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Checklist of piercing-sucking insects in North-eastern Tunisia in the region of Cap-Bon and their host plants

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Abstract
The study of the biodiversity of piercing-sucking insects on various crops and weeds in North-eastern Tunisia in the region of Cap-Bon, permitted to identify several pest species. In the different investigated regions and sampled crops, aphids were the most dominant and abundant compared to the others. Twelve aphid species were identified; *Aphis gossypii*, *A. craccivora*, *A. spiraecola*, *A. punicae*, *A. fabae*, *A. illinoisensis*, *Toxoptera aurantii*, *Myzus persicae*, *Sitobion avenae*, *Pterocholorides persicae*, *Rhopalosiphum maidis* and *Schizaphis graminum*. Regarding thrips, seven species were identified; *Thrips angusticeps*, *T. tabaci*, *Bregmatothrips dimorphus*, *Anaphothrips sudanensis*, *Limothrips cerealium*, *Liothrips oleae* and *Frankliniella occidentalis*, which was the most polyphagous thrips species. Five scale-insect species were recorded in the different investigated locations; *Parlatoria ziziphi*, *Aonidiella aurantii*, *Icerya purchasi*, *S. oleae*, and *Planococcus citri*. One species of Psyllidae was registered: *Euphyllura olivina* in all visited olive stations. One leafhopper species *Empoasca vitis* in grapevine orchards and finally two species of whiteflies that were reported; *Dialeurodes citri* in citrus orchard and *Bemisia tabaci* on pepper crops.

Keywords: Aphids, thrips, scale insects, whiteflies, leafhopper, psyllids, host-plants

Introduction
Phytophagous insects feed generally in different ways. For this, they are classed as monophagous (hosts are an only one or similar plants belongs to a single genus), oligophagous (hosts belong to one botanical family) and polyphagous (hosts belong to different plant families) [1]. Most of the Sap-sucking pests or piercing-sucking pests belong to these different categories [2] and cause significant damages in wild or farming fields and closed systems like greenhouses [3, 4].
They belong to two orders; Thysanoptera to, which belong thrips species, and Hemiptera, such as Aphids, Leafhopper, Scale insects, Psyllids and Whiteflies [5, 6, 7, 8, 4]. These insects cause direct damages on their host plants by feeding on different plants' parts. On the other hand, they may cause indirect damages by transmitting diseases such as bacteria, viruses and phytoplasma [7, 3, 9, 8]. Some of these insect species, especially aphids, whiteflies, psyllids and some scale insect species, produce honeydew on which some species of fungi may develop, which gives a dirty black aspect on leaves and affects photosynthesis [3, 6, 8, 9, 10].
Aphids are small phytophagous insects. Plenty species are important crop pests that may cause damage and lower yields by sucking plant sap, producing chlorotic areas and sooty mould at feeding locations which lead to weak plants, leaf drop prematurely and distorted stems and bark. A severe attack can kill branches or hole plants [11, 12, 13, 14]. Barjadze and Japoshvili (2007) [15] had carried out a study on aphids' biodiversity of ornamental plants in Georgia which showed a huge diversity of aphids on different host plants with a total of 160 species of Aphids (Hemiptera: Aphidoidea) belonging to 3 families: Aphididae (156 species), Adelgidae (3 species) and Phylloxeridae (1 species).
Psyllids and leafhoppers are commonly known as the largest and most common groups of plant sap-sucking pests found on crops or ornamental plants in wild and agricultural habitats, causing damage to crops worldwide [16, 17, 18, 19]. They may cause damages to plants either directly, through feeding and oviposition, or indirectly, through the transmission of dangerous plant pathogens such as bacteria and viruses [17, 20, 21, 22, 106, 24, 25]. Psyllids includes several important emerging pest species [17]. Borghi *et al.* (2018) [26] confirm that leafhoppers are considered as the most critical pests associated with pasture degradation.

Scale insects have been reported as severe polyphagous pests attacking a large number of host plants around the world and distributed in various ecosystems over the world [27, 28, 29, 30, 31]. Similarly, other sap-sucking insects cause direct damage by sucking plants sap and indirect damage by the secretion of honey dew and by transmitting or promoting the attack of plant pathogens [32]. The most harmful families are those with the most species, namely the Diaspididae, Pseudococcidae, and Coccidae [30].

This study aims to identify piercing-sucking insect species on principal crops and on weeds growing in the region of Cap-Bon in Tunisia, which is considered as an important agronomic center in order to establish integrated pest control strategies in the future and minimize damages.

Material and Methods

Investigated locations

This study was carried out in five locations belonging to the governorate of Nabeul (North-east of Tunisia) in the region of Cap-Bon. These locations are Takelsa (T), Menzel-Bouzelfa (MB), Beni-Khiar (BK), Grombelia (G), and Bou-Argoub (BA). These regions are considered as important agronomic centers (Figure 1) (Table 1).

