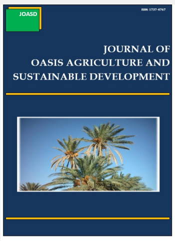

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A review of the management of *Aphis fabae* Scopoli (Hemiptera: Aphididae)

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Abstract

The black-bean aphid *Aphis fabae Scopoli* is a serious agricultural threat spreaded almost worldwide. It threatens more than 200 host plant species and causes several damages through sucking sap, injuring leaves, the excretion of honeydew -inducing the development of sooty mould- and the transmission of plant viruses. Chemical aphicides are the most approach used to control *A. fabae*. Nevertheless, their extensive use has led to serious problems concerning human health and environment. These drawbacks led to apply eco-friendly strategies based on entomopahtogenic fungi, natural enemies and plants to manage the pest. In this paper, we review the biological control of *A. fabae* with special reference to management using plant extracts. Many plants belonging to several families are opted to control *A. fabae*. Several parts of these plants in particular leaves, stems and peels are used to eradicate it. Aqueous and alcoholic extracts are the most used forms. The mode of action of the major compounds of botanicals is through stomach or/and nerve poisoning.

1. INTRODUCTION

The black-bean aphid *Aphis fabae* Scopoli (Hemiptera: Aphididae) remains one of the most important pests of many cultivated crops and ornamental plant species; its host range encompasses more than 200 host plant species worldwide (Akca et al., 2015). *Aphis fabae* is a complex species that sucks the sap of the host plant and decreases the effeciency of its respiratory and photosynthetic gaz exchanges by causing injury in its leaves and the excretion of honeydew (Shannag, 2007). It can also transmit tens plant viruses (Blackman & Eastop, 2007). Chemical aphicides are the most used approach to manage *A. fabae*. The insecticides dominating market were mostly organophosphates (OPs) and carbamates, with pyrethroids and neonicotinoids (Dewar et al., 2017). Nevertheless, the excessive use of these pesticides led to various problems related to human health risk, the developpment of aphid resistance and the elimination of non-target organisms. To avoid these problems, several researchs have shown an increasing interest in using biological management agents including entomopatheogenic fungi, natural enemies and plants. The aim of this paper is to discuss the management of *A. fabae* with special reference to biological control.

2. TAXONOMY, ORIGIN AND DISTRIBUTION OF *APHIS FABAE*

Aphis fabae Scopoli (Hemiptera: Aphididae) is a small-sized dull-black aphid (1.5–2mm), sometimes with a segmented abdomen marked with a powdery secretion (Muimba-Kankolongo, 2018). It have both apterous and alate adult forms (Giblin & Manners, 2019). *Aphis fabae* is a complex species including six closely related taxa differentiated based on morphological characters and genetic differences: *Aphis fabae fabae, Aphis fabae cirsiiacanthoidis, Aphis fabae evonymi, Aphis fabae mordvilkoi, Aphis fabae solanella* and *Aphis fabae eryngii* (Zhang et al., 2010). Subspecies are identified based on the host plant that they can feed on (Giblin & Manners, 2019) (Table 1). According to Blackman & Eastop (2007), *A. fabae* fabae is originated in Europe and occurs in Europe, Western Asia, Africa and South America while *A.*

Table 1. Subspecies of *Aphis fabae* complex

Subspecies	**Main overwentering host plant**	**Main feeding host plant**
Aphis fabae fabae	*Euonymous europaeus*	*Vicia faba*
Aphis fabae mordvilkoi (often spelt *mordwilkoi*)	*Euonymous europaeus*	*Tropaeolum majus*, host alternates to *Arctium sp.*
Aphis fabae cirsiiacanthoidis	*Euonymous europaeus*	*Cirsium spp.*
Aphis fabae solanella	*Euonymous europaeus*	*Solanum nigrum*
Aphis fabae evonymi (often spelt *euonymi*)	*Euonymous europaeus*	*Euonymous europaeus*
Aphis fabae eryngii		*Eryngium spp.*

fabae solanella is the most dominant species in the Mediterranean basin, the Middle East, the Indian subcontinent, and warm parts of Africa and South America.

3. BIOLOGY OF *APHIS FABAE*

The black-bean aphid *Aphis fabae* Scopoli is a heterecious aphid with 1-3 winter (primary) hosts : (*Euonymus europae*, *Viburnum opulus* and *Philadelphus coronarius*) and a wide range summer (secondary) hosts belonging to several families : Asteraceae (*Arctium lappa*), Fabaceae (*Vicia faba*), Brassicaceae (*Armoracia rusticana*), Apiaceae (*Apium graveolens*)… (Tosh et al., 2001 ; Blackman & Eastop, 2007 ; Plant Health Australia Ltd, (2015); Giblin & Manners, 2019). It feeds, in particular, on phloem sap (Tosh et al., 2001).

