial moisture content increased, the rice varieties became more inclined. No adult emergence was detected in all the preserved grains.Acetonic extracts were best used to decrease *R. dominica* infestations in stored sorghum (Ramlatu Abubakar *et al*., 2021). Sylvia Awino Opiyo (2021) investigated the repellent efficacy of *Ocimum suave* extracts and compounds in the control of *P. truncates*. The insecticidal and repellant characteristics of cherry and black pepper seeds was reported by Fatma Mohamed Amin Sleem (2021). Muhammad Nawaz Khan *et al*., (2020) investigated the effects of different storage times on insect dispersion and found that plant product impacted. Antixenosis and antibiosis levels were shown to have a negative connection with storage days. Mohanny *et al*., (2020) The embarrassment rates in decreasing the primary generation of *R. dominica* and *S. granarius* adults in grains preserved with numerous extracts were greater than mortality on all concentrations towards selected plant extracts.

5. 0 CONCLUSION

The *Impatiens balsamina* was chosen for this investigation. Its efficacies in repellent and insecticidal activities against the stored grains pest, the lesser borer grains *R. dominica*, were examined. The efficacy of various solvent extracts of plant name was tested at different concentrations were recorded and computed. The data about the above experiments reveal that the ethanol extracts of plant name produced remarkable results against the *R. dominica* for all the concentrations and for different exposure times. So it concluded that natural products, primarily plant-based chemicals offer an excellent alternative to synthetic pesticides.

CONFLICT OF INTERESTS

The authors have no conflict of interests.

ACKNOWLEDGEMENTS

The authors expressed sincere thanks to the institutional authorities for their support.

REFERENCES

[1] Abubakar, Ramlatu, Mohammed Suleiman, and Nasir H Wagini. (2021). “Phytochemical and insecticidal properties of some botanical extracts against the lesser grain borer , *Rhyzopertha dominica* F . (Coleoptera : Bostrichidae)”. **9 (2)**: 6–13.

[2] Adesina, Jacobs Mobolade, Anjanappa Raghavendra, Yallappa Rajashekar, and Thomas Inomisan Ofuya. (2019). “Potential use of *Clerodendrum Capitatum* extracts and its formulation for control of three major stored product beetles.” *Food Quality and Safety* **3 (3)**: 179–185.

[3] Ahmad, Ishtiaq, Mansoor-ul-Hasan, Muhammad Rashid Arshad, Muhammad Fahad Khan, Hafeez-ur-Rehman, Syed Muhammad Ali, and Muhammad Arshad. (2016). "Efficacy of different medicinal plant extracts against *Rhyzopertha dominica* (Fabr .) (Bostrichidae : Coleoptera)." *Journal of Entomology and Zoology Studies* **4 (6)**: 87–91.

[4] Ali, Zeeshan, and Urooj Mazhar. (2018). "Toxic effects of *Nigella sativa* against *Rhyzopertha dominica* (Coleoptera: Bostrichidae)." *Journal of Agricultural Science and Botany* **02 (04)**: 4–7.

[5] Asiry, Khalid A., and Ahmed A. Zaitoun. 2020. "Evaluation of the toxicity of three plant extracts against the khapra beetle *Trogoderma granarium* Everts (Coleoptera: Dermestidae) under laboratory conditions." *Revista de La Sociedad Entomologica Argentina* **79 (1)**: 5–12.

[6] Astuti, Ludji Pantja, Gatot Mudjiono, Siti Ch Rasminah, and Bambang Tri Rahardjo. (2021). "The physical and biochemical characteristics of resistance in different rice varieties and initial moisture content for their susceptibility to *Rhyzopertha dominica* F. (Coleoptera: Bostrichidae)." *Walailak Journal of Science and Technology* **18 (1)**: 1–11.

[7] Bashir, Tariq. (2001). "Reproduction of *Rhyzopertha dominica* (F.) (Coleoptera: Bostrichidae) on different host-grains." *Pakistan Journal of Biological Sciences* **5 (1)**: 91–93.