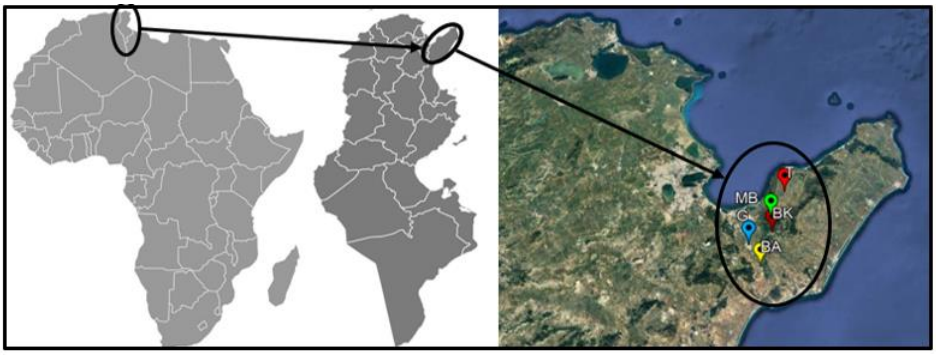

Fig 1: Localization of the experimental sites in the Cap-Bon region in Tunisia (Legend: T: Takelsa, MB: Menzel-Bouzelfa, BK: Beni-Khiar, G: Grombelia, BA: Bou-Argoub).

Table 1: Geographical localization of different investigated sites.

Experimental Site	Abbreviation	Geographical localization	Host plants
Takelsa	T	36°31'48.11"N10°33'11.54"E	P, C, O, Pe, Po, B, W
Menzel-Bouzelfa	MB	36°41'49.21"N10°34'54.53"E	P, C, O, Po, W
Beni Khaled	BN	36°38'55.87"N10°35'29.70"E	C, O, W
Grombelia	G	36°36'05.47"N10°29'54.20"E	C, V, W
Bou-Argoub	BA	36°31'48.11"N10°33'11.54"E	P, C, O, Po, B, W

Legend: T: Takelsa, MB: Menzel-Bouzelfa, BK: Beni-Khiar, G: Grombelia, BA: Bou-Argoub, P: pepper, C: citrus, O: Olive, Pe: peach, Po: pomegranate, B: Barley, V: grapevine, W: weeds.

Crops

This inventory interested different crops in the investigated locations such as citrus, olive, peach, pomegranate, grapevine, barley, pepper and weeds. Samples were taken weekly. The study took place from February to July 2017.

Nine citrus orchards were served for this inventory. Two of them are located in the region of Takelsa A1 and A2 with respective areas of 4 and 8 Ha. Four are situated in the region of Menzel-Bouzelfa; A3, A4, A5 and A6 with respectively 0.5, 2, 3 and 4 Ha. The seventh citrus orchard is located in the region of Bou-Argoub (A7) with an area of 8 Ha. A8 is situated in the region of Grombelia and A9 in Beni-Khiar with areas respectively of 1 Ha and 0.6 Ha. Five olive orchards were visited during this inventory. Each one has an area of 1 Ha. First orchard O1 is in the region of Takelsa, O2 in Bouargoub, O3 and O4 in Menzel-Bouzelfa and O5 in Beni-Khaled. Two peach orchards were served for the inventory P1 (2 Ha) and P2 (0.5 Ha). Both are situated in the region of Takelsa. Three pomegranate orchards were investigated during this inventory. Each one has an area of 1 Ha. Po1 in Takelsa, Po2 in Menzel-Bouzelfa and Po3 in Bou-Argoub. Two grapevine orchards in the region of Grombelia with areas of 0.5 (V1) and 0.7 (V2) Ha. Three pepper crop greenhouses served for this study where each of which is situated in a location, first greenhouse (P1) is located in Takelsa, P2 in Menzel Bouzelfa and P3 in Bou-Argoub. Two barley fields with an area of 2 Ha each where B1 is located in Takelsa and B2 in Bou-Argoub.

From all investigated locations, different weeds species were collected during each sampling date. Identification of weed species was based on Carem (1990) [33].

Sampling

Sampling pepper crop leaves and flowers were carried weekly. From each greenhouse 10 pepper plants were chosen randomly. From each plant, three leaves and three flowers were sampled from each stratum (apical stratum, central stratum and basal stratum). Sampling was carried out by a similar method in all investigated stations concerning citrus, olive, peach and pomegranate, where ten trees were chosen randomly from each orchard and from each tree four twigs of about 30 cm were sampled from each side (North, South, East and West). From the same trees, ten flowers were sampled and placed in vials containing alcohol 70%. Regarding grapevine, fifty plants were chosen randomly from each orchard during each sampling date. From each plant, three leaves were sampled from each stratum. Regarding barley, forty plants were sampled weekly in zigzag from each plot.

Results and Discussion

Weeds identification

According to the identification key, 24 species of weeds belonging to 15 botanical families were sampled during the study period from all visited experimental sites (Table 2).

