Population Trend, Host Susceptibility and Damage Study on the Eucalyptus Gall Wasp *Ophelimus maskelli* (Ashmead) (Hym., Eulophidae) in Jordan

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ABSTRACT

Results showed that there are three generations per year for the eucalyptus gall wasp *Ophelimus maskelli* (Ashmead) (Hym., Eulophidae) in Jordan. It was found that the pest is active during spring, summer and early autumn; starting from March to late November. Low parasitism rate was noticed against this pest not exceeded 9%. *Eucalyptus camaldulensis* was the most susceptible eucalyptus species to the pest and *E. torquata* was the most resistant species among the seven investigated species grown in Jordan. The pest is widely distributed in Jordan due to the wide distribution of the susceptible *E. camaldulensis* allover the country. More than 90% reduction in eucalyptus stem diameter increment was recorded due to 90% of pest infestation for plants of three year-old and less compared with the control. Therefore, searching for effective natural enemies and introducing resistant plant species for controlling this serious pest is of vital importance.

Keywords: *Ophelimus maskelli,* Eucalyptus Gall Wasp, *Eucalyptus camaldulensis,* Eucalyptus Susceptibility, Damage.

INTRODUCTION

Eucalyptus plantation plays an important role in soil conservation, management of rain runoff and production of wood and wood fiber. It also considered a major source of timber and food source for foraging honeybee as along with its use in recreation areas (Mendel *et al.*, 2004). Six serious pests have been reported to invade the eucalyptus trees forests in the Mediterranean region including the gall wasps, *Ophelimus maskelli* (Ashmead) (Mendel *et al.*, 2004; Ramadan, 2004), and *Leptocybe invasa* Fisher and La Salle (Hymen., Eulophidae) (Mendel *et al.*, 2004). The detrimental impact of these exogenous pests on the growth of eucalyptus trees was attributed to high infestation level resulted from the lack of natural enemies in the new region that may remain beyond in the native region, Australia (Mendel *et al.*, 2004). The gall wasps have an adverse effect on their host by removal the nutrients and making galls on the plant tissues (Stone and Schonrogge, 2003). Heavy leaf galling results in pre-mature shedding of the leaves. Furthermore, there is a sample evidence that adult wasps caused many health problems near heavily infested trees in which the respiratory system is disturbed during the mass emergence of adults which acts as wasp clouds (Laudonia *et al.*, 2006). Moreover, the attraction of the wasps to the green color is probably the reason for their mass occurrence in field crops surrounded by eucalyptus trees. Thus, lettuce growers, for example, face

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Received on 11/11/2014 and Accepted for Publication on 16/4/2015.

difficulties in marketing their crop in Australia because of the presence of the wasps inside (Protasov *et al.*, 2007).

The gall wasp, *O. maskelli* was found to develop populations buildup rapidly; it produces more than one generation per year in Italy (Bagnoli and Roversi, 2004; Lo Verde *et al.*, 2009) and three generations in Palestine (Protasov *et al.*, 2007). The gall wasp was active throughout the warm period but no activity was detected between November and March. Intensive flight was noticed in the spring in Palestine with the emergence of the overwintering gall-makers (Protasov *et al.*, 2007). In Australia, numerous parasitic species were found attacking *O. maskelli;* including *Stethynium ophelimi* Huber, *Stethynium breviovipositor* Huber (Huber *et al.*, 2006) and *Closterocerus chamaeleon* (Girault) (Branco *et al.*, 2009). Among the 84 eucalyptus species tested, 14 species like *E. camaldulensis* and *E. tereticornis* were detected to be susceptible for infestation by *O. maskelli*. The findings of Ramanagouda *et al.* (2010) suggested that *E. camaldulensis* and *E. tereticornis* are more susceptible to attack than the other species.

The goals of the present study were to monitor the *O. maskelli* activity, specifically the emergent periods of the adults for two successive years, to screen the resistant eucalyptus species grown in Jordan against such a pest and to assess the pest damage to eucalyptus using *E. camaldulensis* saplings.