[8] Buonocore, E., D. Lo Monaco, A. Russo, H. P. Aberlenc, and G. Tropea Garzia. (2017). "*Rhyzopertha dominica* (F., 1792) (Coleoptera: Bostrichidae): A stored grain pest on olive trees in sicily." *EPPO Bulletin* **47 (2)**: 263–268.

[9] Cheraghi Niroumand, Mina, Mohammad Hosein Farzaei, Elahe Elahe Karimpour-Razkenari, Gholamreza Amin, Mahnaz Khanavi, Tahmineh Akbarzadeh, and Mohammad Reza Shams-Ardekani. (2016). "An evidence-based review on medicinal plants used as insecticide and insect repellent in traditional Iranian medicine." *Iranian Red Crescent Medical Journal* **18 (2)**1-8.

[10] Deshwal, Rajat, P K Gupta, Visvash Vaibhav, Nitin Kumar, and Ankit Kumar. (2018). "Biology of lesser grain borer (*Rhyzopertha dominica* Fab .), under different temperature and humidity at laboratory condition." *Journal of Entomology and Zoology Studies* **6 (4)**: 364–368.

[11] Ebadollahi, Asgar, and William N. Setzer. (2020). "Evaluation of the toxicity of *Satureja Intermedia* C. A. Mey essential oil to Storage and greenhouse insect pests and a predator ladybird." *Foods* **9 (6)**: 1–12.

[12] Edde, Peter A., Thomas W. Phillips, and Michael D. Toews. (2005). "Responses of *Rhyzopertha dominica* (coleoptera: bostrichidae) to its aggregation pheromones as influenced by trap design, trap height, and habitat." *Environmental Entomology* **34 (6)**: 1549–1557.

[13] Fajarwati, Dewi, Ludji Pantja Astuti, and Toto Himawan. 2019. "Growth and development of *Rhyzopertha dominica* fabricius (coleoptera: bostrichidae) on white, red and black rice." *The Journal of Experimental Life Sciences* **9 (2)**: 81–89.

[14]Farag, Shaimaa M., Mohamed A. Hussein, Soryia E. Hafez, Amany S. Khaled, Omnia M. Kamel, and Ola H. Zyaan. (2021). "Larvicidal, biological, and histopathological alterations induced by pomegranate peel extract, *Punica granatum* against *Culex pipiens* l. (Diptera: Culicidae)." *Egyptian Journal of Aquatic Biology and Fisheries* **25 (2)**: 139–161.

[15]Gitahi, Stephen Maina, Mathew Ngugi Piero, David Nganga Mburu, and Alex Kingori Machocho. (2021). "Repellent effects of selected organic leaf extracts of *Tithonia diversifolia* (Hemsl.) A. Gray and Vernonia Lasiopus (O. Hoffman) against *Sitophilus Zeamais* Motschulsky (Coleoptera: Curculionidae)." *Scientific World Journal*.

[16]Giunti, Giulia, Orlando Campolo, Pasquale Caccamo, Francesca Laudani, and Vincenzo Palmeri. (2021). "Volatile infochemicals from *Rhyzopertha dominica* larvae and larval feces involved in *Theocolax elegans* host habitat location." *Insects* **12 (2)**: 1–12.

[17] Gvozdenac, Sonja, Jovana Šućur, Ana Manojlović, Dejan Prvulović, and Dorde Malenčić. (2018). "Influence of winter savory (*Satureja montana*) aqueous extract on mortality of lesser grain borer (*Rhyzopertha dominica)*." *Botanica Serbica* **42 (2)**: 277–281.

[18] Hampton, Rachel M., Griffiths G. Atungulu, Zephania Odek, Virginie Rolland, Terry J. Siebenmorgen, Shantae A. Wilson, and Tanja McKay. (2019). "Assessment of *Rhyzopertha dominica* (F.) progeny and feeding damage on rice dried with infrared radiation." *Journal of Stored Products Research* **81**: 69–75.

