Oak Forests Infestation by *Tortrix viridana* and its Performance on Three *Quercus* Species

Yaussra Mannai, Olfa Ezzine, and Mohamed Lahbib Ben Jamâa, Laboratoire de Gestion et de Valorisation des Ressources Forestières, Institut National de Recherches en Génie Rural, Eaux et Forêts, Université de Carthage, Ariana, Tunisia

ABSTRACT

Mannai, Y., Ezzine, O., and Ben Jamâa, M.L. 2018. Oak forests infestation by *Tortrix viridana* and its performance on three *Quercus* species. Tunisian Journal of Plant Protection 13 (si): 171-181.

The Tunisian oak forests are susceptible and sensitive to invasion of various pests, among them, the green oak leaf roller, *Tortrix viridana*, which is considered one of the most destructive defoliators of oak trees in the western Palearctic region. Important defoliations caused by this pest have been observed in different cork oak forests of north-western Tunisia. The study was carried out in five native cork oak (*Quercus suber*) forests (Ain El Baya, Bellif 1, Bellif 2, Bellif 10, and El Jouza), one zeen oak (*Q. canariensis*) forest Mzara and the Ain Zena forest which is a mixed cork oak, zeen oak and afares oak (*Q. afares*) located in the north-west of Tunisia. The average number of larvae per branch varied significantly between sites (6.6 ± 0.77 larvae/branche in El jouza and 0.11 ± 0.05 larva/branche on *Q. afares* in Ain Zena forest). Budburst timing did not differ between *Q. canariensis* and *Q. afares* whereas that of *Q. suber* occurred about 3 weeks later than the other two species. As the host plant phenology differs from species to another, the larval survival and their development are likely different across the host plant species. Feeding performance of the green oak leaf roller was determined on three host plants including *Q. suber*, *Q. canariensis* and *Q. afares* under laboratory conditions. Larvae grew best on *Q. suber*. Total larval development time from the 1^{st} to the 5^{th} instar was shorter on *Q. suber* (24.92 ± 0.26 days) than on *Q. canariensis* (26.69 ± 0.29 days) and *Q. afares* (29.03 ± 0.39 days). Larval mortality of the three host plants did not differ significantly while for the pupal weight, data showed a significant difference where 35.52 ± 9.44, 30.43 ± 8.25, and 22.95 ± 5.34 mg of pupae from the larvae reared on *Q. suber*, *Q. canariensis* and *Q. afares* were noted, respectively.

Keywords: Infestation, oaks, performance, *Tortrix viridana*, Tunisia

---

Early spring feeding Lepidoptera demonstrate synchronization of larval emergence with host leaf flush (Jones and Despland 2006). They can show reduced survival and performance if they miss the phenological window of young foliage (Scriber and Slansky 1981). In Tunisia, oak forests are subjected of various aggressions, mainly by insect attacks. The early spring green oak moth, *Tortrix viridana*, is one of the most important defoliators of oaks in the western Palearctic region (Du Merle 1999a). Their larvae can cause complete defoliation during outbreaks (Rubtsov and Utkina 2003). Significant defoliations caused by this insect have been observed in different

Corresponding author: Yaussra Mannai
Email: yaussra.mannai@yahoo.fr

Accepted for publication 24 January 2018

cork oak forests of north-west of Tunisia (Mannai et al. 2010). *T. viridana* has one generation per year (Mannai et al. 2010). Females laid their eggs preferentially on the twig tips and buds of oak trees during the spring. The insect overwinter as eggs on branches, and they hatch in mid-March (Du Merle 1999a; Hunter 1990; Ivashov et al. 2002). Budburst timing varies among and within tree species (Van Dongen et al. 1997). The first larval stage needs newly opened buds for successful development (Hunter 1990). Advances or delays in leafing are important for insect life cycles (Foster et al. 2013). Many studies were investigated on the close coincidence that occurred between the budburst and *T. viridana* larval hatching (Du Merle 1983; Hunter 1992; Ivashov et al. 2002).

Study of the effect of food on the biology of insects is critical for understanding host plant suitability for herbivore species (Yazdanfar et al. 2015). *T. viridana* is oligophagous feeding on oak species (Du Merle 1999b). The quality of trees varies greatly within this plant genus (Kapeller 2009). Information on the process of oak leaf roller infestation in forests is critical for forest management activities (Gooshbor et al. 2016). In Tunisia, Mannai (2017) showed that cork oak (*Quercus suber*), zeen oak (*Q. canariensis*), and afares oak (*Q. afares*) were attacked by *T. viridana* larvae. Besides, there is very little information on the outbreaks of this pest in these forests. Therefore, to estimate the risk of defoliation, we studied the infestation and compared the performance of the oak leaf roller larvae fed on leaves of three oak species of ecological and economic importance. In this research, we studied the larvae density on host plants and their performance and monitored their development time, mortality and pupal weight on the three host species namely *Q. suber*, *Q. canariensis*, and *Q. afares*.