The life cycle of *A. fabae* consists of five stages (Fig. 1.) : egg, four nymphal stages and adult (Saruhan et al., 2015b). Eggs are initially green and they turn soon shiny black while nymphs are dark with four pairs of white bars on the dorsal face of the abdomen (Capinera, 2001). The four nymphal stages last respectively 2, 2, 1.5 and 2.5 days at 20° C (Tsitsipis & Mittler, 1976). Bean aphid females are 1.8-2.4 mm long while males are slightly smaller (Capinera, 2001). According to Fericean et al (2012), *Aphis fabae* life cycle is made by sexual and asexual generations : in autumn, aphids mate and winged females laid eggs on primary host plants where they overwinter ; in spring, these eggs hatch and give birth to wingless females. These fundatrix (stem mothers) reproduce partenogenetically and give birth to live offspring (nymphs). These nymphs

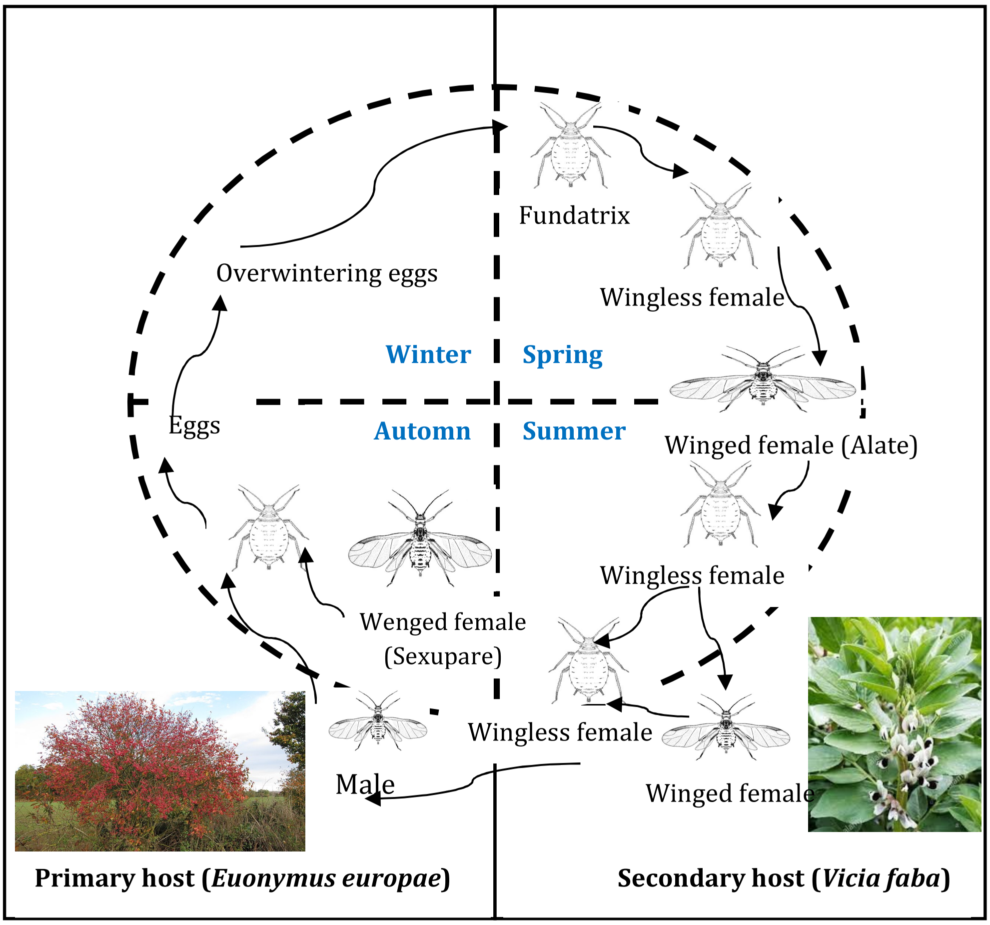

Fig 1. *Aphis fabae* life cycle

are also parthenogenetic females but further generations are usually winged (alates). Winged virginoparae migrate to their secondary host plants where they reproduce asexually on the underside of leaves or at the tips of stems in summer and large populations develop rapidly. As autumn approaches, winged sexuparae, produced as response to overcrowding, migrate back to primary host plants where both males and females are produced asexually. Mated females lay eggs witch overwinter.