MATERIALS AND METHODS

Population trends of Eucalyptus gall wasp

One to two-year-old *E. camaldulensis* saplings were used to monitor the population trends of the pest throughout the year. At monthly intervals, twenty eucalyptus saplings were naturally exposed to the wasp infestation in one site in Amman area (32 0 56.29N 35 50 40.35E) and another in Jordan Valley (32 5 14.19N 35 39 40.93E) for two successive 2012 and 2013 years. The potted saplings were put in the two sites near eucalyptus forests to be infested. These sites represented two different geo-climatic areas (cold semi-arid climate for Amman and hot arid climate for Jordan Valley) and had well-established populations of the gall wasp as noticed in the last two years. Before and after the saplings natural exposure to infestation, plants were kept inside 2x2x2m cages covered with fine muslin, to keep them insect–free. Random leaf samples (each composed of 50 leaves) were monthly excised and kept inside transparent plastic boxes specified for the period of the exposure until the insects emerge. The number of the emerged wasps from leaves sample was monthly recorded. The temperature data were monthly received from the Amman Meteorological Station.

Population trends of parasitoids associated with the pest

Random samples of 50 eucalyptus leaves each, infested with the *O. maskeli* were monthly collected from eucalyptus forests located in Amman and Jordan Valley for two successive years from January to December. The leaves were kept inside ventilated transparent plastic boxes until the insects emerged. The emerged insects were sorted into parasitoids and/or pest wasps. The emerged parasitoids were counted and recorded.

Susceptibility of different Eucalyptus speceis to the O. maskelli

Two variables were considered for the susceptibility test of the eucalyptus species; the infestation percentage and the pest adult emergence percentage. The percentage of the pest emergence was used because it reflected the success of the pest in the development.

At early spring, 5 plants (two-year-old) of each of the seven *Eucalyptus* species were placed in one location. These are: *E. camaldulensis*, *E. globulus*, *E. grandis*, *E. tereticornis*, *E. torquata*, *E. trabuti* and *E. woodwardii*. At mid of March, the percentage of infestation was estimated per sapling. All the infested leaves were detached and the galls were counted. The galled leaves were placed inside a transparent plastic box. The numbers of the emerged pest wasps were recorded per plant and per eucalyptus species. The percentages of wasp emergence were calculated in relation to the number of galls.

Effect of pest infestation on plant growth

Healthy plants of 3 different groups of age; one, two and three-year's old plants, were naturally exposed to the pest infestation during early spring. The plants of each group, which showed gradient percentages of infestation, were selected for accessing the pest damage using the stem-base diameter as a criterion (Schreuder *et al.*, 1993). Saplings in all treatments were labeled with numbers and then the stem diameter at the base was measured while the plants were healthy and then measured at the end of the one year of infestation. Another three groups of plants of the same three ages were kept free of pest infestation inside cages covered with fine muslin at the same period of time served as controls. The plant growth increments were calculated and compared with the control treatments. The severity of infestation was evaluated and related to the plant stem growth increment. *E. camaldulensis* was used in this experiment as a bioassay host species.

Statistical analysis

The statistical analysis was performed using the proc GLM of the statistical package SigmaStat version 16.0 (SPSS, 1997). The Complete Randomized Design (CRD) was used in the plant susceptibility test and means were separated by the Least Significant Difference (Steel and Torrie, 1980). The best fit line was used in modeling the relationship between the infestation and the plant growth was determined using the regression analysis. The coefficients of determination (R^2) were also determined for all plant ages investigated (Draper and Smith, 1998).