MATERIALS AND METHODS

Study area.

The study was carried out in five native cork oak forests (Ain El Baya, Bellif 1, Bellif 2, Bellif 10 and El Jouza), one zeen oak forest Mzara and the Ain Zena forest which is a mixed cork oak, zeen oak and afares oak located in the north-west of Tunisia (Table 1).

Table 1. Ecological characteristics of the different studied forests

Site	Type of forest	Long.	Lat.	Alt	P	T	Bioclimatic stage
Ain El Baya	cork oak	8°938'	36°65'	380	600	18.8	Sub-humid to temperate winter
Bellif 1	cork oak	9°538'	37°152'	73	1000	18	Wet, sub-floor to mild winter
Bellif 2	cork oak	9°074'	37°029'	162	1000	18	Wet, sub-floor to mild winter
Bellif 10	cork oak	9°014'	37°04'	199	1000	18	Wet, sub-floor to mild winter
El Jouza	cork oak	9°015'	36°513'	550	1222	16	Wet inferior than temperate and mild winter
Mzara	zeen oak	8°72'	36°769'	653	950	16.75	Fresh wet
Ain Zena	cork oak, zeen oak, afares oak	8°515'	36°435'	924	1780	16.1	Wet at mild and temperate winter

Long.: Longitude; Lat.: Latitude; Alt.: Altitude (m), P.: Precipitation (mm), and T.: Temperature (°C)

Budburst phenology and larvae collect.

In 2010, 2011 and 2012, samples of branches were taken weekly from mid-March to the end of April, for six weeks (W1-W6) to collect larvae and nine weeks for budburst, until the first of May (W1-W9). Every week and per host species, two branches from 10 mature trees, one low-level branch (2.5 to 5 m) and one from crown height level (> 5 m) were randomly monitored (Mannai et al. 2017).

Larvae density.

From 2009 to 2013, samples were taken weekly from the beginning of spring to the beginning of summer. Every week, one branch from 10 mature trees per host species was randomly monitored. The branches were carefully cut and conserved in a large plastic bags to prevent losing larvae. In the laboratory, larvae were counted and set in breeding (Mannai et al. 2017).

Laboratory feeding trials.

The performance of *T. viridana* on the three hosts: *Q. canariensis*, *Q. afares* and *Q. suber* was compared in laboratory by feeding trials. Experiments were performed in the spring of 2010, coinciding with the budburst of the host plants. Buds hosting neonate larvae were collected in the field from the three host plants in March 2010. A total of 90 larvae were used for each tested plant. Larvae (n = 270) were individually placed in Petri dishes, kept at 25 ± 2°C in light regime of 12:12 h L:D as in natural conditions and they were reared ad libitum on leaves of the three tested plant species. Young still-expanding leaves were collected daily from plantlets of each species, planted in the same conditions at the nursery of *the Institut National de Recherches en Génie Rural, Eaux et Forêts*, Tunisia. Larvae were checked daily and the number of molted larvae was recorded. Larval development time for each tested oak species was reported. To evaluate larval performance, development time, larvae survival and pupal weight of the 5th instar larvae were assessed on each tested species as biological parameters (Mannai et al. 2017).

Statistical analysis.

The statistical analysis was performed using the SPSS-10.0 software package for Windows. Generalized linear models (GLMs) were applied to the following dependent variables: (1) the Julian day when 50% of budburst occurred (2) the number of larvae per branch, considering the factors host species and year; (3) larvae development (number of days spent in each instar), considering the factor plant species. A normal distribution model best fitted the Julian day when 50% of budburst occurred and larvae development. A Poisson distribution model best fitted the number of larvae per branch. The effect of each tested oak species on the larval development time and the pupal weight were assessed with an analysis of variance (ANOVA) and complemented by multiple comparisons of means by the Student-Newman-Keuls (SNK) test and was expressed as mean ± SE of mean (MSE).

The proportion of dead larvae among the total individuals obtained in the feeding experiments was analyzed by GLM using a Binomial model with log-link function, considering the factor plant species. Results are presented in the form of the Wald's chi-square test value (χ^2), parameter estimates and the respective *P* value.

RESULTS

Budburst variation.