In general, *Aphis fabae* produces four generations (Douglas, 1997 ; Cichocka et al,. 2002). Aphids multiplication depend on several factors such as the extent of initial colonization, temperature, luminosity, the abundance of natural enemies and the intraspecific competition for food and space (Way, 1967 ; Way & Banks, 1967).

The life cycle of *Aphis fabae* depends on climate factors : in areas with cold winters the pest reproduces sexually on its primary host, and parthenogenetically on the secondary hosts, while in areas with mild winters, it keeps reproducing exclusively asexually (Béji et al., 2013 ; Blackman & Eastop, 2007).

4. DAMAGE AND LOSSES CAUSED BY *APHIS FABAE*

Aphid attacks can cause two types of damages : direct damages (due to sieve drain and plant reaction to aphid feeding) and indirect damages related to viruses transmission (Dedryver et al,. 2010).

Aphis fabae feeds on phloem sap rich on sugar and aminoacids (Wilkinson & Douglas, 2003). Only alates feed on the xylem sap (Powell & Hardie, 2003). When feeding, it causes injury to the host plant. Also, the pest excrets excess sugars as honeydew and can develop sooty mould reducing the effeciency of respiration and photosynthesis and consequently the quality of produced pods (Dedryver et al., 2010). *Aphis fabae* infestation decreases the nonstructural carbohydrate concentration in sugarbeet stem tissue and sucrose content in roots (Capinera, 1981). It damages about 7-33% of crude protein levels in tissues infested (Shannag, 2007). As response to *Aphis fabae* attack, the leaves wrinkle, discolor and dry, and the pods remain small and give low yields (Calin et al., 2020).

Aphis fabae can transmit over 42 plant viruses including non-persistent viruses of beans, peas, beets, crucifers, cucurbits, dahlia, potato, tobacco, tomato and tulip, and persistent viruses such as Beet yellow net virus (BYNV) and Potato leaf roll virus (PLRV) (McKinlay, 1992 ; Blackman & Eastop, 2007 ; Shannag, 2007).

The Black bean aphid is recognised as having a risk to the grains industry (Plant Health Australia Ltd, 2015). Also, losses induced by *Aphis fabae* infestation are related to the aphid abundance. Indeed, losses are about 6.3-13.6% when aphid populations reached 0.2-85 aphids/faba bean plant while losses reached 100% when aphid population is about 6920 aphids/plant (Way, 1967).

5. CONTROL AND MANAGEMENT OF *APHIS FABAE*

5.1. Chemical insecticides

Several synthetic insecticides are used to control *A. fabae*. Pyrethroid insecticides are the main class used for foliar application to manage aphids (Johnson et al., 2009). Pyrethroid (e.g fenvalerate) and neonicotinoid pesticides (e.g thiacloprid) were highly effective against *A. fabae* under laboratory conditions (Purhematy et al., 2013). According to (Ayala et al., 1996), chlorpyrifos methyl plus cypermethrin, oxydemeton methyl, imidacloprid and thiometon are the most efficient. Nevertheless, some studies showed that some resistance to pirimicarb and high resistance to methamidophos has been developed by *A. fabae* (Ioannidis, 2000). In addition to the problem of resistance, the use of chemical insecticides threatens human health, non-target organisms and the environment.

5.2. Inert dust based control

Silicon dioxide is considered as a promising alternative active ingredient for the control of *A. fabae*. The dust is applied directly or using mesh coated with SiO_2 nanoparticles on adults of *A. fabae* and high mortality levels of the pset were recorded after 1 day of post exposure to silica-based dust formulation (Agrafioti et al., 2020 ; Faliagka et al., 2020). Silicon dioxide act on arthropods through contact leading to desiccation (Faliagka et al., 2020).

5.3. Biological control

Biological management of pests has the advantages to be of low-cost and safe both of human health and environment (Mwanauta et al., 2015). They enclude the use of entomopathogenic fungi, natural enemies as predators or parasitoids, plants as resitant varieties, cultural practices or botanicals.