RESULTS

The pest adults emerged in February formed the first and the highest peak at April in Jordan Valley in both years (Figure 1, C and D). In Amman area, the pest appeared one month before in 2013 than 2012 and also the first peak appeared one month before (Figure 1, A and B). The second peak was after two months of the first one in both areas during the two years. It was in July in Amman area and in June in the Jordan Valley during 2012 and in June in both areas during 2013. The third peak occurred between September and October and the insects disappeared starting November in Amman area when temperature dropped below 20˚C. In Jordan Valley, the third peak of the pest was occurred between August and September and the insects disappeared in late November. Therefore, three generations per year were noticed in both areas (Figure 1). The highest peak of insects' emergence was the first one which was emerged from the overwintering pupae when temperature rose above 11˚C. The parasitoids activities were minor most of the year in both areas and years of the study (Figure 1). In both years, parasitoids activity started one month before in Jordan Valley than in Amman area. They started between February and March in Jordan Valley and between March and April in Amman Area (Figure 1). The highest recorded number of parasitoids was 160 in Jordan Valley during April which forms only 9% parasitism (Figure 1, D).

E. camaldulensis had significantly the highest percentage of infestation (64%) [$F_{6,28}$=104.5, P<0.0001] and had also the highest wasp emergence percentage (82.4%) [$F_{6,28}$=613.8, P<0.0001] (Figure 2). On the contrary, *E. torquata* showed the lowest infestation percentage (2%) [$F_{6,28}$=104.5, P<0.0001] and prevented the insect development which was reflected by a neglected percentage of wasp emergence (1%) [$F_{6,28}$=613.8, P<0.0001]. Moreover, *E. woodwardii* showed a moderate infestation level (22%) [$F_{6,28}$=104.5, P<0.0001] and also prevented the pest development; where only 6% of the wasps emerged [$F_{6,28}$=613.8, P<0.0001].

