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Impact of alkaloids extract of *Moringa olievera* Lam. leaves on the development, fertility and demography of the southern cowpea beetle insect *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)

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Abstract

The Southern Cowpea Beetle *Callosobruchus maculatus* (F.) is one of the most widespread insect pests of stored legumes, causing a considerable loss during storage, decreasing the net weight of the crops, and resulting in reduced the quality of the crops. This study has been conducted to determine the lifetime, fertility and life table parameters of *C. maculatus* by using an alkaloids extract from *Moringa oleifera* leaves at different concentrations 1000, 2000, and 3000 ppm. The result was shown that the lowest survival rate was 49% at a concentration of 1000, 2000 ppm, as compared with the control which was 77%. The lowest reproductive rate (Ro) was 4.76 female/female/generation at the concentration of 1000 ppm, compared with the control which was 10.34 female/ female /generation while the lowest rate of egg hatching was 62% at the concentration of 3000 ppm as compared with the control 88%. Similarly, the sex ratio of male: to female was decreased after the use of the three concentrations, mostly at the concentration of 1000 ppm, in which the ratio was 1.31:0.69 compared to 1.11:0.89 for the control. Overall, the life tables curve shows that the survival rate, the ratio of the females and the productivity was affected in a negative way causing a decline in the whole insect population. It is clear from the above that the alkaloids extract of the leaves of the Moringa plant is effective and has an impact on the insect population, and can be an eco-friendly method of controlling on pest population.

Keywords: Alkaloids extract, Callosobruchus maculatus, Insecticidal-activity, Life table, Moringa oleifera.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp.) is an important legume in tropical and subtropical regions that provides nutritious grains with high concentrations of proteins, carbohydrates, lipids, minerals (Fe, Zn and P), vitamins, thiamine, and riboflavin for human consumption [1, 2]. So, it is an important crop economically and nutritionally [3]. After harvest, cowpea beans are stored and used until the following harvest. However, the beans may include storage insects, primarily *C. maculatus* [4].

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The beetle *C. maculatus* (F.) (Coleoptera: Chrysomelidae) is the most harmful storage pest of cowpea (*V. unguiculata* (L.)) seeds. The quality of the stored seeds is quickly reduced when the insect is present [5], which causes a lot of money to be lost [6], and it causes huge losses, up to about 9% in developed countries and 20% or more in developing countries [7, 8].

Many scientific studies have been done on fumigating seeds with different concentrations of organic pesticides to mortality *C. maculatus* while the seeds are in storage. But because some species have become resistant to these chemical materials, they are not enough to get rid of this pest. Also, these pesticides were very expensive, and the peasants had trouble using them because of how they were made. Also, these chemicals could be harmful to the environment if they end up in food waste, and they can mortality other insects that are friendly with the environment [9, 10] so, researchers recently ended up using Inorganic salts and antioxidants can be used instead of pesticides because they work just as well against insects that don't live long, are safe, and cost less. Careful preparation of this material leads to eliminate of insects and achieving the goal in small quantities and in safe substances that lead to eliminate insects in a safe way and do not harm human health [11, 12]. Insect pests have been controlled in ways that are better for the environment by using traditional extracts or products made from plants instead of conventional pesticides made from chemicals. Studies have shown that many plants have materials that are poisonous, repel, or attract insects [13]. *M. oleifera* (Mo), which is in the family Moringaceae, is one of these plants. It has a lot of glucosinolates, which kill insect pests by acting like a biological fumigant [14]. *M. oleifera* grows in the tropics. It is called a "miracle tree" or "wonder tree" because it has a lot of social and economic benefits because it is used in pharmaceutical, nutritional, anti-hypertension, and industrial applications [15]. Studies have shown that the plant's leaves have an effect on the pests that live in warehouses [16]. Also, the alcoholic extract of *M. oleifera*. Leaves have useful biological properties that depend on the type of solvent used to get the active ingredients out of the leaves [17]. The phytochemical analysis of Moringa leaves showed the presence of alkaloids, tannins, saponins and phenols as major secondary metabolites present in the leaves of the plant [18]. Alkaloids are toxic secondary metabolites that block ion channels, inhibit enzymes or interfere with neurotransmission leading to the death of insect pests [19]. So, the goal of this study was to find out how well alcoholic extracts of *M. oleifera* leaves protect cowpea *V. unguiculata* (L.) from being infected by southern cowpea beetle as a safe alternative for chemical insecticides, by using age-stage two sex, life table analysis.