5.3.1. Entomopathogenic fungi

Several entomopathogenic fungi are used to manage *A. fabae*. The most species are *Beauveria bassiana* (Akello & Sikora, 2012 ; Jensen et al., 2019), Gibberella moniliformis*,* Trichoderma asperellum (Akello & Sikora, 2012), *Simplicillium lamellicola* (Saruhan et al., 2015a), *Lecanicillium muscarium* (Mohammed, 2018), *Verticillium lecanii* (Saruhan et al., 2014), *Paecilomyces fumosoroseus* (Saruhan et al., 2014), *Paecilomyces lilacinus* (Saruhan et al., 2014), *Metarhizium anisopliae* (Saruhan et al., 2014), *Aspergillus flavus* and *Aspergillus tamarii* (Boni et al., 2020). Several methods are used to assess the effect of entomopathogenic fungi on populations of *A. fabae* : the evaluation of the mortality rate of adults by treated by fungal spore suspension in Petri dishes (Boni et al., 2020), the assessement of the fecundity rate of the insect on plant following seed or leaf inoculation with the fungi (Akello & Sikora, 2012 ; Mohammed, 2018 ; Jensen et al., 2019)... Toxicosis and nutrient exhaustion resulting from fungi penetration leads to death of the insect (Sani et al, 2020). Several biomassy methods are used to evaluate the effect of endopathogenic fungi on *A. fabae* population: (i) Direct inoculation of seeds or leaves of the host plant by the fungi (ii) Using entomopathogenic fungi remains an ecofriendly approach to manage pests. However, it has some demerits like lenghy duration of action and the risk of resistance. To avoid the disadvantages of this approach, some studies use combination of entomopathogenic fungi and animals in integrated pest

Table 2. Predators associated with *A. fabae*.

Order	Family	Species	Reference
Coleoptera	Cantharidae	*Cantharis haemorrhoidalis*	Talebi-Chaichi (1982)
Coleoptera	Cantharidae	*Cantharis pallida*	Talebi-Chaichi (1982)
Coleoptera	Cantharidae	*Rhagonycha lignosa*	Talebi-Chaichi (1982)
Coleoptera	Cantharidae	*Rhagonycha limbata*	Talebi-Chaichi (1982)
Coleoptera	Carabidae	*Demetrias atricapillus*	Traugott & Symondson (2008)
Coleoptera	Coccinellidae	*Adalia bipunctata*	Mohammed (2018)
Coleoptera	Coccinellidae	*Adalia decempunctata*	Way & Banks (1968)
Coleoptera	Coccinellidae	*Aphidecta obliterata*	Way & Banks (1968)
Coleoptera	Coccinellidae	*Calvia 10-guttata*	Way & Banks (1968)
Coleoptera	Coccinellidae	Calvia 14-guttata	Way & Banks (1968)
Coleoptera	Coccinellidae	*Chilocorus bipustulatus*	Way & Banks (1968)
Coleoptera	Coccinellidae	*Chilocorus calvus*	Nordey et al (2021)
Coleoptera	Coccinellidae	*Cheilomenes propinqua*	Nordey et al (2021)
Coleoptera	Coccinellidae	*Coccinella septempunctata*	Shannag & Obeidat (2008) ; Azimi & Amini, (2015)
Coleoptera	Coccinellidae	*Coccinella 11-punctata*	Way & Banks (1968)
Coleoptera	Coccinellidae	*Coccinula quatuordecimpustulata*	Wojciechowicz-Zytko (2009)
Coleoptera	Coccinellidae	*Coccinella quinquepunctata*	Wojciechowicz-Żytko & Jankowska (2011)
Coleoptera	Coccinellidae	*Harmonia axyridis*	Wojciechowicz-Żytko & Jankowska (2011)
Coleoptera	Coccinellidae	*Hippodamia variegata*	Azimi & Amini, (2015) ; Jafari & Goldasteh (2009) ; Farhadi et al (2011)
Coleoptera	Coccinellidae	*Propylea quatuordecimpunctata*	Keshavarz et al (2015)
Dermaptera	Forficulidae	*Forficula auricularia*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Betasyrphu***s** serarius	Verma et al (2005) ;
Diptera	Syrphidae	*Episyrphus balteatus*	Talebi-Chaichi (1982), Verma et al (2005) ; Wojciechowicz-Zytko (2000, 2006)
Diptera	Syrphidae	*Epistrophe eligans*	Wojciechowicz-Zytko (2006)
Diptera	Syrphidae	*Eupeodes frequens*	Verma et al (2005)
Diptera	Syrphidae	*Lasiopticus pyrastri*	Schneider, F. (1969).
Diptera	Syrphidae	*Melanostoma mellinum*	Wojciechowicz-Zytko & Wnuk (2012)
Diptera	Syrphidae	*Metasyrphus corollae [Eupeodes corollae]*	Verma et al (2005) ; Wojciechowicz-Zytko (2006)
Diptera	Syrphidae	*Syrphus vitripennis*	Talebi-Chaichi (1982), Wojciechowicz-Zytko (2006)
Diptera	Syrphidae	*Syrphus ribesii*	Wojciechowicz-Zytko (2000, 2006)
Diptera	Syrphidae	*Platycheirus albimanus*	Schneider (1969), Talebi-Chaichi (1982)
Diptera	Syrphidae	*Platycheirus clypeatus*	Schneider (1969)
Diptera	Syrphidae	*Platycheirus scutatus*	Wojciechowicz-Zytko (2009)
Diptera	Syrphidae	*Pipiza noctiluca*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Scaeva pyrastri*	Wojciechowicz-Zytko (2006)
Diptera	Syrphidae	*Sphaerophoria menthastri*	Wojciechowicz-Zytko (2006)
Diptera	Syrphidae	*Sphaerophoria scripta*	Wojciechowicz-Zytko (2000, 2006)
Diptera	Syrphidae	*Syrphus auricollis*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Syrphus labiatarum*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Syrphus nitidicollis*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Syrphus torvus*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Syrphus triangulifer*	Talebi-Chaichi (1982)
Diptera	Syrphidae	*Syrphus tricinctus*	Talebi-Chaichi (1982)
Hemiptera	Anthocoridae	*Anthocoris confusus*	Way & Banks (1968)
Hemiptera	Anthocoridae	*Anthocoris pilosus*	Talebi-Chaichi (1982)
Hemiptera	Anthocoridae	*Anthocoris nemoralis*	Way & Banks (1968)
Hemiptera	Anthocoridae	*Anthocoris nemorum*	Way & Banks (1968) Talebi-Chaichi (1982)
Hemiptera	Anthocoridae	*Orius albidipennis*	Rashedi et al (2019)
Hemiptera	Anthocoridae	*Orius majusculus*	Way & Banks (1968)
Hemiptera	Anthocoridae	*Orius niger*	Alaserhat et al (2021)
Hemiptera	Miridae	*Deraeocoris (Camptobrochis) punctulatus*	Alaserhat et al (2021)
Neuroptera	Chrysopidae	*Chrysopa perla*	Talebi-Chaichi (1982)
Neuroptera	Chrysopidae	*Chrysoperla carnea*	Talebi-Chaichi (1982), Kunert et al (2008), Hassanpour et al (2015)
Neuroptera	Chrysopidae	*Chrysoperla lucasina*	Maisonneuve et al (2003)
Neuroptera	Hemerobiidae	*Hemerobius humulinus*	Talebi-Chaichi (1982)
Neuroptera	Hemerobiidae	*Hemerobius lutescens*	Talebi-Chaichi (1982)
Neuroptera	Hemerobiidae	*Hemerobius micans*	Talebi-Chaichi (1982)
Thysanoptera	Thripidae	*Frankliniella sp*	Talebi-Chaichi (1982)