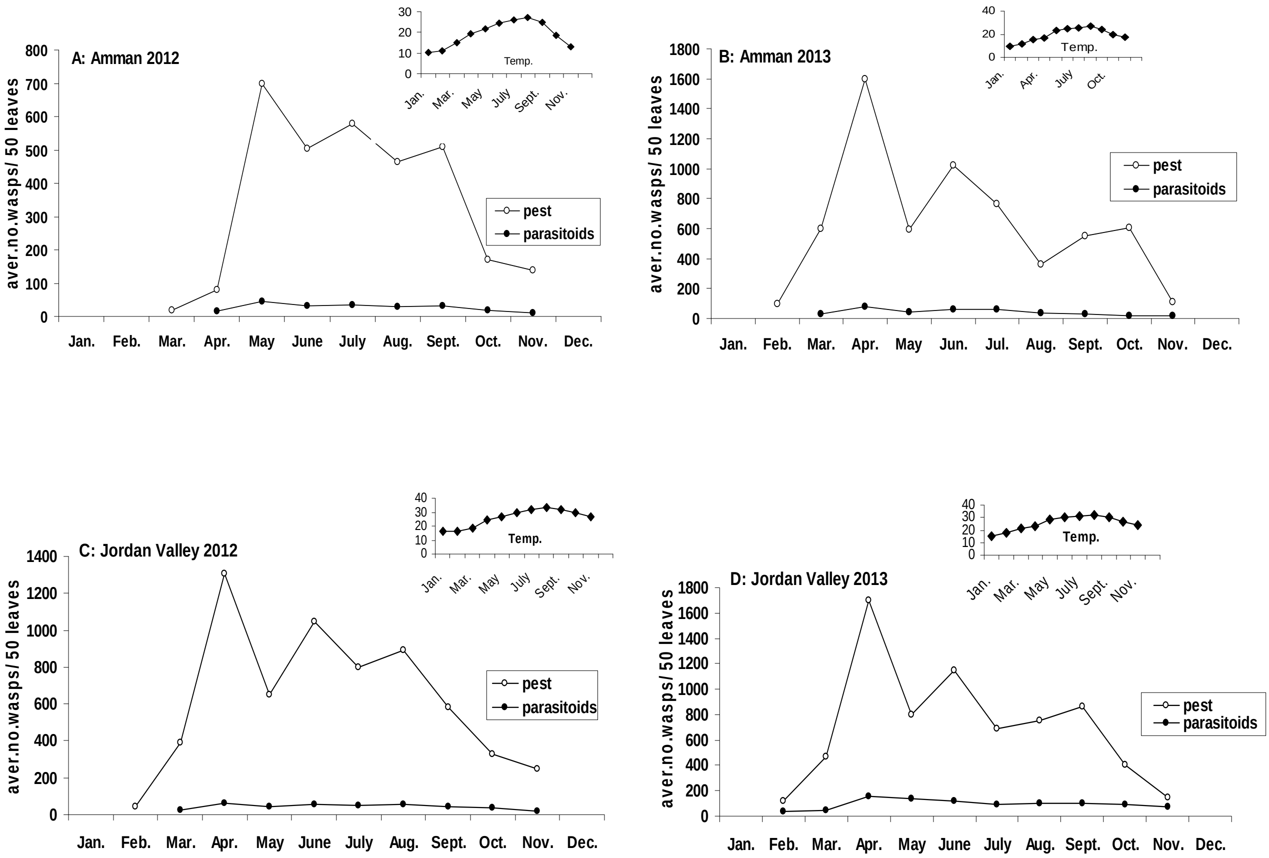

Figure (1): Yearly emergence trends of *Ophelimus maskelli* (-◦-) and its associated parasitoids (-•-) by area (Amman; A, B and Jordan Valley; C, D) for two years (2012;A, C and 2013; B, D), associated with the temperatures

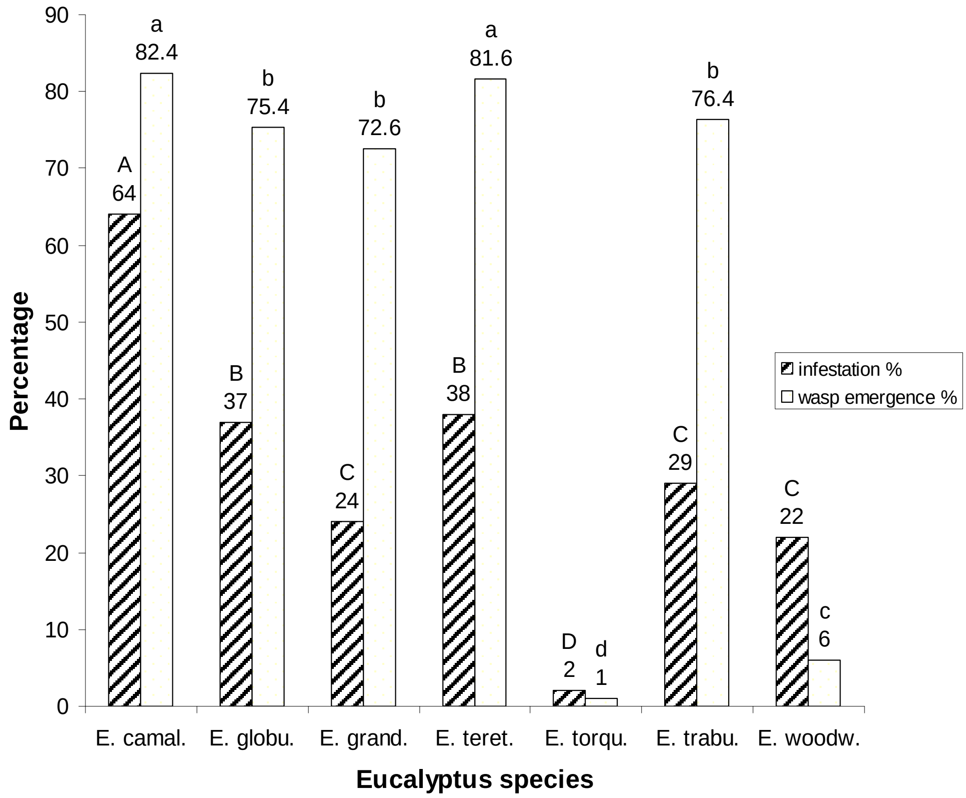

Figure (2): Susceptibility of eucalyptus to *Ophelimus maskelli* based on infestation % and wasp emergence %. [Bars represent means. Means that share the same letter do not differ significantly by a LSD test (P = 0.05). Capital letters are for comparisons of infestation %, lower case for comparisons of wasp emergence %].