Materials and Methods

Insect culture

Cowpea seeds infested with this insect were gathered from Baghdad's local marketplaces. The seeds were cleansed of contaminants and purified by Prof. Imad Ahmed Mahmoud of the entomology laboratory of the College of Science for women at the University of Baghdad identified this insect as the southern cowpea beetle (*C. maculatus*). In order to create a permanent stock culture, 250 g of uninfected cowpea seeds were placed in the sterilized jar 16 × 8 × 8 Cm^3 for 24 hours to verify that they were free of beetle infestation. Males and females of the southern cowpea beetle were then introduced, wrapped with organza fabric, and secured with an elastic band to prevent insects from escaping. The bottles were placed in the incubator at 28± 2 °C and 60± 5% relative humidity, and the colony was continuously replenished [20].

Preparation and Separation of Extraction Leaves *M. oleifera* Alkaloids

Moringa oleifera leaves were collected from the garden of the College of Science Woman - University of Baghdad and diagnosed in the same college. Then the leaves were cleaned, washed from dust with distilled water and dried at room temperature. After the Moringa leaves were well dried, they were crushed by an electric grinder (Monilex Australia Pvt. Ltd.) for 45 s. Samples were stored in airtight glass containers at room temperature until use. Alkaloids were extracted as

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described previously [21] .100g of *M. oleifera* leaf powder was extracted three times with 50% ethanol before being filtered and mixed. In a rotary evaporator set at 50 °C, the mixed ethanol extracts were then concentrated. By adding 10% HCl, the concentrated extracts were brought to pH 2, after which they were extracted three times with ethyl acetate. With a rotary evaporator, the extracts were mixed and concentrated to get rid of the ethyl acetate. With the help of sodium hydroxide, the acidic aqueous solution was brought to a pH 10, and then chloroform was used to extract it three times. After the extracts were mixed and concentrated to eliminate the chloroform, 30 g of alkaloids extract was produced.

Phytochemical screening of alkaloids

1- Mayer's reagent: It consists of mercury chloride $HgCl_2$ and potassium iodide KI, to which a quantity of distilled water is added. Several drops of Mayer's reagent were added to the extract contained in a watch bottle [22].

2- Wagner reagent: It consists of iodine I_2 and potassium iodide KI added to it with distilled water. Several drops of Wagner reagent were added to the extract in an hour bottle [22].

Determination of the insect population growth indicators for *C. maculatus* by using age stage two sex life table

Insects are stage-structured. An accurate description of their stage differentiation is not only important in basic ecological studies, but is also crucial in practical applications such as IPM and biological control. Traditional female age-specific life tables ignore both the male portion of the population and stage differentiation; and are, therefore, incapable of accurately describing insect development and reproduction. The age-stage, two-sex life table includes both sexes and precisely describes the stage differentiation in raw data analysis; moreover, it produces a solid relationship between the mean fecundity and net reproductive rate (R0) via mathematical proof. By incorporating the stage-specific predation or consumption rate, the age-stage, two-sex life table offers a promising method for studies involving predator-prey relationships, biological control programs, economical injury levels in IPM, and determining the precise timing of various control measures[23] .

The effect of three concentrations of the alcoholic extract of the leaves of the *M. oleifera* plant was tested on the indicators of the growth of the insect population, as the fertility and life tables were adopted to test this effect.

The life table and fertility were regulated by rearing the beetle under standard conditions. The early-emerging insect 24 hour's age was isolated from a small test colony taken from the original colony. After the emergence of the insect, the males were separated from the females, by distinguishing them based on their size, as the females are larger than the males, in addition to the presence of two dark bands at the end of the female's abdomen. 10 adults (5 males, 5 females) were placed in a plastic petri dish (6 cm diameter) with 3 replications for each concentration in addition to the control treatment. Then the adults were treated with concentrations 1000, 2000, and 3000 ppm by spraying them with a 100 ml hand sprayer from a distance of about 10 cm to ensure that the insect was exposed well, then left to dry. Then 15 healthy cowpea seeds were added to each dish and incubated under standard incubation conditions. The beetle was followed daily, and the number of eggs laid daily and the survival rates of adults were recorded. 30 eggs were isolated for each replicate and left until emergence. After emergence, a newly emerging pair (male and female) was taken and placed in a plastic petri dish, and healthy and infested cowpea was added to it by 14 replicates for each concentration. Then follow up and record, the number of eggs laid/ day and the number of dead adult/ day.