Table 2: Identified sampled weed species in the region of Cap-Bon in Tunisia.

Clade	Family	Species
Monocotyledons	Poaceae	*Phalaris canariensis* L. (1753)
		Cynodon dactylon (L.) Pers. (1805)
		Avena sterilis L. (1762)
		Bromus rigidus Roth (1790)
Dicotyledons	Amarantaceae	*Amaranthus albus* L. (1753)
	Asteraceae	*Anacyclus clavatus* (Desf.) Pers. (1807)
		Chrysanthemum coronarium L. (1753)
		Calendula arvensis L. (1763)
	Brassicaceae	*Sinapis arvensis* L. (1753)
		Diplotaxis muralis L. (1821)
	Chenopodiaceae	*Chenopodium album* L. (1753)
	Cucurbitaceae	*Ecballium elaterium* (L.) A. Rich. (1824)
	Convolvulaceae	*Convolvulus arvensis* L. (1753)
	Oxalidaceae	*Oxalis pes-caprae* L. (1753)
	Fabaceae	*Vicia sativa* L. (1753)
		Lotus edulis L. (1753)
		Melilotus indica L. All.
	Geraniaceae	*Geranium tuberosum* L. (1753)
	Malvaceae	*Malva sylvestris* L. (1753)
	Papaveraceae	*Papaver rhoeas* L. (1753)
	Plantaginaceae	*Plantago lagopus* L. (1753)
	Primulaceae	*Anagallis arvensis* L. (1753)
		Anagallis monelli L. (1753)
	Renonculaceae	*Adonis annua* L. (1953)

This inventory permitted to identify several species of piercing-sucking insects in the investigated regions on various crops and weeds. These species include aphids, scale-insects, psyllids, whiteflies and leafhopper that all belong to the order Hemiptera and the sub-order Sternorryncha and Auchenorryncha for the last one, and thrips that belong to the Order Thysanoptera.

Aphids

Twelve Aphid species were identified on the different sampled crops. They all belong to the Family Aphididae and to two Sub-Families, Aphidinae and Pterocommatinae (Table 3). In the Aphidinae Sub-Family nine species were identified; *Aphis gossypii* Glover (1877), *A. craccivora* Koch (1854), *A. spiraecola* Patch (1914), *A. punicae* Passerini (1863), *A. fabae* Scopoli (1763), *A. illinoisensis* Shimer (1866), *Toxoptera aurantii* Boyer de Fonscolombe (1841), *Myzus persicae* Sulzer (1776), *Sitobion avenae* Fabricius (1794), *Rhopalosiphum maidis* Fitch (1856) and *Schizaphis graminum* Rondani (1852). Only one species was registered in the Pterocommatinae Sub-family; *Pterochloroides persicae* Cholodkovsky (1899). Aphidinae is an important Sub-family with more than 70% of Aphid species with an agronomic interest [6].

Table 3: Inventoried Aphid species on different sampled crops.

Sub-Family	Genus	Species	P	B	C	Po	O	Pe	V
Aphidinae	*Aphis*	*gossypii*	+	-	+	+	-	-	-
		craccivora	+	-	+	-	-	-	-
		spiraecola	-	-	+	-	-	-	-
		punicae	-	-	-	+	-	-	-
		fabae	+	-	-	-	-	-	-
		illinoisensis	-	-	-	-	-	-	+
	Toxoptera	*aurantii*	-	-	+	-	-	-	-
	Schizaphis	*graminum*	-	+	-	-	-	-	-
	Rhopalosiphum	*maidis*	-	+	-	-	-	-	-
	Sitobion	*avenae*	-	+	-	-	-	-	-
	Myzus	*persicae*	+	-	+	-	-	+	-
Pterocommatinae	*Pterochloroides*	*persicae*	-	-	-	-	-	+	-

Legend: (+) present, (-) absent, P: pepper, C: citrus, O: Olive, Pe: peach, Po: pomegranate, B: Barley, V: Vine

Regarding sampled weeds, the most polyphagous aphid species that were found on several host plants belonging to many botanical families are *A. gossypii, A. fabae* and *M. persicae,* followed by *A. craccivora* (three host plants), *R. maidis* (two host plants) and *S. avenae* (one host plant). *A. puncae, A. spiraecola, A. illinoisensis* and *T. aurantii* were not found on sampled weeds (Table 4).

Table 4: Weeds host plant range of aphid species collected from the investigated locations.