There was a negative relationship between the infestation level and the plant stem growth increment. This indicated that at high percentages of infestation, the stem growth increment is low (Figure 3). The coefficients of determination ranged from R^2=0.959 [$F_{(1,5)}$=116.4, P<0.0001] to R^2=0.961 [$F_{(1,5)}$=122.9, P<0.0001]. It means that by about 96% the regression lines represented the data. The linear extracted models were: [y= -0.299× + 27.6] for one year-old plant, [y= -0.264× + 29.38] for two year-old plants, and [y= -0.254× + 28.92] for three year-old plants (Figure 3). At zero infestations, the stem diameter increment was 27% for both the two and the three-year old plants. At 90% of infestation, the stem diameter increments were 3% and 4% for the two and three year-old plants, respectively. The loss in stem growth is estimated by about 90%. For the one year-old plants, the stem diameter increment was 25% at no infestation. Whereas, at 80% of infestation, the stem growth increment was 2% and the loss was about 92%.

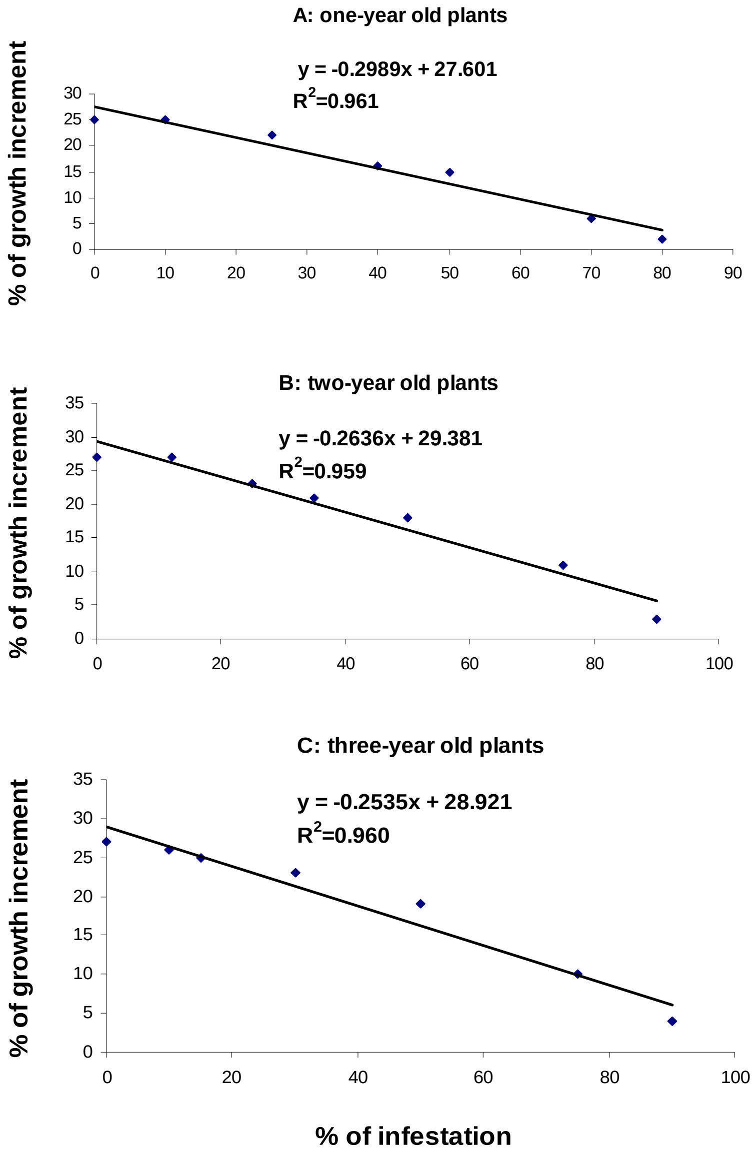

Figure (3): Scatter diagram with a line of best fit curve of obtained stem growth increment percentages as a function of infestation percentages due to *Ophelimus maskelli* infestation for one (A), two (B) and three (C) year-old *Eucalyptus camaldulensis* saplings.