[19] Hendrival, Hendrival, Dhea Afriani, and Dewi Sartika Aryani. (2019). "Susceptibility and damage cereals to infestation *Rhyzopertha dominica* (f.) (coleoptera: bostrichidae) in storage." *Journal Agro* **6 (1)**: 57–65.

[20] Imran, Muhammad, Hasnain Jan, Shah Faisal, Sajjad Ali Shah, Sumaira Shah, Muhammad Naeem Khan, Muhammad Taj Akbar, Muhammad Rizwan, Faheem Jan, and Suliman Syed. (2021). "*In vitro* examination of anti-parasitic, anti-alzheimer, insecticidal and cytotoxic potential of *Ajuga bracteosa* wallich leaves extracts." *Saudi Journal of Biological Sciences* **28 (5)**: 3031–3036.

[21] Joshi, Rashmi, Neeta Gaur, Ashish Devrani, and Mritunjoy Barman. (2019). "Repellency of neem oil against Red rust flour beetle, *Tribolium castaneum* Herbst, (Coleoptera:Tenebronidae) and lesser grain borer, *Rhyzopertha dominica* (Fabricius) (Coleoptera: Bostrichidae)." *International Journal of Current Microbiology and Applied Sciences* **8 (01)**: 521–524.

[22] Junior, J Nolasco, and P R D E Massaguer. (2019). "Thermal death kinetics of *Cryptolestes pusillus* (Schonherr) *Rhizopertha dominica* (Fabricius) and *Tribolium confusm* (Jacquelin du val) using a heating block system.*Insect*.**10(119)**: 2-13.

[23]Khan, I., A. Qamar, S. H. Mehdi, and M. Shahid. (2011). "Histopathological effects of *Datura alba* leaf extract on the midgut of *Periplaneta americana*." *Biology and Medicine* **3 (2)**: 260–264.

[24]Khan, Muhammad Nawaz, Naima Din, Muhammad Babar, Shahzad Afzal, Misbah Ashraf, and Ummara Khan. (2020). "Antixenotic and antibiotic impact of synthetic and plant extracted chemicals against *Rhyzopertha dominica* (Fabricius) (Coleoptera : Bostrichidae) at different storage periods in stored wheat" **5**: 52–58.

[25]Khani, Mousa, Rita Muhamad Awang, Dzolkhifli Omar, and Mawardi Rahmani. 2013. "Toxicity, antifeedant, egg hatchability and adult emergence effect of *Piper nigrum* L. and *jatropha curcas* L. extracts against rice moth, *Corcyra cephalonica* (Stainton)." *Journal of Medicinal Plants Research* **7 (18)**: 1255–1262.

[26]Koehler, P. G., and R. M. Pereira. (2012). "Lesser grain borer, *Rhyzopertha Dominica* (Coleoptera, Bostrichidae),"University of Floride .1–2.

[27]Kumar, P. Sudheer, T. Uma Maheswari, and A.P. Padmakumari. (2017). "Comparative biology of *Rhyzopertha dominica* (Fab.) in major cereals." *International Journal of Current Microbiology and Applied Sciences* **6 (7)**: 2205–2210.

[28]Mohamed, Fatma, and Amin Sleem. (2021). "Insecticidal Effect of *Piper nigrum* L . (Pipeaceae) and *Prunus cerasus* L . (Rosaceae) seeds extract against *Rhyzopertha dominica* F . (Coleoptera : Bostrichidae)" **9 (3)**: 245–52.

[29]Mohanny, K.M., A.E. Abd El-Aziz, G.S. Mohamed, and W.A.A. Abazied. (2020). "The Insecticidal activity of some plant-seeds extracts against two coleopteran pest granary weevils *Sitophilus granarius* (Linnaeus.) and the Lesser grain borer *Rhyzopertha dominica* (Fabricius)." *SVU-International Journal of Agricultural Sciences* **2 (1)**: 98–108.