Sub-Family	Genus	Species	Weed species
Aphidinae	*Aphis*	*gossypii*	*Chenopodium album* *Chrysanthemum coronarium* *Ecbalium elaterium*

			Malva syslvestris *Plantago lagopus* *Vicia sativa*
		craccivora	*Amaranthus albus* *Lotus edulis* *Vicia sativa*
		spiraecola	-
		punicae	-
		fabae	*Calendula arvensis* *Chenopodium album* *Chrysanthemum coronarium* *Covolvolus arvensis* *Ecbalium elaterium* *Vicia sativa* *Lotus edulis* *Papaver rhoeas*
		illinoisensis	-
	Toxoptera	*aurantii*	-
	Schizaphis	*graminum*	*Avena sterilis*
	Rhopalosiphum	*maidis*	*Phalaris canariensis* *Avena sterilis*
	Sitobion	*avenae*	*Avena sterilis*
	Myzus	*persicae*	*Amaranthus albus* *Chenopodium album* *Chrysanthemum coronarium* *Covolvolus arvensis* *Plantago lagopus* *Malva syslvestris*
Pterocommatinae	*Pterochloroides*	*persicae*	-

The cotton aphid *A. gossypii* was found during this inventory on three crops which are pepper, citrus and pomegranate. *A. gossypii* is distributed in temperate regions and is considered as a major pest that causes important economic losses [34]. It is a polyphagous species that may attack a wide range of plants and weeds [35] and may transmit over than fifty viral diseases [6].

The cowpea aphid *A. craccivora* was observed on pepper crop and citrus. This species is polyphagous and may attack various crops such as Fabaceae and Solanaceae [3]. However, it is considered as an occasional and secondary pest on citrus [36].

The green citrus aphid *A. spiraecola* was only observed on citrus in the different investigated locations. It is considered among most important aphid species on citrus. However, it has a wild range of secondary hosts such as Caprifoliaceae, Asteraceae, Rosaceae, Rubiaceae and Rutaceae [37]. *A. spiraecola* is observed essentially on citrus in North-eastern Tunisia [38].

The pomegranate aphid *A. punicae* was observed in the region of Cap-Bon only on pomegranate. This species is the most dominant aphid species on pomegranate in Tunisia [11] and widespread in the Mediterranean and central Asia [39]. It is considered as a dangerous pest of this crop causing serious damages and attacking all plants' parts [36, 39, 40].

A. illinoisensis or the grapevine aphid, was reported for the first time in Tunisia in 2009 by Kamel-Ben Halima and Mdellel [41]. *A. illinoisensis, a* North American aphid species [37, 39], invades *Vitis vinifera*, but damages are less than those caused by *Phylloxera* [9]. This aphid prefers the lower side of *V. vinifera* young leaves. It had not been reported yet as a vector of grapevine viruses, but it transmits the Watermelon mosaic virus [42, 43].

T. aurantii was observed during this inventory only on citrus which it causes several damages and losses in Tunisia [9, 36]. It is widespread in the Mediterranean. This pest mainly attacks citrus but can be found on other host plants such as Anacardiaceae, Anonaceae, Araliaceae, Euphorbiaceae, Lauraceae, Moraceae, Rubiaceae, Rutaceae, Sterculiaceae and Theaceae. Damages on citrus may be caused by sap puncture which causes weakening of the tree, as well as by the excessive production of honeydew. *T. aurantii* is considered as a vector of Tristeza virus [44, 45, 39, 46].

S. graminum, also known as the green wheat aphid, was observed in the region of Cap-Bon only on barley. Native to the Palearctic, this species can be adapted to different climates such as the Mediterranean. Currently, it is present in several parts of the world, such as North and South America, Europe, Africa and Asia [47]. *S. graminum* can be found in more than 60 species of cereals including cultivated species such as wheat, barley and sorghum [48]. Considered as a serious pest worldwide, it may cause damage and losses and transmits the virus to cereals [47]. However, in Tunisia, despite its presence and the damages that it can cause, losses remain fairly limited [3]. Another aphid species were observed on barley in the region of Cap-Bon, the corn leaf aphid or *R. maidis*. This species is among the most important cereal pests especially corn, sorghum, barley and wheat [49]. Species of the genus *Rhopalosiphum* were also recoded on Poaceae weeds such as *Phalaris canariensis* [50]. *R. maidis* is cosmopolitan and causes serious damage especially by virus transmission [51]. Same as for *S. graminum*, in Tunisia losses caused by *R. maidis* remain limited [3].

S. avenae also known as the English grain aphid, is the third species found on barley. *S. avenae* is dependent on grasses and mainly cereals such as wheat, barley, oats and corn. This species causes <wimportant losses worldwide and in Tunisia by sap punction and virus transmission [52, 53].

M. persicae or the green peach aphid, was observed in investigated locations on pepper under the greenhouse and the peach orchards. This serious pest is cosmopolitan and polyphagous. It may be found on several botanical species. Several weed species may host *M. persicae* [54]. *M. persicae* causes important damage on any attacked plant. It is also known as a vector of the Sharka virus and the Potato leafroll virus [3, 9].