Life table analysis of *C. maculatus* (L.)

Individual *C.maculatus* life history raw data were analyzed using the TWO-SEX-MSChart program12, which is based on the age-stage, two-sex life table theory [23] and the method described by Chi. [24,25]. As follows:

Survival rate (sxj)

(x = age, j = stage), which is the probability that a newly laid egg will survive to age x and stage j, and fecundity fxj, which is the number of hatched eggs produced by a female adult at age x were calculated.

The age-specific survival rate (lx) was then computed.

Ix=Nx/N0
Where,
Ix survival rate through age x,
Nx number of individuals at the end of the age stage x,
N0 number of individuals at the beginning of the age stage x.
Mx=Fx/nx
Where,
Mx female productivity of eggs at the age stage x,
Fx total eggs laid at the age stage x,
nx number of live females at the age stage x.
mx = number of female from productivity of eggs at the age stage x,
By knowing the survival rates and productivity rates, it was possible to extract the net reproductive rate(Ro) and average generation length(T) e generation Mean, The rate of internal increase in population(rm) Intrinsic rate of increase, specific rate of population increase(λ), (DT)h how long does it take for a population to double? as follows:
Ro=∑ 〖lx.mx〗
Where,
Ro as the net Reproductive rate (number of productive females/female/generation),
∑ 〖lx.mx〗 the sum of the product of multiplying the life expectancy rates of females with the age productivity rates
Tc=∑ 〖X.lx.mx〗 /∑ 〖lx.mx〗
Where,
Tc cohort generation time (in days)
∑ 〖X.lx.mx The sum of the product of multiplication lx.mx with the age group X,
∑ 〖lx.mx〗 as the net compensation rate.
T = ln Ro/rm
T the corrected generation time
rc = ln Ro/Tc
rc innate capacity for increase
Ln. Ro the inverse of the logarithm of the net compensation rate,
Tc cohort generation time (in days)
rm= $\sum e^{-rm.X} l_X m_X = 1$
Where,
rm rate of intrinsic increase in population, the maximum population growth, the intrinsic rate of natural increase or the innate capacity for increase (females/female/day)
$\lambda = e^{rm}$
Where,
λ the finite rate of increase, the number of female offspring per female per day
e represent antiloge Against the natural logarithm and its amount=2.718,
rm rate of internal increase.
DT=In2/rm
DT doubling time, the number of days required by a population to double,

Results

Phytochemical screening of alkaloids

1- Mayer reagent: The result was the appearance of a white precipitate, evidence of positive detection [26].
2- Wagner reagent: This resulted in the appearance of a brown precipitate as evidence of positive detection [26].

Life table analysis of *C. maculatus* (F.)

The results in Table 1 give information on the population growth of *C. maculatus* after treatment with concentrations of 1000, 2000 and 3000 ppm of the alkaloids extract of *M. oleifera*. First, it can be seen in the table that the highest median survival was at 3000 ppm concentration which is 51%, while the lowest median survival at 1000 and 2000 ppm concentration was 49% respectively. In addition, the survival rates (lx) for the three concentrations decreased compared to the control of 77%. The results of the statistical analysis showed a significant difference in the survival rates between the three concentrations and the control treatment. This indicates that alkaloids extract concentrations have an effect on *C. maculatus* survival rate (lx). Moreover, it is clear from the Table 1 that the net reproduction rate (Ro) reaches its lowest level at the concentration of 1000ppm i.e. 4.76 females/female /generation, compared with the control which is 10.34 female/female/generation. Thus, it can be concluded from the results of the statistical analysis