The Julian day when 50% of budburst occurred varied between forests ($\chi^2_2 = 2163.043$, $P < 0.001$) and years ($\chi^2_2 = 2813.4578$, $P < 0.001$). The interaction term was also significant ($\chi^2_4 = 5418.789$, $P < 0.001$). It varied also in Ain Zena forest between host plants ($\chi^2_2 = 13.03$, $P < 0.001$) and years ($\chi^2_2 = 13.78$, $P < 0.001$). The interaction term was also significant ($\chi^2_4 = 18.89$, $P < 0.001$). In the three Bellif forest sites, budburst began in early April, while it started in mid-April and end of April, depending on the year, in Ain El Baya. Budburst in El Jouza occurred about 4-5 weeks later than Mzara (Table 2). In Ain Zena forest, budburst of *Q. afares* and *Q. canariensis* began in late March, but budburst of *Q. suber* occurred about 3 weeks later (Table 3). For all years, *Q. canariensis* and *Q. afares* budburst was before *Q. suber*.

Larval density on host plants.

Larvae in the Bellif 1, Bellif 2, Bellif 10, Mzara and Ain Zena sites were observed between the end of March and the end of May, whereas they were abundant from late spring until summer in Ain El Baya and El Jouza forests. In Ain Zena, no larva was collected on *Q. suber*. The average number of larvae per branch varied between sites ($\chi^2_5 = 433.888$, $P < 0.001$) and years ($\chi^2_4 = 1.081$, $P = 0.01$). The interaction between the two variables was also highly significant ($\chi^2_{20} = 74.455$, $P < 0.001$). El Jouza forest was the most infested in 2009. This rate was also important at Bellif 10. In 2010, the number of larvae decreased progressively in all the oak forests. This rate was also quite high in Bellif 10 and Bellif 2 sites between 2009 and 2011. The number of larvae was low in the Ain El Baya, Mzara and Ain Zena forests (Table 4).

Larval development and mortality.

This investigation highlighted that the total larval development time from the 1st to the 5th instar was shorter on *Q. suber* (24.92 ± 0.26 days) than on *Q. canariensis* (26.69 ± 0.29 days) and *Q. afares* (29.03 ± 0.39 days). The host species had a significant effect on larval development ($F_{(2,206)} = 245.84$, $P < 0.001$); for the 1st instar ($F_{(2,267)} = 4.25$, $P = 0.015$), 2nd instar ($F_{(2,254)} = 5.77$, $P = 0.004$), 3rd instar ($F_{(2,252)} = 6.28$, $P = 0.002$), 4th instar ($F_{(2,249)} = 11.99$, $P < 0.001$) and the 5th instar ($F_{(6,241)} = 4.67$, $P < 0.001$). For each instar larva, the development was faster on *Q. suber* than on *Q. afares* and *Q. canariensis* (Fig. 1).

Mortality of larvae reared on the three host plants was higher on *Q. canariensis* for the 1st, 2nd and 3rd instars of larvae than the other host species. For the 4th and 5th instars, mortality was higher on *Q. afares* than the other host species (Fig. 2).

Pupal weight.

Pupal weight varied significantly among host species ($F_{(2,233)} = 75.957$, $P < 0.001$). It was higher for pupae coming from larvae reared on *Q. suber* with an average of 35.52 ± 9.44 mg than for *Q. canariensis* (30.43 ± 8.25 mg) and *Q. afares* (22.95 ± 5.34 mg) (Fig. 3).

Table 2. Results of budburst monitoring (%) in native oak forests performed in 2010, 2011 and 2012

Time	Mzara			Bellif 1			Bellif 2			Bellif 10			Ain El Baya			El Jouza		
	2010	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**	**2010**	**2011**	**2012**
S1	11. 2	19.3	15.07	0	0	0		0	0	0	0	0	0	0	0	0	0	0
S2	28.3	31.5	21.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S3	49.2	40.14	42.1	14.33	14.17	22.91	0	0	0	0	0	7.51	0	0	0	0	0	0
S4	55.6	61.4	51.35	24.25	31.18	36	3.55	5.65	17.87	2.56	11.02	27.23	0	0	0	0	0	0
S5	67.1	67.3	63.3	43.68	52.55	41.3	19.74	22.81	37	13.19	27.77	40.56	0.85	1.94	20	0	0	1.54
S6	69.15	71.1	68.1	55.65	59.89	62.84	40.33	31.01	47.3	32.39	32.93	56..88	26.64	17.79	31.77	17.23	22.5	16.51
S7	74.02	72.78	69.4	61.46	64.5	64.47	52.67	45.68	51.3	50.04	57.94	60.31	45.79	23.77	47.46	21.68	25.5	31.77
S8	75.32	77.1	71.4	68.86	73.98	72.49	61.43	63.7	58.6	60.9	63	67.93	58.58	42.62	54.28	40.27	38.67	49.2
S9				71.64	75	72.7	62.66	69.76	62	63.29	70.5	69.8	65.96	57.69	62.3	52.82	57.88	57.27
S10				73.15	77.2	79.88	74.74	75.21	65	75	75	74.16	64.69	61.65	69.41	63.86	68	63.33
S11							76	76	70	78	79		70	77.1	71.39	69.1	71	67.51
S12													71	81.82	81.71	70.45	77	73.2
S13																73.4	78.21	

S1: 3rd week of March; S2: 4th week of March; S3: 1st week of April S4: 2nd week of April; S5: 3rd week of April; S6: 4th week of April; S7: 1st week of May; S8: 2nd week of May; S9: 3rd week of May; S10 :4th week of May; S11: 1st week of June; S12: 2nd week of June; S13: 3rd week of June.