DISCUSSION

Understanding the natural history of insect pests is fundamental to the success of any pest management program. The dynamics of pest populations are a basic component of pest management systems because details are needed in order to develop predictive models and control agendas (Waters and Stark, 1980). Moreover, predicting the timing of particular stages in the life cycle of pest insects is important for studies of their population dynamics and for forecasting pest insect attacks (Nylin, 2001). Therefore, the current study is the first one dealing with *O. maskelli* threatening eucalyptus in Jordan. It came after noticing a large damage to the eucalyptus trees, especially in the last five years. In addition, *O. maskelli* was recently added to the European and Mediterranean Plant Protection Organization alert list as a quarantine pest (EPPO, 2006).

Three generations of the pest were noticed in Jordan, similar number of generations was also found by Protasov *et al.* (2007) in Palestine. Moreover, our results are in line with findings of Mendel *et al.* (2007), who indicated that the insect may produce two or three generations annually. The early generation appeared when adults emerged from their over wintering galls in Jordan Valley in spring between early to mid-March. Adults' insects started emergence in Amman area two weeks later. Then the two other emergence peaks were followed in mid August and late November while maintaining the same two-week interval differences between the two areas. The times of emergence in the two areas seemed to be driven by the effect of temperature; about 5-6 degrees is the difference between the two areas and the increment is for the benefit of Jordan Valley. Spodek (2007) found nearly the same trend; in which the adult emergence in the highlands of Palestine occurred a month later of the south-eastern areas. He attributed this difference in the wasp emergence time to the accumulated temperatures. According to Mendel *et al.* (2004), the gall wasp prefers warmer climates. A few numbers of parasitoids associated with the pest were noticed most of the time. Thus the lower percentages of parasitism have increased the insect damage and subsequently increased the economic importance of the pest. This low parasitism activity was attributed to the fact that the pest is an imported one (Protasov *et al.*, 2007). It was introduced from Australia to the Mediterranean basin (Sánchez, 2003; Mendel *et al.*, 2004), including Jordan, where the pest entered without being accompanied by its natural enemies (Protasov *et al.*, 2007). Only two unidentified species of parasitoids were recorded in both areas of the study. These parasitoids were moved to Jordan from Palestine where more than four species were released in Palestine (Huber *et al.*, 2006). Furthermore, host plant played an important role in increasing the threat of the pest. About twenty species of eucalyptus were introduced into Jordan, most of them did not succeed to establish, and only seven of them succeeded (personal communication). These seven acclimatized species were propagated and cultivated all over Jordan. The most adapted and distributed species in Jordan is *E. camaldulensis*. It is one of the best known *Eucalyptus* species outside Australia. Economically it is the most important hardwood species of the dry-lowland areas in the entire Mediterranean and Middle East regions (CABI, 2005; FAO, 1979). Results of the susceptibility test showed that *E. camaldulensis* was the most susceptible one to the pest attack among the seven investigated eucalyptus species. The same results were obtained in Tunisia by Dhahri *et al.* (2010). *E. camaldulensis* is also known to be one of the most susceptible hosts to the closest species to *O. maskelli*, which is *L. invasa* (Mendel *et al.*, 2004; Branco *et al.*, 2009; Thu, *et al.*, 2009; Krishnakumar and Jacob, 2010).