[30]Ncibi, Sarra, Abir Ben amor, and Faten Ben Abdelkader. (2021). "Efficacy of essential oils from *Thymbra capitata* and *Mentha pulegium* from Tunisia on larvae of *Galleria mellonella*." *Uludağ Arıcılık Dergisi* .**21 (1)**: 31–38.

[31]Negbenebor, H.E., and S. Nura. (2020). "Effect of plants powdered extracts against lesser grain borer (*Rhyzopertha dominica*) infestation of stored wheat." *Singapore Journal of Scientific Research.* **10 (4)**: 451–57.

[32]Omran, I. M., N. A. AL Mansour, and K. S. Hassan. (2021). "Effect of mixing of organic solvent plant extracts with pesticide runner on adult of lesser grain borer *Rhyzopertha dominica*." *International Journal of Agricultural and Statistical Sciences* .**16 (1)**: 1827–1833.

[33]Opiyo, Sylvia Awino. (2021). "Repellent Effects of *Ocimum suave* extracts and compounds against *Prostephanus truncatus* Horn". **11 (2)**: 23–27.

[34]Qahtani, A.M. Al, Z.M. Al-Dhafar, and M.H. Rady. 2012. "Insecticidal and biochemical effect of some dried plants against *Oryzaephilus surinamensis* (Coleoptera-Silvanidae)." *The Journal of Basic & Applied Zoology* **.65 (1)**: 88–93.

[35]Sabbour, Magda MA. (2020). "Effect of some essential oils on *Rhyzopertha Dominica* (Coleoptera: Bostrichidae)."*Int. Res. J. Biological Science.*1-6

[36]Sakhi Laraib, Moon Bushra, Shaker Muhammad Afsar Ali, Arslan Muhammad, Rubab Sana, Shahzad Muhammad, and Awais Muhammad. (2020). "Effectiveness of plant extracts (lemon grass and tobacco) and insecticide spinosad against *Tribolium castaneum* and *Rhyzopertha dominica*." *GSC Biological and Pharmaceutical Sciences* .**10 (2)**: 156–60.

[37]Shah, Tahir Bad, Muhammad Saeed, Inamullah Khan, Amanullah Khan, Gul Zamin Khan, Abid Farid, and Shah Masaud Khan. (2015). "Repellency evaluation of selected indigenous medicinal plant materials against *Rhyzopertha Dominica* (Herbst) (Coleoptera: Tenebrionidae)." *Journal of Entomology and Zoology Studies (JEZS)* .**3 (31)**: 65–68.

[38]Souza, Valdeany Núbia de, Carlos Romero Ferreira de Oliveira, Cláudia Helena Cysneiros Matos, and Daiany Keila Florentino de Almeida. (2016). "Fumigation toxicity of essential oils against *Rhyzopertha dominica* (F.) in stored maize grain." *Revista Caatinga* **29 (2)**: 435–40.

[39]Tolba, Eman F M, and Hany A Fouad. 2019. "Bioactivity of some plant extracts against the lesser grain borer , *Rhyzopertha Dominica* (Fabr.) (Coleoptera : Bostrichidae)" *Journal of Phytopathology and Pest Management*.**6 (1)**: 32–39.

[40]Ukeh, Donald A, Ene E Oku, Idorenyin A Udo, Abo I Nta, and Jude A Ukeh. (2012). "Insecticidal effect of fruit extracts from *Xylopia aethiopica*".*Chilean Journal of Agricultural Reasearch*. **72** : 195–200.

[41]Vargas, Alessandro N., Denis W.F. De Souza, Adriana M. Freitas, Irineu Lorini, and Joo B.R. do Val. 2016. "A silo for suppressing the population of *Rhyzopertha dominica* (F.) (Coleoptera, Bostrichidae) in stored wheat." *Cogent Food & Agriculture*. **2 (1)**. 1-9.