Table 3. Results of budburst monitoring (%) of three *Quercus* species performed in Ain Zena in 2010, 2011 and 2012

Time	2010			2011			2012		
	Q. canariensis	*Q. afares*	*Q. suber*	*Q. canariensis*	*Q. afares*	*Q. suber*	*Q. canariensis*	*Q. afares*	*Q. suber*
S1	4.78	2.78	0	1.5	0.54	0	0	3.06	0
S2	11.53	6.14	0	2.38	8.52	0	1.74	10.7	0
S3	26.18	14.06	0	21.6	16.31	0	8.5	19.85	0
S4	44.68	34.28	0	53.77	42.36	0	22.12	30.7	0
S5	59.82	45.25	8.62	71.6	61.16	20.79	34.26	49.8	10.16
S6	72.12	61.67	24.36	76.33	70.78	40.68	45.1	59.84	18.08
S7	75.27	67.87	46.95	79	77.21	52.98	55.7	68.45	37.99
S8	78.48	77.14	53.82	81.77	79.1	61.83	68.39	73.64	48.8

S1: 3rd week of March; S2: 4th week of March; S3: 1st week of April S4: 2nd week of April; S5: 3rd week of April; S6: 4th week of April; S7: 1st week of May; S8: 2nd week of May.

Table 4. Larvae density (Main number of larvae ± SE per branch) in the studied sites between 2009 and 2013

Site	Quercus species	Year				
		2009	**2010**	**2011**	**2012**	**2013**
El Jouza	*Q. suber*	6.6 ± 0.77	5.53 ± 0.7	4.96 ± 0.83	2.43 ± 0.45	3.61 ± 0.57
Bellif 1	*Q. suber*	2.78 ± 0.41	2 ± 0.35	1.88 ± 0.28	1.65 ± 0.27	1.68 ± 0.29
Bellif 2	*Q. suber*	0.81 ± 0.18	1.28 ± 0.32	1.55 ± 0.31	1.31 ± 0.28	0.76 ± 0.17
Bellif 10	*Q. suber*	3.46 ± 0.5	2.76 ± 0.42	1.6 ± 0.33	1.1 ± 0.23	0.55 ± 0.15
Ain El Baya	*Q. suber*	0.56 ± 0.14	0.51 ± 0.16	0.85 ± 0.24	0.88 ± 0.24	0.78 ± 0.18
Mzara	*Q. canariensis*	0.23 ± 0.11	0.03 ± 0.03	0.13 ± 0.06	0.25 ± 0.09	0.21 ± 0.11
Ain Zena	*Q. canariensis*	0.15 ± 0.06	0.36 ± 0.1	0.51 ± 0.17	0.86 ± 0.22	0.75 ± 0.22
	Q. afares	0.05 ± 0.02	0.13 ± 0.05	0.13 ± 0.06	0.11 ± 0.05	0

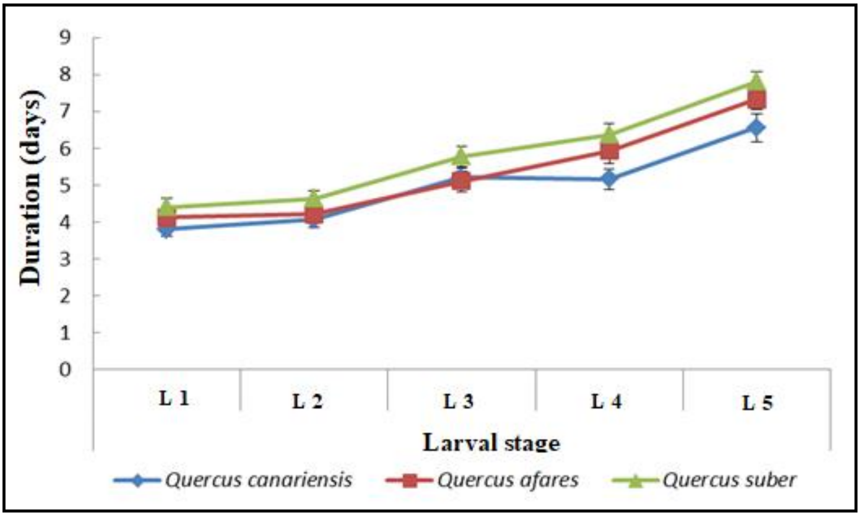

Fig. 1. Development time of *Tortrix viridana* in days (± SE) from 1st to 5th instar larvae on the tree *Quercus* species.