P. persicae or the peach black aphid is the only species that belong to the sub-family Pterocommatinae. It is a dark brown aphid and quite large in size [9]. This species is cosmopolitan and occurs on peach, almond, apricot, apple and citrus. It has been reported in Europe, Asia, North America and some countries of the Mediterranean [55]. In Tunisia, it was reported for the first time in 1987 on almond [56].

Scale insects

During this study, six scale insects were identified in the investigated locations and on different sampled crops. Scale insects belong to the Super Family Coccoidea. The identified species are *Parlatoria ziziphi* Lucas (1853), *Aonidiella aurantii* Maskell (1879), *Icerya purchasi* Maskell (1878), *Saissetia oleae* Olivier (1791), *Planococcus citri* Risso (1813) and *Pl. ficus* Signoret (1875). These species belong to four Families; Diaspidae, Coccidae, Pseudococcidae and Monophlebidae [9] (Table 5). Those species were not reported on sampled weeds.

Table 5: Inventoried scale-insect species on different sampled crops.

Super Family	Family	Genus	Species	O	C	Po	V
Coccoidea	Diaspididae	*Parlatoria*	*ziziphi*	-	+	-	-
		Aonidiella	*aurantii*	-	+	-	-
	Coccidae	*Saissetia*	*oleae*	+	+	+	-
	Pseudococcidae	*Planococcus*	*citri*	-	+	+	-
			ficus	-	-	-	+
	Monophlebidae	*Icerya*	*purchasi*	-	+	-	-

C: citrus, O: Olive, Po: pomegranate, V: Vine.

The black parlatoria scale *P. ziziphi* was observed only in citrus in all investigated sites. This scale insect belongs to the sub-family Diaspididae [9]. In Tunisia, it is considered as the most important scale insect and one of the key pests in citrus orchards [57, 58]. *P. ziziphi*, originates from the palearctic, is a serious pest on Citrus and Rutaceae and caused enormous losses [59, 60].

A. aurantii or the red California scale was observed on citrus. This species is a major pest on citrus in Tunisia and a serious pest worldwide [57, 58]. Originates from the palearctic, it is a cosmopolitan species throughout the tropics and subtropics and had been established in almost all citrus areas of the Mediterranean coast. It can be can be found on several plant species [61, 62, 63].

S. oleae or the Mediterranean black scale, which belongs to the Coccidae Family, was the only species that was observed on olive, pomegranate and citrus orchards. This species is Afrotropical and polyphagous. It is considered as a major pest in olive in the Mediterranean region and in citrus in many other regions around the world [64, 65]. This species was mainly observed on olive. In fact, *S. oleae* is among the most important species attacking olive orchards as well as the olive fruit fly *Bactrocera oleae* and the olive moth *Prays oleae*. It can cause weakening of attacked trees [9, 66]. On the other hand, it was registered in a pomegranate orchard which confirm that it is a polyphagous species [9].

The citrus mealybug, *Pl. citri*, was observed in citrus and pomegranate orchards. It is one of the most important pests of citrus and many other host plants in subtropical and tropical regions as well as the Mediterranean region [9, 67].

Regarding the vine mealybug *Pl. ficus*, it occurs on the grapevine and causes significant economically damages by excreting honeydew which induces the appearance of sooty mold fungi, feeding on grapevine leaves which prevents photosynthesis and causes defoliation [68].

The cottony cushion scale *I. purchasi* was reported only on citrus though it is a polyphagous species. It is known to establish three generations per year on citrus and had been already recorded in Tunisia [57, 69].

Thrips

Thrips identification on different sampled crops in investigated sites leaded to twenty-one species (Table 6) among which seventeen are phytophagous; *Frankliniella occidentalis* Pergande (1895), *Thrips angusticeps* Uzel (1895), *T. tabaci* Lindemann (1888), *T. imaginis* Bagnall (1926), *T. palmi* Karny (1925), *T. australis* Bagnall (1915), *Bregmatothrips dimorphus* Priesner (1919), *Anaphothrips sudanensis* Trybom (1911), *Limothrips cerealium* Haliday (1836), *Pezothrips kellyanus* Bagnall (1916), *Chirothrips manicatus* Haliday (1836), *Microcephalothrips abdominalis* Crawford (1910), *Retithrips syriacus* Mayet (1890), *Melanthrips fuscus* Sulzzer (1776), *Haplothrips tritici* Kurdjumov (1913) and *Liothrips oleae* Costa (1857). Five predatory thrips species were identified during this inventory and they all belong to the family Aeolothripidae; *Aeolothrips tenuicornis* Bagnall (1926), *Ae. collaris* Priesner (1919), *Ae. intermedius* Bagnall (1934), *Ae. fasciatus* L. (1758) and *Franklinothrips megalops* Trybom (1912).

Table 6: Inventoried Thrips species on different sampled crops.