management (Mohammed, 2018).

5.3.2. Natural enemies

5.3.2.1. Predators

54 species belonging to 6 orders (Coleoptera, Diptera, Hemiptera, Neuroptera, Thysanoptera and Dermaptera) and 9 families (Cantharidae, Carabidae, Coccinellidae, Forficulidae, Syrphidae, Anthocoridae, Chrysopidae, Hemerobiidae and Thripidae) are predators of *A. fabae* (Table 2).

The effect of the predator is studied in laboratory as well as in field. Only the adults of some species but adults as well as larvae of other species prey on *A. fabae* (Talebi-Chaichi, 1982). Some studies investigate the effeciency of the predator at different densities ot the prey (Jafari & Goldasteh (2009). Others study the relation between the age of predator and the stage of the prey (Farhadi et al., 2011).

Aphis fabae has other predators than insects such as spiders : *Pardosa amentata* (Toft, 1995), *Erigone sp.* (Traugott & Symondson, 2008) and birds : *Apus apus* (Lack & Owen, 1955).

5.3.2.2. Parasitoids

32 species belonging to 1 order (Hymenoptera) and 4 families (Aphelinidae, Braconidae, Figitidae and Pteromalidae) are parasitoids of *A. fabae* (Table 3). Some of them have preference to some host stages (Tahriri, 2007). The parasitism rate rely on climatic factors and host plant species (Matin et al., 2009).

To control *A. fabae*, integrated pest management involve some strategies combining animals and cultural practicies uses.

5.3.3. Plants

The management of *A. fabae* based on plants includes, the use of resistant varieties of host plant combined with aphid enemies (Shannag & Obeidat, 2008), cultural practicies or plant extracts.

5.3.3.1. Cultural practices

Aphids can be managed by using some

Table 3. Parasitoids associated with *A. fabae*.