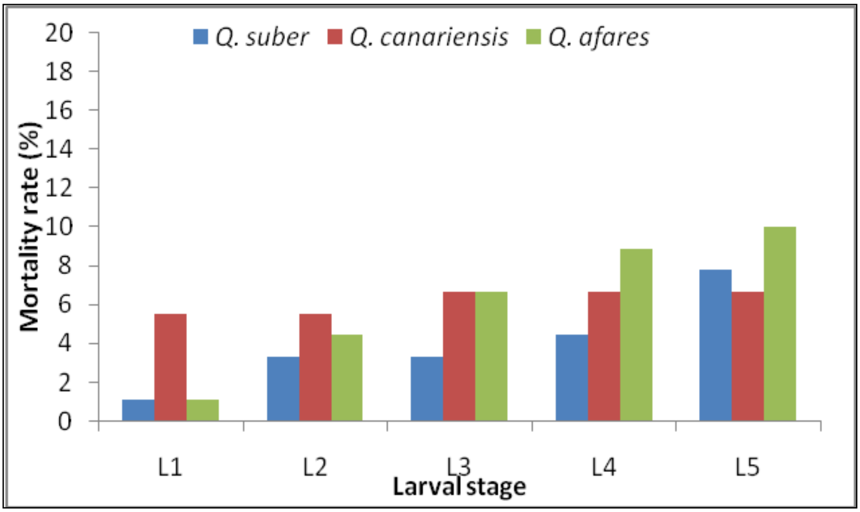

Fig. 2. Mortality rate of each larval stage from 1st to 5th instar larvae reared on the three *Quercus* species.

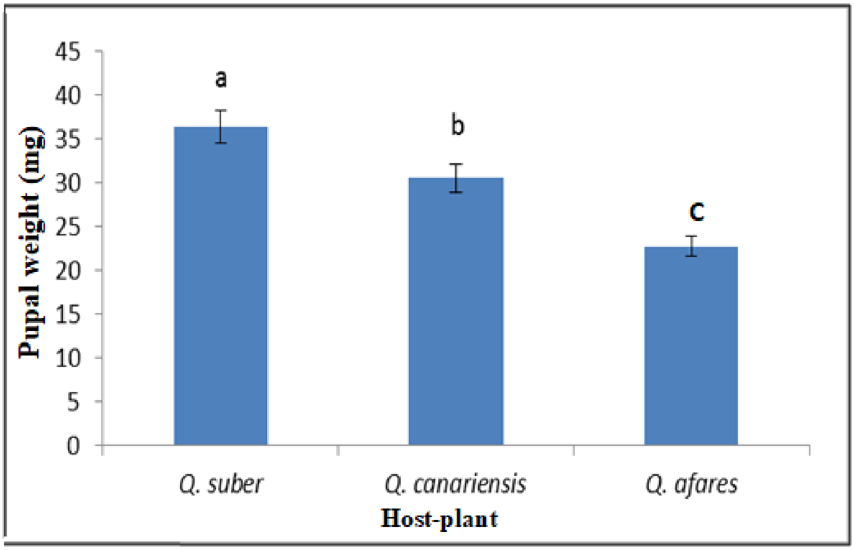

Fig. 3. Mean pupal weight in mg (± SE) of *Tortrix viridana* reared on the three *Quercus* species. Bars with different letters are significantly different based on SNK test at $P \leq 0.05$.

DISCUSSION

Development of many phyto-phagous insects is closely related with host plant phenology (Bale et al. 2002). Early or late budburst can directly affect both the quantity and quality of suitable food available to herbivores at specific times (Lawrence et al. 1997). Many studies focused on the interactions between budburst variation and the ecological consequences for trees and their associated phytophages (Du Merle 1983; Holliday 1985). The variation of altitude effects the leafing. In the three sites of Bellif forest, budburst began in early April and it was late in the sites in higher altitude (El Jouza and Ain El Baya forests) where the temperature was low. Budburst also varied depending on tree species. Our observations highlighted that in the Zen and Afares oaks budburst was observed before the cork oak. In the mixed forest of Ain Zena, budburst timing did not differ between *Q. canariensis* and *Q. afares* but for *Q. suber*, it occurred about three weeks later. Said (1993) and Mannai et al. (2017) reported that the budding of *Q. canariensis* and *Q. afares* precedes that of *Q. suber*. There was synchronization between budburst and larval hatching of *T. viridana* which can influence the number and intensity of outbreaks of forest pests (Forkner et al. 2008). Larvae in the Bellif 1, Bellif 2, Bellif 10, Mzara and Ain Zena sites were observed between the end of March and the end of May, whereas they were abundant from late spring until summer in Ain El Baya and El Jouza forests, because of the bursting of the oaks which is realized with a shift according to the geographical conditions mainly the altitude (Du Merle 1983) and the host plant (Mannai et al. 2017; Said 1993). Our results corroborate with several studies conducted on this subject that proved the variation of phenology of trees which is considered as the major determinant factor of the track dispersal behavior (Du Merle 1983; Hunter 1990; 1992; Mannai et al. 2017).