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that there is a clear variation in the three concentrations. Also, the Table 1 gives information about the mean generation length (T) for 1000 ppm concentration which equals 24.58 days, while the (T) for 2000 ppm and 3000 ppm is 24.72 days and 24.6 days, respectively, compared to 24.62 days to control. However, statistical analysis shows that the extract does not cause any significant change in the mean generation length. Regarding the increased capacity (RC) female/female/day, it can be seen that it is equal to 0.063 for the concentration of 1000 ppm compared to 0.08 for the concentration of 2000 and 3000 ppm, while the control treatment is 0.09. Once again, the statistical analysis indicates that there is no significant difference between the concentrations on the one hand and between the concentrations and control on the other hand. Looking at the intrinsic rate of increase (rm) female/female/day, it is 0.08 for each of 2000 and 3000 ppm compared to 0.06 for the concentration of 1000ppm and 0.09 for the control treatment. The statistical analysis shows that there are significant differences between the concentration of 1000ppm and all the concentrations, and there are no significant differences between the concentration of 2000 and 3000 ppm and also between control treatments. As for the finite rate of increase in female offspring per female per day it was found that it was 1.08 for each of 2000 and 3000 ppm compared to 1.06 for the concentration of 1000ppm and 1.09 for the control treatment, as well as the statistical analysis between the presence of a significant difference only in the concentration 1000 ppm from the rest of the concentrations, as well as between it and the control. Moreover, both the 2000 and 3000 ppm concentrations have the same weekly multiplication rate which is equal to 1.75, while it is 1.52 for the 1000 ppm concentration, and 1.88 for the control treatment. Statistical analysis showed that there was no significant difference between concentrations 2000 and 3000, while it was clear between concentrations 1000 and other concentrations and between the studied concentrations compared with the control treatment. The table 1 gives information about the corrected generation time (Tc) for the three concentrations 1000, 2000 and 3000 which are 26, 24.82 and 25.34 days, respectively, compared to 25.96 days for the control. However, there is not much difference between the concentrations. About the doubling time of the population, it reaches its highest level at a concentration of 1000 ppm, which is equivalent to 10.92 days, while it reaches its lowest level of 8.41 at a concentration of 3000 ppm, compared to the control treatment of 7.31 days. In fact, statistical analysis indicates significant difference between the 1000ppm concentration on one side, and the other and the control treatment on the other side. On the other hand, there was no significant change between the concentrations of 2000 and 3000 ppm or between them and the control treatment. The study showed that the fecundity rate or the number of eggs laid by a female reaches its highest level of 42.44 egg at a concentration of 3000ppm, while it becomes at its lowest level of 34.55 egg at a concentration of 1000ppm. It is worth noting that the fecundity rate of the control treatment is 32.75 egg .The statistical analysis showed that there was no significant change between the concentrations 1000 and 2000, but it was significant between the concentration of 3000 and the other two concentrations, as well as between all concentrations and the control. the results also showed that the fertility (percentage of hatching eggs) decreased gradually with increasing the concentration of the alkaloid extract, as the lowest percentage of hatching for eggs was recorded, which amounted to 62% at a concentration of 3000 ppm, while at a concentration of 1000 ppm it recorded 77%, while the highest percentage of fertility was recorded when the control treatment 88 %. The results of the statistical analysis indicated that there were significant differences between the fertility (hatching eggs) at the three concentrations, in addition to the control treatment. The results also showed in the Table1 that there was no effect of the different concentrations of the alkaloid extract on the longevity of the male and female the insect. No significant differences were recorded between the longevity when treated with different concentrations and with the control. As for the sex ratio (female: male), it was not affected much in the different treatments, as the ratio between males and females of the insect was close to (1:1) with a slight tendency to increase the proportions of males compared to females.

Table 1. Population growth Indicators of *Callosobruchus maculatus* when treated with different concentrations of alkaloid extract of *Moringa oleifera*

Population Growth Parameters	Concentration (ppm)				LSD0.05
	1000	**2000**	**3000**	**control**	
Survival rates % (from egg to adult)	49	49	51	77	2.97
Net reproduction rate (R0)	4.76	7.28	7.59	10.34	1.34
Cohort generation time (in days) (TC)	24.58	24.72	24.6	24.62	0.96
Capacity of increase (rc) female/female /day	0.063	0.08	0.08	0.09	0.019
Intrinsic rate of increase (rm)	0.06	0.08	0.08	0.09	0.019
Finite rate of increase (λ)	1.06	1.08	1.08	1.09	0.019
Weekly multiplication rate	1.52	1.75	1.75	1.88	0.19
Corrected generation time (T)/day	26	24.82	25.34	25.96	1.63
Doubling time (DT)/day	10.92	8.63	8.41	7.31	1.88
Fecundity (Mx)	34.55	42.42	42.44	32.75	1.93
Fertility (% egg hatching)	77	72	62	88	2.49
Male longevity (day)	5.5	5.21	5.07	5.71	1.88
Female longevity (day)	4.0	5.14	4.86	5.43	1.88
Sex ratio (male: female)	1.31 :0.69	1.09 : 0.91	1.08:0.92	1.11: 0.89	