This explains the wide spread and the large damage of such pest in almost all regions of Jordan. On the other hand, *E. torquata* was the most resistant species to the pest. This species is characterized by its slow growth rate in the Jordanian environment, and therefore it did not spread too much, and this is contributed to increase the economic importance of this pest. The damage assessment of the pest clarified that the pest is of economic importance in Jordan and the young saplings of eucalyptus particularly *E. camaldulensis* is at high risk. In conclusion, three generations of the eucalyptus gall wasp, *O. maskelli* were noticed in Jordan. The pest is widely distributed in Jordan due to the wide distribution of the susceptible *E. camaldulensis* species in the country. Therefore, searching for effective natural enemies and resistant host species is of vital importance for development of well-planned control program.

REFERENCES

Bagnoli, B. and Roversi, P.F. 2004. Annotazioni morfologiche e biologiche su un Eulofide di recente introduzione in Italia galligeno fogliare su Eucalipto. *In:* Atti XIX Cogresso Nazionale italiano di Entomologia, Catania 10-15 giugno 2002, Sondrio, pp. 955-960.

Branco, M., Boavida C., Durand. N., Franco J.C. and Mendel. Z. 2009. Presence of the *Eucalyptus* gall wasp *Ophelimus maskelli* and its parasitoid *Closterocerus chamaeleon* in Portugal: first record, geographic distribution and host preference. ***Phytoparasitica***, 37 (1): 51-54.

CABI. 2005. Forestry Compendium. CABI International, Wallingford. http://www.cabi.org/compendia/fc/

Dhahri, S., Ben Jamaa M.L. and Lo Verde, G. 2010. First record of *Leptocybe invasa* and *Ophelimus maskelli* eucalyptus gall wasps in Tunisia. ***Tunisian Journal of Plant Protection***, 5: 229-234.

Draper, N.R. and Smith H. 1998. Applied Regression Analysis, Wiley-Interscience.

EPPO. 2006. First records of *Ophelimus eucalypti* on eucalyptus in Italy, Greece and Spain, ***EPPO Reporting Service***, 2006-09: 188.

FAO. 1979. Eucalyptus for Planting, FAO Forestry Series, 11, FAO, Rome, Italy.

Huber, J.T., Mendel; Z., Protasov, A. and La Salle, J. 2006. Two new Australian species of *Stethynium* (Hymenoptera: Mymaridae), larval parasitoids of *Ophelimus maskelli* (Ashmead) (Hymenoptera: Eulophidae) on Eucalyptus. ***Journal Natural History***, 40 (32/34): 1909-1921.

Krishnakumar, N. and Jacob, J. 2010. Eucalyptus gall – A recent invasive in man-modified forest ecosystem in Andhra Pradesh. ***Karnataka Journal Agricultural Sciences***, 23 (1): 217-219.

Laudonia, S., Viggiani G. and Sasso, R. 2006. Parasitoide esotico in aiuto degli eucalypti. ***Informatore Agrario***, 40: 74.

Lo Verde, G., Rizzo R. and Barraco, G. 2009. Dannosita e controllo di *Ophelimus maskelli* (Ashmead) su *Eucalyptus camaldulensis* in vivaio, Atti III Congresso Naz. Selvicoltura, Taormina, 16-19 ottobre 2008: 1409-1412.

Mendel, Z., Protasov A., Blumberg, D. Brand D., Saphir, N., Madar Z. and LaSalle, J. 2007. Release and recovery of parasitoids of the *Eucalyptus* gall wasp *Ophelimus maskelli* in Israel. ***Phytoparasitica***, 35 (4): 330-332.

Mendel, Z., Protasov A., Fisher, N. and LaSalle, J. 2004. The taxonomy and biology of *Leptocybe invasa* gen and sp. n. (Hym., Eulophidae), an invasive gall inducer on Eucalyptus. ***Australian Journal Entomology***, 43: 101-113.

Nylin, S., 2001, Life history perspectives on pest insects: what's the use? ***Australia Ecology***, 26: 507-517.