Order	Family	Species	Reference
Hymenoptera	Aphelinidae	*Aphelinus abdominalis*	Japoshvili & Abrantes (2006).
Hymenoptera	Aphelinidae	*Aphelinus albipodus*	Abd-Rabou et al (2013)
Hymenoptera	Aphelinidae	*Aphelinus asychis*	Behrendt (1968)
Hymenoptera	Aphelinidae	*Aphelinus chaonia*	Benhamacha et al (2020)
Hymenoptera	Aphelinidae	*Aphelinus humilis*	Fryč & Rychlý (2018)
Hymenoptera	Aphelinidae	*Aphelinus varipes*	Japoshvili & Abrantes (2006)
Hymenoptera	Braconidae	*Diaeretiella Rapae*	Singh & Singh (2015)
Hymenoptera	Braconidae	*Aphidius arvenses*	Labdaoui et al (2018)
Hymenoptera	Braconidae	*Aphidius colemani*	Mkenda et al (2019)
Hymenoptera	Braconidae	*Aphidius ervi*	Rakhshani et al (2019)
Hymenoptera	Braconidae	*Aphidius funebris*	Rakhshani et al (2019)
Hymenoptera	Braconidae	*Aphidius matricariae*	Tahriri et al (2007) Adabi et al (2010)
Hymenoptera	Braconidae	*Aphidius platensis*	Rakhshani et al (2019)
Hymenoptera	Braconidae	*Binodoxys acalephae (Trioxys acalephae)*	Labdaoui et al (2018)
Hymenoptera	Braconidae	*Binodoxys brevicornis*	Labdaoui et al (2018)
Hymenoptera	Braconidae	*Ephedrus nacheri*	Labdaoui et al (2018)
Hymenoptera	Braconidae	*Ephedrus persicae*	Žikić et al (2009)
Hymenoptera	Braconidae	*Ephedrus plagiator*	Talebi-Chaichi (1982)
Hymenoptera	Braconidae	*Ephedrus validus*	Talebi-Chaichi (1982)
Hymenoptera	Braconidae	*Lipolexis gracilis*	Talebi-Chaichi (1982)
Hymenoptera	Braconidae	*Lysiphlebus ambiguus*	Cheng et al (2011)
Hymenoptera	Braconidae	*Lysiphlebus cardui*	Labdaoui et al (2018)
Hymenoptera	Braconidae	*Lysiphlebus confusus (Lysiphlebus marismortui)*	Satar et al (2019)
Hymenoptera	Braconidae	*Lysiphlebus fabarum*	Mahmoudi et al (2010), Rashedi et al (20
Hymenoptera	Braconidae	*Lysiphlebus* melandriicola	Prelipcean et al (2004)
Hymenoptera	Braconidae	*Lysiphlebus testaceipes*	Rodrigues & Bueno (2001).
Hymenoptera	Braconidae	*Praon objectum*	Talebi-Chaichi (1982)
Hymenoptera	Braconidae	*Praon volucre*	Starý et al (2014)
Hymenoptera	Braconidae	*Trioxys angelicae (Binodoxys angelica)*	Talebi-Chaichi (1982), Khan et al (2012)
Hymenoptera	Braconidae	*Trioxys centaureae*	Talebi-Chaichi (1982)
Hymenoptera	Braconidae	*Trioxys indicus*	Khan et al (2012)
Hymenoptera	Cynipidae	*Alloxysta campyla* Kieff	Prelipcean et al (2004)
Hymenoptera	Cynipidae	*Aloxysta semiclausa* Kieff	Prelipcean et al (2004)
Hymenoptera	Cynipidae	*Charips arcuatus* (Kieff)	Prelipcean et al (2004)
Hymenoptera	Cynipidae	*Charips carpenteri* (Kieff)	Prelipcean et al (2004)
Hymenoptera	Cynipidae	*Charips melanogaster (Hartig)*	Prelipcean et al (2004)
Hymenoptera	Cynipidae	*Charips minutum*	Prelipcean et al (2004)
Hymenoptera	Encyrtidae	*Aphidencyrtus aphidivorus* (Mayr.)	Prelipcean et al (2004)
Hymenoptera	Figitidae	Charipinae sp	Mkenda et al (2019)
Hymenoptera	Megaspilidae	Dendrocerus aphidum (Rond.)	Prelipcean et al (2004)
Hymenoptera	Megaspilidae	Dendrocerus carpenteri (Kieff.)	Prelipcean et al (2004)
Hymenoptera	Pteromalidae	Pachyneuron aphidis	Mkenda et al (2019)

Table 4. List of plants used to make botanicals used against *Aphis fabae*.