Fig. 1 showed some information derived from life tables where the figure appears the relationship between the survival rates of the insect, its egg productivity and the sex ratio of the female during the life cycle of the *C.maculatus* after using three concentrations 1000, 2000, 3000 ppm of alkaloid extract of *Moringa oleifera* leaves It can be observed when using 1000 ppm of alkaloid extract, the first day of laying eggs was two days after the appearance of the beetle, which corresponds to the 24th day of its life cycle. In addition, the highest survival rate for when using this concentration was 49% and the highest number of eggs laid by each female was 14.35 egg and the number of females was 4.95 egg according to the sex ratio. On the contrary, on the sixth day of a female's life the lowest number of eggs being laid was on the 28th, which was 0 eggs when the survival rate was 0.02. As for the results, after using the concentration of 2000 ppm, the first laying of eggs was after two days from the emergence of the mature beetle, and the survival rate reached 49% and which corresponded to the 24th day of the life cycle. the highest number of eggs was 16.99 eggs for each female and noted that the number of females is 7.73 according to the sex ratio, while the lowest rate of laying eggs on the sixth day of female life was (0), and the survival rate was 0.07%. Regarding the results after using the concentration of 3000 ppm concentration, the first egg laying was after two days from the emergence of a mature female, and the highest survival rate was 51%, which occurred on day 24 of the life cycle. and the highest number of eggs laid by each female was 17egg.The number

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of females was 7.73 female, according to the sex ratio, It is worth noting that the lowest rate of laying eggs was on the sixth day of life, the female was zero and the survival rate was 0.07%. In addition, it has been noticed that control treatment, has begun laying eggs after two days from the emergence of the female. At the same time, the survival rate reached its highest level, which is 77%, and the highest number of eggs laid was 16.79 egg and the number of females was 7.47 female according to the sex ratio. However, the average of the lowest eggs laid on day 28 of the life cycle corresponding to the sixth day of a female's life was zero, meanwhile, the beetle's survival rate was 0.14%.