Protasov, A., LaSalle, J., Blumberg, D., Brand; D., Saphir, N., Assael F., Fisher N. and Mendel Z. 2007. Biology, revised taxonomy and impact on host plants of *Ophelimus maskelli*, an invasive gall inducer on *Eucalyptus* spp. In the Mediterranean Area. ***Phytoparasitica***, 35 (1): 50-76.

Ramadan, H.M. 2004. Morphological characteristics and distribution of *Aprostocetus* sp. (Hym., Eulophidae: Tetrastichinae) a gall wasp of eucalyptus new for Egypt. ***Alexandria Journal Agricultural Research***, 49: 59-63.

Ramanagouda, S.H., N. Kavithakumari; Vastrad, A.S., Basavanagoud, K. and Kulkarni, H. 2010. Potential alien insects threatening eucalyptus plantations in India. ***Karnataka Journal Agricultural Sciences***, 23 (1): 93-96.

Sánchez, I. 2003. Descubiertas dos nuevas plagas del eucalipto en España. ***Quercus***, 214: 32-33.

Schreuder, H.T., Gregoire T.G. and Wood, G.B. 1993. Sampling methods for multiresource forest inventory. John Wiley and Sons, Inc.: 285.

Spodek, M. 2007. Injury and population assessment tools for the eucalyptus gall wasp *Ophelimus maskelli* (Ashmead), M. Sc. Dissertation, The Hebrew University of Jerusalem, Rehovot-Israel.

SPSS, Statistical Product and Service Solutions INC. 1997. SIGMASTAT 2.03: SigmaStat Statistical software user's manual, Chicago, United States.

Steel, R.G. and Torrie, J.H. 1980. Principles and Procedures of Statistics, 2nd Edn., McGraw-Hill Text, New York, USA: 633.

Stone, G.N. and Schonrogge K. 2003. The adaptive significance of insect gall morphology. ***Trends Ecology Evolution***, 18: 512-521.

Thu, P. Q., Dell, B. and Burgess, T. I. 2009. Susceptibility of 18 eucalypt species to the gall wasp *Leptocybe invasa* in the nursery and young plantations in Vietnam. ***Science Asia***, 35: 113–117.

Waters, W.E. and Stark, R.W. 1980. Forest pest management: concept and reality. Annual ***Review Entomology***, 25: 479-509.

دراسة تغيرات أعداد وحساسية العائل وضرر دبور درنات الكينا *Ophelimus maskelli* (Ashmead) (Hym., Eulophidae) في الأردن

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ملخص

لوحظت ثلاثة أجيال في الأردن لدبور درنات الكينا *Ophelimus maskelli* في السنة. ووجد أن الآفة تكون نشطة خلال فصول الربيع والصيف وبداية الخريف، ابتداءً من شهر آذار وحتى نهاية شهر تشرين الثاني. ولوحظ تدني معدل التطفل على الآفة حيث لم تتجاوز النسبة 9%. وكان نوع الكينا *Eucalyptus camaldulensis* هو الأكثر حساسية للإصابة بالآفة بينما كان *Eucalyptus torquata* هو النوع الأكثر مقاومة من بين الأنواع السبعة التي تزرع في الأردن. وتبين أن الآفة واسعة الإنتشار في الأردن بسبب الإنتشار الواسع للنوع الحساس *E. camaldulensis* في كافة أرجاء الأردن. وقد وصلت الخسارة في زيادة قطر ساق النباتات إلى ما يزيد عن 90% بسبب الإصابة والتي وصلت الى 90% في الشتلات ذوات عمر ثلاث سنوات وما دون مقارنة بالزيادة في الشاهد. لذا أصبح البحث عن أعداء طبيعية فاعلة وإدخال أنواع نباتات مقاومة لمكافحة هذه الآفة الخطرة ذو أهمية.

الكلمات الدالة: *Ophelimus maskelli*، دبور أوراق الكينا، *Eucalyptus camaldulensis*، حساسية الكينا للإصابة، الضرر.

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تاريخ استلام البحث 2014/11/11 وتاريخ قبوله 2015/4/16.