N O T E

Terellia fuscicornis (Diptera: Tephritidae) and *Cassida deflorata* (Coleoptera: Chrysomelidae) in Tunisian Artichoke Crops[1]

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Terellia fuscicornis (Loew) (Diptera: Tephritidae) and *Cassida deflorata* (Suffiran) (Coleoptera: Chrysomelidae) are serious pests that cause significant yield losses in Asteraceae crops (El Harym and Belqat 2017, ZooKeys 702: 137–171; Knio et al. 2002, J. Nat. Hist., 36: 617–629; Sayar et al. 2009, J. Nat. Hist., 43: 1159–1181). The economically important globe artichoke (*Cynara cardunculus* L. var. *scolymus*) is native to the Mediterranean basin (Cronquiest 1981, An Integrated System of Classification of Flowering Plants. Columbia Univ. Press, NY). It is a perennial herbaceous plant grown for its edible head, which may be processed or consumed fresh (Gominho et al. 2018, Biomass Bioenerg 109: 257–275; Mazzeo et al. 2020, Ann. Appl. Biol. 176: 241–248). Little, if any, data are available on the occurrence and pest status of *T. fuscicornis* and *C. deflorata* on artichoke in Tunisia.

Terellia fuscicornis is a fruit fly that has been reported on the flower heads of artichokes (*Cynara scolymus* L. and *Cynara syriaca* Boiss) and milk thistle (*Silybum marianum* [L.] Gaertn.) in southern Europe, North Africa and recently in Turkey (Effil 2018, Turk. J. Agric. Nat. Sci. 5: 291–297; El Harym and Belqat 2017; Gherbin et al. 2001, Ital. J. Agron., 5: 11–19; Knio et al. 2002; Sayar et al. 2009; Whittington 2002, Entomol. Mon. Mag. 138: 119–120).

Cassida deflorata also occurs in the Mediterranean region with reports from several European and African countries (Balachowsky and Mesnil 1936, Presses des établissements Busson, Paris, France; Jerraya 2003, Principaux Nuisibles des Plantes Cultivées et des Denrées Stockées en Afrique du Nord: Leurs Biologie,

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Leurs Ennemis Naturels, Leurs Dégâts et Leur Contrôle, Edition Climate Publ., Tunis, Tunisia; Zwölfer and Eichhorn 1966, J. App. Entomol., 58: 384–397). In Tunisia, this pest exhibits up to two generations with a short life cycle (up to 1 mo) (Jerraya 2003). Feeding damage by adults and especially larvae appears as small irregular holes in the foliage that may compromise the vigor of the host artichoke plant (Jerraya 2003). Growers are generally recommended to control infestations with organophosphate pesticides (Gominho et al. 2018).

Our study was conducted in an artichoke crop in Sidi-Thabet region (N 36°54′31″, E 10°02′33″E, governorate of Ariana) covering an area of 0.5 ha and containing 1,099 plants in seven rows with 1.2 m between adjacent rows and 0.6 m between adjacent plants. The field was planted in the 'Violet d'Hyères' variety in early November of each study year (2017, 2018, 2019). Fertilization, irrigation, and chemical treatments followed standard growing practices. Damage caused by *C. deflorata* was assessed by collecting 30 randomly selected artichoke leaves at weekly intervals. In the first and second years, sampling was conducted from early February to early May (2018, 2019). In the third year, sampling was from early November 2019 to late July 2020. *Terellia fuscicornis* occurrence and damage were assessed by collecting 30 randomly selected artichoke globes in July 2020. Samples of leaves, flower heads, or globes were transported to the laboratory and microscopically examined. *Terellia fuscicornis* larvae, pupae and adults (males and females) (20 per stage) were measured.

Data were analyzed for homoscedasticity (Levene test) and normality (Shapiro-Wilk test) before being subjected to one-way analysis of variance. Tukey's honestly significant difference post-hoc test was used for treatment mean separation at $P \leq 0.05$ (SPSS Inc. 12; IBM Corp. 2012, Chicago, IL).

Cassida deflorata eggs ($F = 13.15$, df = 55, $P = 0.001$), larvae ($F = 6.95$, df = 55, $P = 0.011$), and pupae ($F = 8.15$, df = 55, $P = 0.006$) were significantly more numerous on the lower versus the upper surfaces of the artichoke leaves. Numbers (mean ± SE) of eggs on lower and upper leaf surfaces were 6.57 ± 1.53 and 0.85 ± 0.25, respectively. Larval numbers were 93.96 ± 21.04 on the lower surface and 32.39 ± 10.10 on the upper surface, while 0.64 ± 0.19 pupae were found on the lower side and 0.07 ± 0.04 on the upper surface. Numbers of adults on the lower (0.78 ± 0.22) versus the upper (0.96 ± 0.31) sides of the leaves did not differ ($F = 0.21$, df = 55, $P = 0.647$). Our sampling yielded higher numbers of eggs and larvae on the leaves than pupae or adults. In fact, a greater preponderance of damaged leaves (67.82%) was infested by larvae ($F = 25.45$, df = 57, $P < 0.001$). Our observation that all *C. deflorata* stages except adults exhibited a strong preference to the undersurface compared to the upper surface of artichoke leaves corroborates results of Balachowsky and Mesnil (1936) and Rabaux (1915, Bull. Soc. Entomol. Fr. 20:196–198). In fact, Rabaux (1915) reported that *C. deflorata* females usually oviposit on the undersurface of leaves likely because the surface is not totally flat but more suitable for oviposition than the upper surface.