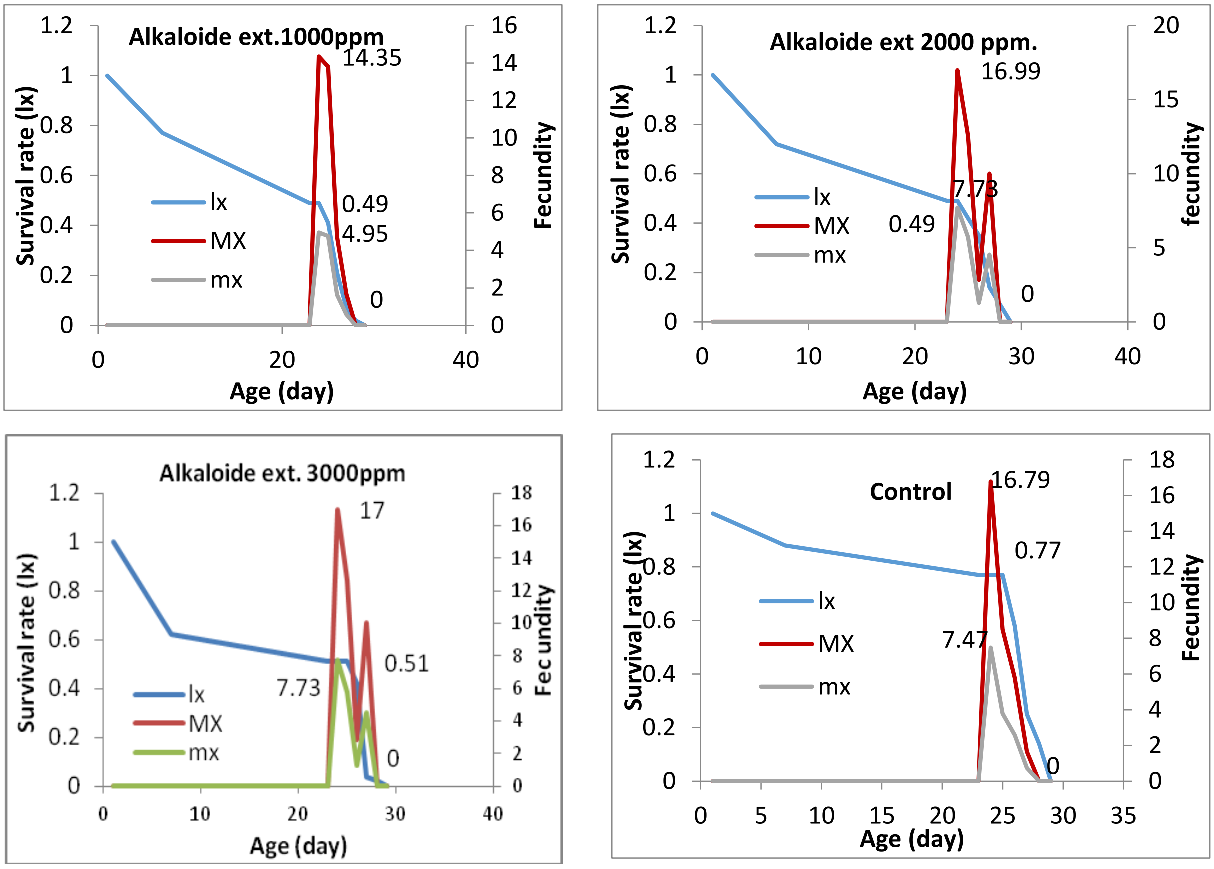

Figure 1. Survival rate (lx) and fecundity (Mx) curves of *Callosobruchus maculatus* when treated by Alkaloids extract of *Moringa oleifera*

Discussion

Understanding pest parameters is essential in Integration Pest Management (IPM). Our results showed that using the alcoholic extract of *M, oleifera* leaves in different concentrations 1000, 2000, and 3000 ppm reduced the survival rates (lx) of *C. maculatus*. This is due to the fact that the secondary compounds of plants, including alkaloids, may delay or speed up development or interfere with the life cycle of insects in other ways Earlier, [26] reported that alkaloids have a toxic and anti-nutritional effect on storage insects. This observation is consistent with the results of [27],[28] it was reported that alkaloids, when increased in concentration, are better anti-appearances and more effective against immature stages of *C. maculatus*. Hence alkaloids in increasing concentrations may have acted as ovulatory (active against eggs) and larvicides (active against larvae). This result is consistent with the work of the researcher [29, 30] where he used extracts and powders of each of *zanthoxyliodes*, *A. occidentale* and *M. oleifera*, which contain alkaloids in preventing the

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emergence of the insect and inhibiting its development. Here, it turns out that the lower the survival rates, the less damage to cowpeas, whereas [30] indicated that the extent of damage during storage depends on the number of adults for each generation, the life span and the diversity of the host. Also, the net compensation rate (Ro) decreased compared to the control treatment, an indication that the alkaloid extract reduced the number of females that replace a female in the generation a higher rate of population increase was observed in the populations of females treated with insecticides. It was noted that the three alkaloid extracts of Moringa leaves - compared to the comparison group - have a clear effect in reducing the egg hatching rate. The noticeable decrease in egg hatching can be linked to the fact that the extracts affected their general metabolic activities, including sexual activities, as indicated by [31,32] that plant extracts have the ability to pass through the chorion of eggs and thus prevent further development. Jaafar [33, 34] mentioned that there was a significant effect of radish seeds and leaf extract Radish *Raphanus sativus* L containing alkaloids on the hatchability of cowpea beetle eggs for three generations, as the hatching rate of eggs decreased in the second and third generations than in the first generation. The results in the table also show the variation in the numbers of females and males that appeared between the treatments, and the concentration of 1000 shows the lowest percentage of females versus males, and this result is close to other results of [35],[36] Where it was shown that extracts of *Moringa oleifera*, *Ziziphus joazeiro* reduced the appearance of male and female C. maculatus. In addition, the alkaloid extracts slightly shortened the longevity of the female at a concentration of 1000, and this contradicted the result of [37],[38] where the methanol extract of leaves *Anchomanes difformis* (Blume) Engl and containing alkaloids was recorded the lowest mortality rate and longest lifespan for *Callosobruchus maculatus* 18.43-86.67% due to the presence of some bioactive compounds. However, the results showed an increase in the number of eggs laid by the female for the three concentrations compared to the control coefficient. However, the results show an adaptive reproductive strategy adopted by the females of the southern cowpea beetle, which seems to increase their daily fertility in line with the alkaloid extract that reduced their survival rates.