Family	Genus	Species	P	B	C	Po	O	Pe	V
Thripidae	*Frankliniella*	*occidentalis*	+	+	+	+	-	+	+
	Thrips	*angusticeps*	-	+	+	-	-	+	-
		tabaci	+	+	+	+	-	+	+
		imaginis	-	-	+	-	-	-	+
		palmi	-	-	+	-	-	+	+
		australis	-	-	-	-	-	-	-
	Bregmatothrips	*dimorphus*	-	+	-	-	-	-	-
	Anaphothrips	*sudanensis*	-	+	-	-	-	-	-
	Limothrips	*cerealium*	-	+	+	+	-	-	+
	Pezothrips	*kellyanus*	-	-	+	-	-	-	-
	Chirothrips	*manicatus*	-	+	-	-	-	-	-

	Microcephalothrips	*abdominalis*	-	-	+	-	-	+	+
	Retithrips	*syriacus*	-	-	-	-	-	-	+
Aeolothripidae	*Aeolothrips*	*tenuicornis*	+	+	+	+	-	+	+
		collaris	-	-	+	-	-	-	+
		intermedius	+	-	+	+	-	-	-
		fasciatus	+	+	+	-	-	+	+
	Franklinothrips	*megalops*	-	-	+	-	-	-	+
	Melanthrips	*fuscus*	-	+	+	-	-	+	+
Phlaeothripidae	*Haplothrips*	*tritici*	-	+	-	-	-	-	-
	Liothrips	*oleae*	-	-	-	-	+	-	-

P: Pepper, C: Citrus, O: Olive, Pe: Peach, Po: Pomegranate, B: Barley, V: Vine.

On sampled weeds (Table 7), the most polyphagous thrips species that were found on several plant species is *F. occidentalis*, followed by species of the genus *Thrips*, especially *T. tabaci* and *T. angusticeps*.

Table 7: Weeds host plant range of thrips species collected from the investigated locations.

Family	Genus	Species	Weed species
Thripidae	*Frankliniella*	*occidentalis*	*Cynodon dactylon* *Avena sterilis* *Amaranthus albus* *Anacyclus clavatus* *Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Diplotaxis muralis* *Chenopodium album* *Ecbalium elaterium* *Convolvolus arvensis* *Vicia sativa* *Melilotus indica* *Geranium tuberosum* *Papaver rhoeas* *Plantago lagopus* *Anagalis arvensis* *Anagallis monelli* *Adonis annua*
	Thrips	*angusticeps*	*Phalaris canariensis* *Amaranthus albus* *Anacyclus clavatus* *Chrysanthemum coronarium* *Calendula arvensis* *Lotus edulis* *Geranium tuberosum* *Anagallis arvensis* *Malva sylvestris*
		tabaci	*Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Diplotaxis muralis* *Chenopodium album* *Convolvolus arvensis* *Vicia sativa* *Geranium tuberosum* *Papaver rhoeas* *Plantago lagopus* *Anagalis arvensis*
		imaginis	*Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Malva sylvestris*
		palmi	*Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Convolvolus arvensis* *Geranium tuberosum*
		australis	*Anacyclus clavatus* *Chrysanthemum coronarium* *Calendula arvensis*
	Bregmatothrips	*dimorphus*	*Phalaris canariensis* *Avena sterilis*

			Bromus rigidus
	Anaphothrips	*sudanensis*	*Phalaris canariensis* *Avena sterilis*
	Limothrips	*cerealium*	*Chrysanthemum coronarium* *Calendula arvensis* *Phalaris canariensis* *Avena sterilis* *Bromus rigidus*
	Pezothrips	*kellyanus*	-
	Chirothrips	*manicatus*	*Phalaris canariensis* *Avena sterilis*
	Microcephalothrips	*abdominalis*	*Anacyclus clavatus* *Chrysanthemum coronarium* *Calendula arvensis*
	Retithrips	*syriacus*	-
Aeolothripidae	*Aeolothrips*	*tenuicornis*	*Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Convolvolus arvensis* *Geranium tuberosum* *Malva sylvestris*
		collaris	*Chrysanthemum coronarium* *Calendula arvensis*
		intermedius	*Chrysanthemum coronarium* *Calendula arvensis* *Anacyclus clavatus*
		fasciatus	*Chrysanthemum coronarium* *Calendula arvensis* *Sinapis arvensis* *Convolvolus arvensis* *Geranium tuberosum* *Anacyclus clavatus*
	Franklinothrips	*megalops*	-
	Melanthrips	*fuscus*	*Chrysanthemum coronarium* *Calendula arvensis* *Geranium tuberosum* *Anacyclus clavatus*
Phlaeothripidae	*Haplothrips*	*tritici*	-
	Liothrips	*oleae*	-

The Western Flower Thrips *F. occidentalis* was reported during this inventory on all crops except olive and on several weed species. It is a polyphagous thrips species that may attack a wide range of botanical species such as cultivated crops or even ornamental plants [70, 71]. It is an economically important pest that causes several damage and can be found in crops under greenhouses, such as pepper or roses, as well as in orchards and fields [3, 70, 71, 72]. This species is very common in citrus orchards [72] and is indicated as the most abundant species in citrus in Tunisia [74, 75]. The same results are reported in Spain and Turkey [76, 77].