Species	Extracted organ	Form of extract	Biomassy method and pest developmental stage	Major compenent	Significant Effects/Results	Reference
Allium cepa (Liliaceae)		Aqueous extract	*V. faba* plants holding immature and adults insects were sprayed with the extract at 100g/l.		Extracts have significant effects on all parameters : *mortality after 6 h : 35.79% *mortality after 24h : 38.54% *Plant height : 25.71 cm *fresh weight/plant : 82.52 g *dry weight/plant : 11.03 g *number of pods/plant : 7.125	Amin & Majeed (2018)
Allium sativum (Liliaceae)		Aqueous extract	*V. faba* plants holding immature and adults insects were sprayed with the extract at 100g/l.		Extracts have significant effects on all parameters : *mortality after 6 h : 31.96% *mortality after 24h : 33.58% *Plant height : 52.71 cm *fresh weight/plant : 78.08 g *dry weight/plant : 11.34 g *number of pods/plant : 7.42 The effect of the extract increases with its rate	Amin & Majeed (2018)
Artemisia judaica L. (Asteraceae)	Arerial parts	Ethanolic extract	Wingless adults were transferred to Petri dishes on leaves of *V. fabae* and sprayed with the extract at different concentrtaions (12.5, 6.25, 3.12 and 1.56 mg.mL^{-1}).	Flavonoids Tannins	100% of mortality were recorded at 12.5 mgmL^{-1} after 2 hours and at 1.56 mgmL^{-1} after 96 hours LD50 calculated 2 hours after treatment is 2.75 mg.mL^{-1}.	Acheuk et al (2017)
Azadirachta indica (Meliaceae)	Seed kernels		**Vicia faba* plants were sprayed with 0.5ml of the extract at different concentrations (0.05 ; 0.1 ; 0.2 ;1 ;2%) and offered to either 2nd or 4th nymphal instars. *Virginoparous female was placed on bean plant seedling after its treatment with different concentrations of extract.	Azadirachtin	At 2%, after 96 hours, the extract induces a mortality of 93% of 2nd instar nymphs. At 0.1%, after 96 hours, the extract induces a mortality of 20% of 4th instar nymphs. The extract reduces the fecundity and longevity of *A. fabae* : at 2%, average fecundity is 0.2 and longevity is 3 days.	Dimetry & Schmidt (1992)
Carissa macrocarpa (Apocynaceae)	Leaves	Phenolic and terpenoid extracts	Adults placed on leaves of broad bean prepared in Petri dish and sprayed with crude phenolic at different concentrations (5, 7.5 and 10 mg/ml). First-instar nymphs were taken and treated by the extract as in the previous case. Growth has been pursued to reach the adult stage. Adults were isolated and their fecundity is evaluated.		At concentration 10 mg/ ml, *The mortality rates of the crude phenolic and terpenoid extracts after 48 hrs. of exposure were 46.4 and 52.3%. * The crude phenolic and terpenoid extracts reduced the number of birth reached 5.33 and 4.67 nymph/ Female respectively.	Mohamed (2019)
Cinnamomum sp (Lauraceae)		Aqueous extract	*V. faba* plants holding immature and adults insects were sprayed with the extract at 100g/l.		Extracts have significant effects on all parameters : *mortality after 6 h : 14.96% *mortality after 24h : 16.17% *Plant height : 46.3 cm *fresh weight/plant : 61.12 g *dry weight/plant : 7.54 g *number of pods/plant : 5.17 The effect of the extract increases with its rate	Amin & Majeed (2018)