Using the taxonomic keys of White (1988, Tephritid Flies (Diptera: Tephritidae): Handbook for the Identification of British Insects. Royal Entomol. Soc., London, UK) and Smit (2006, Nederl. Faun. Med. 24: 117–120), we identified the tephritid fly collected from the artichoke globes in July 2020 as *T. fuscicornis* (Diptera: Tephritidae). Measurements of morphological features of male and female adults are listed in Table 1. Sexual dimorphism was apparent with females being

Table 1. Mean ± SE length and width of *Terellia fuscicornis* larvae collected from artichoke in Sidi-Thabet region, Tunisia.*

Larval Stage	Length (mm)	Width (mm)
First instar larvae (L1)	3.75 ± 0.33 a	1.02 ± 0.11 a
Second instar larvae (L2)	5.05 ± 0.33 b	1.82 ± 0.28 b
Third instar larvae (L3)	6.36 ± 0.40 c	2.46 ± 0.33 c
Statistics	$F = 166.81$, $P < 0.001$	$F = 86.42$, $P < 0.001$

* Means within a column followed by the same lowercase letter are not significantly different (Tukey's hsd; $P = 0.05$).

significantly longer than the males. The length (mean ± SE) of the female oviscapus (3.84 ± 0.23 mm) was longer than the abdomen (2.67 ± 0.23 mm) ($F = 151.08$, df = 39, $P < 0.001$). Males and females are characterized by yellow to light-brown heads, grey thorax, yellow abdomen with a pair of dark spots, and antennae with a yellow base and a black third segment. Despite the sexual dimorphism, measurements of head and wings are almost similar for both sexes.

Our measurements of the larvae collected on the globes indicated three larval instars (Table 2), which agrees with information on this species. We observed that first and second instars were white to light-yellow in color, while the third instar was yellow. Pupal color varied with the age from light to dark brown. The length and width (mean ± SE) of the pupae were 5.52 ± 0.40 mm and 2.07 ± 0.13 mm, respectively. Our measurements of the larvae, pupae, and adults are similar to those obtained by Sayar et al. (2009). We did not measure the eggs, but Sayer et al. (2009) reported that the eggs were elliptical, 1.39 ± 0.01 mm long and 0.29 ± 0.00 mm wide, white, and were oviposited in open globes deep within the bracts close to the florets.

We found in our samples a significantly higher number of larvae (57.1 larvae/30 artichoke globes) compared to pupae (9.2 pupae/30 artichoke globes) ($F = 6.95$, df = 25, $P = 0.014$) on the globes. Only 16.1% of larvae were observed to pupate in the artichoke globes. The predominant damage to globes was inflicted by larvae tunneling into the globes while feeding and subsequently resulting in microbial degradation within the structure. Various species have been reported as suitable hosts for *T. fuscicornis* including *Cynara syriaca* Boiss, *Cynara cardunculis* L. and *Silybum marianum* L. (Whittington 2002). Body size of some tephritid species, including *T. fuscicornis*, is positively correlated with the size the globes of their host plants as in artichoke and milk thistle (Sayar et al. 2009; Zwölfer 1988, Annu. Rev. Entomol. 33: 103–122).

We conclude that *C. deflorata* and *T. fuscicornis* can seriously damage artichoke crops in Tunisia. We observed relatively high infestation levels of *C. deflorata* with 67% of the leaves often infested. In Spain, Iglesias et al. (1999, Bol. San. Veg. Plagas 25: 221–228) demonstrated that damage caused by *C. deflorata* ranged between 37.21 and 58.23% in artichoke crops. Damage to artichoke is usually caused by larvae and adults in the spring (Jerraya 2003; Labeyrie 1961,

Table 2. Mean ± SE measurements of male and female *Terellia fuscicornis* adults collected from artichoke in Sidi-Thabet region, Tunisia.*

Sex	Body Length (mm)	Head Height (mm)	Head Width (mm)	Oviscapus Length (mm)	Wing Length (mm)	Wing Width (mm)
Female	9.95 ± 0.52 a	1.10 ± 0.10 a	1.98 ± 0.09 a	3.84 ± 0.23	5.57 ± 0.43 a	2.13 ± 0.16 a
Male	6.31 ± 0.42 b	1.04 ± 0.07 a	1.83 ± 0.11 a		5.11 ± 0.22 a	2.07 ± 0.16 a
Statistics	$F = 564.76$, $P < 0.001$	$F = 3.86$, $P = 0.05$	$F = 21.05$, $P < 0.001$		$F = 16.96$, $P < 0.001$	$F = 1.15$, $P = 0.29$

* Means within a column followed by the same lowercase letter are not significantly different (Tukey's hsd; $P = 0.05$).

Entomophaga 6: 257–263; Matta et al. 2003, Report, Servizio Territoriale del Medio Campidano, Sanluri, Italy; Rabaux 1915).

The tephritid *T. fuscicornis* has been previously reported as a pest of artichoke, but our report herein is the first for Tunisia. We also observed a relatively high number of *T. fuscicornis* larvae and pupae in the artichoke globes. In Turkey, Effil (2018) reported 45.2% of artichoke seed damaged by *T. fuscicornis*.

In conclusion, our study demonstrates the need for further studies of damage thresholds and possible management tactics for these two pests. Conservation biological control should be enhanced to preserve nontarget organisms (e.g., *Fulmekiella ovata* Soyka, *Anaphes* sp., *Tetrastichus rhosaces* Walker, and others) (Jerraya 2003). Given that artichoke is cultivated by planting in Tunisia, only seeds could be damaged by *T. fuscicornis*, which should be a focus by farmers to avoid heavy seed yield losses. Major efforts should be deployed to better understand the biology of this pest and its associated natural enemies.

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