T. angusticeps was reported on barley, citrus, peach and on several weed species, is known as an important polyphagous and widespread thrips species that may be found on cultivated and spontaneous plant species [78, 79]. These thrips were mentioned on species of the genus *Prunus* such as peach, cherry and nectarine [80]. It attacks citrus with an important population level and is considered among the dominant thrips species in citrus in Tunisia [74, 75, 76]. *T. angusticeps* is considered as a common thrips species in cereal crops such as barley [82]. Many weed species may host *T. angusticeps* [79].

The onion thrips *T. tabaci* were observed on almost all sampled crops and weeds during this study. It is a cosmopolitan and polyphagous thrips species that was registered on several host plants [5, 79]. It may cause important damages to more than 150 botanical species [83, 79].

The plague thrips or *T. imaginis*, which is a polyphagous species that attacks especially flowers [79], was observed on the citrus, vine, and some weed species. It is not a species with an economical importance. It can occur on crops only when flowers are present [79, 84, 85]. In Tunisia, it has already been reported on grapevine in the region of Grombelia [85].

The melon thrips *T. palmi*, was reported on the citrus, peach, grapevine and five weed species of the families Asteraceae, Brassicaceae, Geraniaceae and Convolvulaceae. This species was limited to Asia and Africa. Then it has spread to many other continents. This expansion increased the number of host plants including citrus, grapevine, horticultural plants and weeds such as *Chrysanthemum* spp. [79, 85].

The Gum Tree Thrips, *T. australis* also known as *Isoneurothrips australis* was not reported on sampled crops but only on three weed species belonging to the Asteraceae Family. This species, originating from Australia, is not considered as an important pest and does not cause significant damages [54]. In Tunisia, it was reported for the first time in 2014 on *Eucalyptus* and the same weed species on which it had been observed during this inventory [86].

B. dimorphus was observed on barley and weeds of the Poaceae family only. Nine species are described in the genus *Bregmatothrips*, and all of them live on cereals or grasses of the same family [87]. *B. dimorphus* was reported for the first time in Tunisia in 2012 on barley and had no significant damages on this host plant [88].

Another thrips species that was reported only on the Poaceae

family (barley and weeds), *A. sudanensis.* Widespread in the tropics and subtropics [89], it was found in Tunisia in 2012 on barley without causing significant damages [88].

The grain thrips, *L. cerealium* was observed during this study on barley, citrus, pomegranate grapevine and on weeds of the families Asteraceae and Poaceae. Despite this species is commonly known as a cereal pest [83, 88], it can be observed on other crops such as citrus [74, 90, 75] and grapevine [85]. However, *L. cerealium* populations on host plants other than cereals are low and limited [91], unlike barley, which is considered among the most important thrips species [82, 88].

P. kellyanus, the Kelly's citrus thrips, was reported only in citrus orchards. It is considered as one of the most important thrips pest species of citrus in some Mediterranean countries such as Italy, Spain and Greece [92, 93, 94]. It was first reported in Tunisia in 2009 and it is considered as one of the most important and abundant thrips species in citrus orchards [73, 95, 96]. It was not found during this study on the sampled weed species; however, it was recorded on some Apiaceae and Brassicaceae weeds in Tunisia [81].

C. manicatus was observed on barley and on two weed species *Ph. canariensis* and *A. sterilis*. These thrips species were reported for the first time in Tunisia in 2018 [97]. *C. manicatus* develops mainly on cereals and species of the Poaceae Family [95, 98]. However, it was indicated on the grapevine as an accidental presence [75].

The composite thrips, *M. abdominalis*, were collected from citrus, peach and grapevine as well as on three weed species belonging to the family Asteraceae; *A. clavatus*, *C. coronarium* and *C. arvensis*. This species is known to occur on flowers of some Asteraceae species, such as those of the genus *Calendula* [79]. It was also observed in citrus and grapevine orchards but with low populations [74, 75].

The black vine thrips, *R. syriacus* was only observed in grapevine orchards. It was reported at the first time in Tunisia in 2011 on *Vitis vinifera* and *Dyospiros kaki* [71].

Regarding *M. fuscus*, it was collected from barley, citrus, peach, grapevine and some weed species of the families Asteraceae and Geraniaceae. This thrips species were cited in Tunisia in citrus orchards as one of the most important and abundant species of the Aeolothripidae family [74, 81]. *M. fuscus* is a thrips species that occurs on weeds species of the Asteraceae family [79].

The rest of the species that belong to the family Aeolothripidae are considered predatory thrips [79]. In the genus *Aeolothrips* four species were reported; *Ae. tenuicornis*, *Ae. collaris*, *Ae. intermedius* and *Ae. fasciatus*. Those species were collected from different crops such as pepper, barley, citrus, pomegranate, peach and grapevine. They were not observed in olive orchard. These species were also recorded on many weed species. These species were indicated as thrips predators collected from grapevine and citrus orchards in Tunisia [74, 75, 81].