Host plants affect development, survival and reproduction of phytophagous insects (Marchioro and Foerster 2014). In many tree species, there is considerable variation in the phenology of budburst which has profound effects on insect performance (Hunter 1992). Feeding performance of the green oak leaf roller was determined on three host plants including *Q. suber*, *Q. canariensis* and *Q. afares* under laboratory conditions. The shortest larval development time was recorded for larvae feeding on *Q. suber* which was the most infested host, while the longest development time was recorded for those feeding on *Q. afares* (Fig. 1). Yazdanfar et al. (2015) found that larval development of *T. viridana* was shorter for larvae fed on *Q. libani* and longer for those fed on *Q. brandi* and *Q. infectoria*. Larval development was clearly better on some hosts than on others (Kirsten and Topp 1991). This may be explained by the low density of *T. viridana* in Ain Zena and Mzara because of the absence or the low abundance of their main host (*Q. suber*). Larval mortality was not significantly different on host plants.

Pupal weights of *T. viridana* on *Q. canariensis*, *Q. afares*, and *Q. suber* were compared to investigate the suitability of these hosts for the green roller moth larvae. On *Q. suber,* pupae were the heaviest one with an average weight of 35.52 mg. Mannai et al. (2010) found that the mean pupal weight on *Q. suber* ranged from 24.07 mg to 32.15 mg and suggested that the host plants have a significant effect on the resulting size of pupae. *Q. canariensis* and *Q. afares* are relatively new host plants for this defoliator. There may not have been a selection for the time being for a match between the phenology of oak zen and oak afares and the larvae hatching. Our laboratory rearing also confirmed the low weight of pupae on these two host species.

Studies of Foss and Rieske (2003) on the feeding preferences of gypsy moth in North America indicate that oaks differ greatly in their suitability for this insect. It is also the case of Magnoler and Cambini (1997) findings on European oak and those of Schopf et al. (1999) on sessile and Turkey oaks who indicated differences in their suitability as a food source for *Lymantria dispar*. It will be interesting to study the preference of *T. viridana* to these three host species.

RESUME

Mannai Y., Ezzine O. et Ben Jamâa, M.L. 2018. Infestation des forêts de chênes par *Tortrix viridana* et sa performance sur trois espèces de *Quercus*. Tunisian Journal of Plant Protection 13 (si): 171-181.

Les forêts de chênes sont soumises à des agressions diverses, principalement par les attaques des insectes. La tordeuse verte, *Tortrix viridana*, est un défoliateur de diverses espèces de chênes. Cet insecte a provoqué depuis plusieurs années des défoliations considérables dans différentes subéraies du Nord-Ouest de la Tunisie. L'étude a été conduite entre 2009 et 2013 dans cinq forêts de chêne-liège (*Quercus suber*), une forêt de chêne-zeen (*Q. canariensis*) et une forêt mixte de chêne-liège, chêne-zeen et chêne-afares (*Q. afares*). Le nombre moyen de chenilles par branche variait significativement d'un site à un autre (6,6 ± 0,77 chenilles / branche à El jouza et 0,11 ± 0,05 chenilles / branche sur *Q. afares* dans la forêt d'Ain Zena). La date du débourrement n'a pas différé entre *Q. canariensis* et *Q. afares* alors que celui de *Q. suber* s'est produit environ 3 semaines plus tard que pour les deux autres espèces. Comme la phénologie de la plante hôte diffère entre les essences hôtes, il est évident que la survie et le développement larvaire ne sont pas les mêmes pour toutes les espèces de plantes hôtes. Le développement des chenilles reste plus important sur *Q. suber*. La durée de développement larvaire du 1er au 5ème stades larvaires est plus réduite sur *Q. suber* (24,92 ± 0,26 jours) que sur *Q. canariensis* (26,69 ± 0,29 jours) et sur *Q. afares* (29,03 ± 0,39 jours). La mortalité larvaire n'a pas montré une différence significative entre les plantes hôtes. La comparaison des poids des chrysalides issues de l'élevage des chenilles sur les essences de chênes hôtes a montré un effet significatif. Les chenilles ayant consommé des feuilles de chêne-liège ont donné des chrysalides plus pesantes avec 35,52 ± 9,44 mg que celles élevées sur le chêne-zeen (30,43 ± 8,25 mg) et le chêne-afares (22,95 ±5,34 mg).