Conclusion

These results are of particular interest to those who seek to use biological insecticides such as alkaloid extract of *M. oleifera* leaves to control the pests of stored products. It is worth noting that the use of the lowest doses can have a significant and obvious effect on survival, hatchability and female rates. Where does this help the laboratory study in evaluating the nature of the insect population treated with the alkaloid extract and with the completion of the study of life tables in the future and for several field generations can develop and evaluate appropriate control programs and develop integrated control programs for the insect economic importance.

Authors' Declaration

- Conflicts of Interest: None.
- We hereby confirm that all the Figures and Tables in the manuscript are ours. Furthermore, any Figures and images, that are not ours, have been included with the necessary permission for re-publication, which is attached to the manuscript.
- The author has signed an animal welfare statement.
- Ethical Clearance: The project was approved by the local ethical committee in University of Baghdad.

Authors' Contribution Statement

H. I.AS. and S.A. K conceived of the presented idea and supervised the findings of this work. While T. N.J. did all the experiments and verified the analytical methods .All authors discussed the results and contributed to the final manuscript.

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تأثير المستخلص القلويدي لأوراق *Moringa oleifera* Lam. في تطور وخصوبة سكان حشرة خنفساء اللوبيا الجنوبية *Callosobruchus maculatus* (F.) (Coleoptera: Bruchidae)

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الخلاصة

تعد خنفساء اللُّوبْياء الجنوبية *Callosobruchus maculatus* وَاحِدة مِن أكْثَر الآفَات الحشريَّة إنْتشارًا وتدْميرًا لِلْبقوليَّات المخْزونة ، اذ تسبب خسائر كَبِيرَة أَثْنَاء التَّخْزين ، وتقليل في الوزْن الصَّافي لِلْمحاصيل ، واضعاف قُدْرتِهَا على النُّموِّ الامر الذي يؤدِّي إلى تَقلِيل جَودَة المحاصيل . لِذَا أُجريت هَذِه الدِّراسة لِتحْدِيد تاثير تراكيز مختلفة 1000 ، 2000 و 3000 جزء بالمليون من المستخلص القلويدي لاوراق نبات المورينكا *Moringa oleifera* في بعض مؤشرات النمو للحشرة متمثلة بجداول الحياة والخصوبة ذات الجنسين. تمَّ إسْتخْدام هذَا المسْتخْلص كمبيد حيوي للحشرة فضلا عن عدم سُميَّة لِلْإنْسان والْبيئة بِشَكل عامٍّ . أَظهرَت النتائج أنَّ أقلَّ مُعدَّل بَقَاء للحشرة كان 49 % بِترْكِيز 1000 و 2000 جُزْء فِي الملْيون مُقَارنَة بمعاملة السيطره وَالتِي كَانَت 77 % . كمَا أنَّ أقلَّ مُعدَّل للتعويض الصافي (Ro) كان 4.76 انثى / انثى / جيل بِترْكِيز 1000 جُزْء فِي الملْيون مقارنة عند معاملة السيطرة 10.34 انثى / انثى / جيل ، بيْنمَا سجل أقلَّ مُعدَّل لفقْس البيْض 62 % بِترْكِيز 3000 جُزْء في الملْيون مُقَارنَة مع معاملة السَّيْطرة 88 %. وبالْمثْل ، إنْخفضتْ نِسبَة الذُّكور إلى الإنَاث بَعْد إسْتخْدام التراكيز الثَّلاثة ، ومعْظمهَا بِترْكِيز 1000 جُزْء فِي الملْيون ، حَيْث كَانَت النِّسْبة (ذُكُور : إنَاث) 1.31 : 0.69 مُقَابِل 1.11 : 0.89 لِلسَّيْطرة . بِشَكل عامٍّ ، أنَّ مُعدَّل البقَاء ، ونسب انتاجية الاناث تَأثرَت بِشَكل سَلبِي مِمَّا يؤشر الى اِنخِفاض فِي سكان الحشرات في الجيل القادم . يَتضِح مِمَّا سبق أنَّ المسْتخْلص القلْويديَّ لِأوْرَاق نَبَات المورينْجَا فَعَّال وله تَأْثِير على سكان الحشرة ، وَيمكِن أن يَكُون وَسِيلَة صَدِيقَة لِلْبيئة لِلسَّيْطرة على تَعْداد *C . maculatus*

الكلمات المفتاحية: المستخلص القلويدي , Callosobruchus maculatus , فعالية المبيدات الحشرية , جدول الحياة, Moringa oleifera.