The last predatory species that belong to the family Aeolothripidae is *F. megalops* from citrus and grapevine orchards. This predator was already cited in Tunisia in citrus orchards [74, 81].

Concerning the sub-order Tubulifera, two thrips species were identified *H. tritici* observed only on barley and *L. oleae* only in olive orchards. The wheat thrips *H. tritici* is widespread in the Mediterranean, Europe and North Africa. It attacks mainly *Triticum* but can occurs on barley [82, 100]. Regarding *L. oleae*, which belongs to the family Phlaeothripidae, it is a monophagous thrips species that attacks only olive [79, 101, 102]. This thrips species may cause important damages on olive leaves [103].

Leafhopper

During this study, just one leafhopper that was collected and identified; *Empoasca vitis* Goethe (1875) (Hemiptera; Auchenorrhynca; Cicadellidae). This species was reported only on grapevine in the region of Grombelia. *E. vitis* was indicated as the most predominant species on grapevine and on several weed species in Tunisia in the region of Cap-Bon. This polyphagous species, considered as a secondary pest, had become responsible of important damages on grapevine [7].

Psyllids

During this inventory just one psyllid species that was reported; *Euphyllura olivina* Costa (1839) (Hemiptera; Sternorrhyncha; Psyllidae) in all investigated olive orchards in the regions of Takelsa, Bouargoub, Menzel-Bouzelfa and Beni-Khaled. This species is monophagous and was reported only on olive. It is wide spread in the Mediterranean. *E. olivina* build a protective covering made by white waxy secretions on leaves and twigs of their host plants. Larvae produce a large amount of honeydew on which epiphytic fungal species may develop, giving a black dirty appearance to leaves and affecting photosynthesis [9].

Whiteflies

Two whiteflies' species were reported in this study; *Bemisia tabaci* Gennadius (1889) (Hemiptera; Sternorrhyncha; Aleyrodidae) in pepper crop greenhouses in the regions of Takelsa, Menzel Bouzelfa and Bou-Argoub, and *Dialeurodes citri* Ashmead (1885) (Hemiptera; Sternorrhyncha; Aleyrodidae) in citrus orchards in the regions of Takelsa, Menzel-Bouzelfa and Beni-Khiar. *B. tabaci* is a highly polyphagous pest and may occur on more than 600 botanical species. It is a complex of species containing 35 cryptic species and it is worldwide spread [104]. Regarding *D. citri*, it was reported for the first time in Tunisia in 2021 in citrus orchards when it was first observed in 2017 in the region of Takelsa and then in 2020 in the region of Menzel-Bouzelfa with severe infestations [105].

Conclusion

The actual study of the piercing-sucking insects' biodiversity on various crops and weeds in North-eastern Tunisia in the region of Cap-Bon, permitted to identify several pest species and their distribution on crops and weeds. In fact, 24 species of weeds belonging to 15 botanical families were sampled during the study. Hence, aphids were the most dominant and abundant compared to the others with a total number of twelve aphid species that were identified; *Aphis gossypii*, *A. craccivora*, *A. spiraecola*, *A. punicae*, *A. fabae*, *A. illinoisensis*, *T. aurantii*, *M. persicae*, *S. avenae*, *P. persicae*, *R. maidis* and *S. granaminum.* Though, *A. gossypii*, *A. fabae*, *M. persicae* were the most dispersed once on weeds plants, while *Chenopodium album* and *Chrysanthemum coronarium* were the principal weeds containing a variety of aphids species. Similarly to weeds, *Aphis gossypii* and *M. persicae* were the most species colonizing different crops. In the same time, pepper and Citrus had included various species of aphids. Regarding thrips, seven species were identified; *T. angusticeps*, *T. tabaci*, *B. dimorphus*, *A. sudanensis*, *L. cerealium*, *L. oleae* and *F. occidentalis*. Vine, Citrus and barley were the most attacked crops by multiple thrips'

species; when *T. tabaci, L. cerealium, Ae. tenuicornis, Ae. fasciatus, M. fuscus* and *F. occidentalis* were polyphagous and dispersed on different crops. On weeds, the most polyphagous thrips species were *F. occidentalis* followed by *T. tabaci* and *T. angusticeps.* Indeed, *Ch. Coronarium* and *C. arvensis* were the species of weeds trapping a bunch of thrips species. Five species of scale-insects were recorded in the different investigated locations; *P. ziziphi, A. aurantii, I. purchase, S. oleae* and *P. citri*. One species of Psyllidae was registered; *E. olivina* in all visited olive stations. One species of whitefly was recorded; *D. citri* in citrus orchard. Natural enemies were recorded in different investigated locations.

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