Mots clés: Chênes, infestation, performance, *Tortrix viridana*, Tunisie

---

ملخص

مناعي، يسرى وألفة الزين ومحمد لحبيب بن جامع. إصابة غابات البلوط بواسطة حشرة *Tortrix viridana* ودراسة كفاءتها على ثلاثة أنواع من جنس *Quercus*.

Tunisian Journal of Plant Protection 13 (si): 171-181.

تتعرض غابات البلوط لهجمات مختلفة من الحشرات. تعتبر حشرة *Tortrix viridana* من أهم آفات البلوط وقد تسببت هذه الحشرة لعدة سنوات في إزالة الاوراق في مختلف مناطق شمال غرب تونس. تم تنفيذ هذا العمل بين 2009 و 2010 في خمسة غابات بلوط فلين (*Quercus suber*)، غابة بلوط زان (*Q. canariensis*) وغابة مختلطة من بلوط الفلين وبلوط الزان وبلوط الزان المقلوب (*Q. afares*). سجل متوسط عدد اليرقات في الغصن اختلافا كبيرا بين المواقع (6,6± 0,77 يرقة / غصن في الجوزة و0,11 ± 0,05 يرقة / غصن على *Q. afares* في غابة عين الزانة). لم يختلف وقت ظهور براعم *Q. canariensis* و *Q. afares* بينما ظهرت البراعم على *Q. suber* بعد حوالي 3 أسابيع من النوعين الآخرين. بما أن فينولوجيا النبات العائل تختلف بين الانواع المضيفة فإن بقاء اليرقات على قيد الحيات وتطورها يختلفان من المؤكد حسب أنواع النباتات العائلة. تم تحديد مدة تغذية اليرقات في ظروف المختبر على *Q. suber* و *Q. canariensis* و *Q. afares*. نمت اليرقات بطريقة أسرع على *Q. suber* حيث كان الوقت الاجمالي لنمو اليرقات (من المرحلة الأولى الى الخامسة) أقصر على *Q. suber* (24,92 ± 0,26 يوم) مقارنة بـ *Q. canariensis* (26,69 ± 0,29 يوم) و *Q. afares* (29,03 ± 0,39 يوم). لم تكن وفيات اليرقات مختلفة بشكل كبير على النباتات المضيفة. بينما اظهرت البيانات اختلافا كبيرا بالنسبة لوزن الشرانق حيث ان شرانق اليرقات التي استهلكت أوراق *Q. suber* أثقل (35,52 ± 9,44 مغ) من التي استهلكت *Q. canariensis* (30,43 ± 8,25 مغ) و *Q. afares* (22,95 ± 5,34 مغ).

كلمات مفتاحية: إصابة، بلوط، تونس، كفاء ة، *Tortrix viridana*

LITERATURE CITED

Bale, J.S., Masters, G.J., Hodkinson, I.D., Awmack, C., Bezemer, T.M., Brown, V.K., Butterfield, J., Buse, A., Coulson, J.C., Farrar, J., Good, J.E.G., Harrington, R., Hartley, S., Jones, T.H, Lindroth, R.L., Press, M.C., Symioudis, I., Waltt, A.D., and Whittaker, J.B. 2002. Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biology 8: 1-16.

Du Merle, P. 1983. Phénologies comparées du chêne pubescent, du chêne vert et de *Tortrix viridana* L. (Lep., Tortricidae). Mise en évidence chez l'insecte de deux populations sympatriques adaptées chacune à l'un des chênes. Acta Oecologica 4: 55-74.

Du Merle, P. 1999a. Développement parthénogénétique chez la Tordeuse verte du chêne *Tortrix viridana* L. (Lepidoptera, *Tortricidae*). Bulletin de la Société Entomologique de France 104: 85-90.

Du Merle, P. 1999b. Egg development and diapause: Ecophysiological and genetic basis of phenological polymorphism and adaptation to varied hosts in the green oak *tortrix*, *Tortrix viridana* L. (Lepidoptera : Tortricidae). Journal of Insect Physiology 45: 599- 611.

Forkner, R.E., Marquis, R.J., Lill, J.T., and Le Cor, J. 2008. Timing is everything? Phenological synchrony and population variability in leaf-chewing herbivores of *Quercus*. Ecological Entomology 33: 276-285.

Foss, L.K., and Rieske, L.K. 2003. Species-specific differences in oak foliage affect preference and performance of gypsy moth caterpillars.