Table 4. bis

Citrus aurantium L. (Rutaceae)	Peel	Essential oils	*In a vial, adults are placed with a filter paper impregnated with oil at concentrations 3.33, 8.33, 16.66 and 33.33 µL/L air. *Fava plants infested with *A. fabae* were introduced into a plastic jar and treated with essential oil.	Limonene (67.1%)	*At 33.33 µl / L air dose and 24h exposure time, essential oils cause 60% mortality. LC50 = 31.27 µl / L air. LC90= 58.63 µl / L air. *In vivo, the application of essential oils on infested bean plants show 72.4% mortality.	Chaieb et al (2018)
Eucalyptus sp (Myrtaceae)		Aqueous extract	*V. faba* plants holding immature and adults insects were sprayed with the extract at 100g/l.		Extracts have significant effects on all parameters : *mortality after 6 h : 49.08% *mortality after 24h : 52.21% *Plant height : 55.33 cm *Fresh weight/plant : 77 g *Dry weight/plant : 11.3 g *Number of pods/plant : 7.42	Amin & Majeed (2018)
Euphorbia helioscopia (Euphorbiaceae)	Stems and leaves	Ethanolic extract	* 2nd and 4th nymphal instars were placed on a leave sprayed by 1 ml of the extract at concentrations (0.2, 0.5 and 1%) *The same method was adopted to evaluate the effect of extract on *A. fabae* fecundity.		Nymphs mortality rate 63.33 % at 1%. Extracts reduced the number of birth reached 5.55 at 1% concentration.	Omran (2010)
Euphorbia peplus (Euphorbiaceae)	Stems and leaves		* 2nd and 4th nymphal instars were placed on a leave sprayed by 1 ml of the extract at concentrations (0.2, 0.5 and 1%) *The same method was adopted to evaluate the effect of extract on *A. fabae* fecundity.		Nymphs mortality rate 76.66% at 1% Adults mortality 58.88% Extracts reduced the number of birth reached 3.99 at 1% concentration.	Omran (2010)
Melia azedarach (Meliacaeae)	Fruits		* 2nd and 4th nymphal instars were placed on a leave sprayed by 1 ml of the extract at concentrations (0.2, 0.5 and 1%) *The same method was adopted to evaluate the effect of extract on *A. fabae* fecundity.		Adults mortality 53.33 % at 1%.	Omran (2010)
Sonchus oleraceus (Asteraceae)	Leaves	Aqueous extract	Adults placed in Petri dish containing faba bean leaf were sprayed with extracts at concentrations 25, 50, 75 or 100%.		Adult mortality 69.9 % at 100%.	Al-Jassani et al (2020)
Tephrosia vogelii (Fabaceae)	Leaves	Aqueous extract	Bean plant are sprayed three time with extract at three different concentrations (0.5%, 2%, and 5% w/v).	Flavonoids, rotenoids, terpenoids, and sterols	Extract reduce aphid infestation and abundance of *A. fabae* (1.200 after the 3rd spray at 5% wt/v).	Kayange et al (2019)
Vicia faba (Fabaceae) aphid resistant cultivar	Leaves	Mathanolic and aqueous extract	Repulsive effect : adults placed on *Vicia fabae* leaves submerged in extracts placed in Petri dish. Toxic effect : apterous adults were placed on each treatment leaf.		* Aqueous extract : Repulsive effect : aver.1.3 adults / leaf * Methanolic extract : Repulsive effect : aver.3.7 adults / leaf Toxic effect mortality reached up to 65.71%.	Meradsi & Laamari (2016)

behavioral manipulations like intercropping. According to (Hansen et al., 2008), intercropping with cereals significantly reduced the numbers of *A. fabae* per bean plant and the number of plants infested. Also, 1 faba bean - 1 dragonhead (*Dracocephalum moldavica* L.) cropping patterns decresed the population density of *A. fabae* (Azimi & Amini, 2015). Maize growth and row spacings could be exploited for the control of *A. fabae* on intercropped beans (Ogenga-Latigo et al., 1992). Also, sowing plants of value to *A. fabae* predators, may be a good habitat management practice for early occurrence of these predators and consequently a reduction in crop damage by aphids (Wojciechowicz-Zytko & Wnuk, 2012).

5.3.3.2. Plant extracts

The use of plant extracts to control pests is a more eco-friendly strategie than synthetic insecticides. Botanicals have low effects on human health, non-target organisms and environnement. Also, they are easy to applicate and have low costs (Tarusikirwa et al,. 2020).

Many plants belonging to several families such as Liliaceae, Meliaceae, Euphorbiaceae and Fabaceae are used to control *A. fabae*. Several parts of the plant are used, in particular leaves, stems and peels. Aqueous and alcoholic extracts are the most used forms (Table 4).

Major components are probably responsible of the biological effects. The mode of action of these compounds is through stomach or/and nerve poisoning. According to Acheuk et al (2017), the crude ethanolic extract of *Artemisia judaica* containing flavonoids inhibits *acetylcholinesterase* activity ; the enzyme that regulates nerve impulse transmission. Also, the Glutathione *S*-transferase (enzyme that play a pivotal role in detoxification and antioxidant defense of insects against natural and synthetic insecticides) activity in *A. fabae* was significantly stimulated by the crude ethanolic extract of *A. judaica* containing tannins.

The bioactive compounds in *T. vogelii* leaves (rotenoids and isoflavonoids) are reported to have antifeedant, acaricidal, ovicidal, and be a cause of stomach poison to insects (Kayange et al., 2019).

6. Conclusion

The black-bean aphid *Aphis fabae* Scopoli is a serious agricultural threat which is spreaded almost worldwide. It parasitizes over 200 plant species and causes several damages due to sieve drain, plant reaction to aphid feeding and viruses transmission. Pyrethroid and neonicotinoid are the most chemical pesticides used to control *A. fabae*. Nevertheless, their exessive use lead to serious problems related to human health and environment. Because of these problems, safe strategies using entomopahtogenic fungi, natural enemies and plants are used to manage *A. fabae*. Among these alternate strategies, plant extracts acquired more and more interest in such field. Many species exhibit potential toxic, repulsive and biological cycle distorting effects against *A. fabae*. Cytotoxicity of botanical compounds is mainly directed against the aphid digestive and nervous systems functions.

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