Entomolgia Experimentalis et Applicata 108: 87-93.
Foster, J.R., Townsend, P.A., and Mladenoff, D.J. 2013. Mapping asynchrony between gypsy moth egg-hatch and forest leaf-out: Putting the phenological window hypothesis in a spatial context. Forest Ecology and Management 287: 67-76.
Gooshbor, L., Pir Bavaghar, M., Amanollahi, J., and Ghobari, H. 2016. Monitoring infestations of oak forests by *Tortrix viridana* (Lepidoptera: Tortricidae) using remote sensing. Plant Protection Sciences 52: 270-276.
Holliday, N.J. 1985. Maintenance of the phenology of the winter moth (Lepidoptera, Geometridae). Biologica Journal of the Linnean Society 25: 221-234.
Hunter, M.D. 1990. Differential susceptibility to variable plant phenology and its role in competition between two insect herbivores on oak. Ecological Entomology 15: 401-408.
Hunter, M.D. 1992. A variable insect-plant interaction: the relationship between tree budburst phenology and population levels of insect herbivores among trees. Ecological Entomology 16: 91-95.
Ivashov, A., Boyko, G., and Simchuk, A. 2002. The role of host plant phenology in the development of the oak leafroller moth, *Tortrix viridana* L. (Lepidoptera: Tortricidae). Forest Ecology and Management 157: 7-14.
Jones, B.C., and Despland, E. 2006. Effets of Synchronization with host plant phenology occur early in the larval development of a spring folivore. Canadian Journal of Zoology 84: 628-633.
Kapeller, S. 2009. Modelling of population dynamics of the green oak leaf roller (*Tortrix viridana*) within oak-populations. Magister of Naturwissenschaften, University of Vienna, Austia, 37 pp.
Kirsten, K., and Topp, W. 1991. Acceptance of willow-species for the development of the winter moth, *Operophtera brumata* (Lep., Geometridae). Journal of Applied Entomology 111: 457-468.
Lawrence, R.K., Mattson, W.J., and Haack, R.A. 1997. White spruce and the spruce budworm: defining the phenological window of susceptibility. Canadian Entomologist 129: 291-318.
Magnoler, A., and Cambini, A. 1997: Consumption and utilization of leaf tissue of *Quercus suber* L. and *Quercus ilex* L. by *Lymantria dispar* L. larvae. Redia 80: 99-106.
Mannai, Y., Ben Jamâa, M.L., Mnara, S., Selmi, H., and Nouira, S. 2010. *Tortrix viridana* L. (Lep., Tortricidae) dans les subéraies du Nord-Ouest de la Tunisie. Bulletin de protection intégrée des forêts à *Quercus* ssp. 57: 153-160.
Mannai, Y. 2017. Etude des Lépidoptères défoliateurs des chênes au nord-ouest de la Tunisie: Biodiversité et interactions insectes/plantes-hôtes. Doctorate Thesis in Biology, Université des Sciences de Tunis, Tunisie, 271 pp.
Mannai,Y., Ezzine, O., Hausmann, A., Nouira, S., and Ben Jamâa, M.L. 2017. Budburst phenology and host use by *Operophtera brumata* (Linnaeus, 1758) (Lepidoptera: Geometridae) in three Mediterranean oak species. Annals of Forest Science 74: 1-8.
Marchioro, C.A., and Foerster, L.A. 2014. Preference–performance linkage in the diamondback moth, *Plutella xylostella*, and implications for its management. Journal of Insect Science 14(85):11-14.
Rubtsov, V.V., and Utkina, I. A. 2003. Interrelations of green oak leaf roller population and common oak: Results of 30-year monitoring and mathematical modeling. Pages 90-97. In: McManus, Michael L.; Liebhold, Andrew M., eds. Proceedings: Ecology, Survey and Management of Forest Insects, 2002, September 1-5, Krakow, Poland.
Said, A. 1993. Contribution en la conception d'une méthode d'échantillonnage pour l'étude quantitative de *Tortrix viridana* L., (Lepidoptera, Tortricidae). Bulletin de la Société Entomologique de France 104: 85-90.
Schopf, A., Hoch, G., Klaus, A., Novotny, J., Zubrik, M., and Schafellner, C. 1999: Influence of food quality of two oak species on the development and growth of gypsy moth larvae. Pages 231-247. In: Physiology and Genetics of Tree-Phytophage Interactions F., Lieutier, W.J., Mattson, and M.R., Wagner (eds). Les Colloques 90, Ed. INRA, Paris, France.
Scriber, J.M., and Slansky, F. 1981. The nutritional ecology of immature insects. Annual Review of Entomology 26: 183-211.
Van Dongen, S., Backeljau, T., Matthysen, E., and Dhondt, A.A. 1997. Synchronization of hatching date with budburst of individual host trees (*Quercus robur*) in the winter moth (*Operophtera brumata*) and its fitness consequences. Journal of Animal Ecology 66: 113-121.
Yazdanfar, H., Ghodskhah Daryaei, M., Jalali Sendi, J., and Ghobari, H. 2015. Effects of three *Quercus* species on feeding performance of the green oak leaf roller, *Tortrix viridana* L. (Lepidoptera: Tortricidae). Journal of Crop Protection 4: 711-718.
