International Journal of Advance Study and Research Work (2581-5997)/ Volume 2/Issue 11/November2019

Control Methods against Varroa Mites

Adnan AYAN*[1], Hidayet TUTUN[2], Osman Selçuk ALDEMİR[3]

[1]Department of Genetics, Faculty of Veterinary Medicine, Van Yuzuncu Yil University, Van, Turkey

[2]Department of Pharmacology and Toxicology, Faculty of Veterinary Medicine, Burdur Mehmet Akif Ersoy University, Burdur, Turkey

[3] Department of Parasitology, Faculty of Veterinary Medicine, Aydin Adnan Menderes University, Aydın, Turkey

Email: adnanayan@yyu.edu.tr *[1]

DOI: 10.5281/zenodo.3548388

Abstract

This review delineates the methods used to control Varroa mites and their effectiveness. Varroa mites are the most destructive parasites of honey bees worldwide that cause a weak colony population, resulting in significant economic losses. Varroa infestation in honey bee colonies increases the sensitivity of bees to other pathogens including viruses and bacteria. This requires appropriate measures against Varroa mites. The most widely applied Varroa control method is the application of chemicals by beekeepers. Due to the development of acaricide-resistance in Varroa mites and chemical residues in honeybee products, the application of chemicals does not provide complete control against Varroa. Alternative products and methods have been developed in recent years in order to avoid the mentioned issues. Alternative strategies include the use of natural products such as essential oils, organic acids, and biotechnical methods such as mite-trapping. Moreover, the combinations of different control methods in an integrated pest management program have been applied by different researchers that are effective against Varroa mites. Consequently, economic losses can be reduced by effective treatment, avoiding excessive chemical use and residue problems in bee products.

Keywords: Acaricide, essential oil, organic acid, Varroa

Introduction

Honey bees (*Apis mellifera*) is usually affected by a large spectrum of bacterial, viral and fungal infection such as chalkbrood, American foulbrood (AFB), which decrease productivity, performance, and welfare of them [15,20,24]. Varroa mites (especially *Varroa destructor*) are the most destructive parasite impacting honey bee health and contribute to elevated colony loss rates worldwide [1-3,23,40]. Today, various methods including physical, biological and chemical, are used to control the Varroa population. Complete control of Varroa is not possible with the currently applied methods. The chemical control method is of great importance to reduce parasite intensity. As a result of the widespread use of chemical-based drugs for Varroa control, the beekeeping industry is facing two important public health issues. Firstly, the Varroa mites develop resistance to these chemicals when used repeatedly. The second major problem is the presence of chemical residues in bee products [37].

There are a great number of preparations used in the chemical market to combat bee pests. The majority of these drugs are used to control Varroa. Amongst these, synthetic chemical compounds (tau-fluvalinate, flumetrine, amitraz and coumafos), organic acids (formic acid, oxalic acid, lactic acid) and volatile oils (thymol, carvacrol, and menthol) are most commonly used drugs [11,15,28]. The aim of this paper is to review the application of control methods of Varroa mite.

Chemical Control

Several chemical control strategies have been devised against Varroa. The control strategies for these mites mainly based on chemical treatments. Organophosphates, formamidine, and synthetic pyrethroids have come forth in the chemical control of Varroa. Coumaphos, amitraz, flumethrin, and fluvalinate are the most common drugs in chemical control [37]. Frequent reports have been received from beekeepers complaining of colony damage and a high number of Varroa mites during the winter months. Therefore, the recommended treatment against the mites normally performs in mid and late summer [13].

Amitraz is a main member of the formamidine, a new group of acaricide-insecticides. It is generally synthesized with xylene or petroleum products and has been around since the 1960s. Amitraz acts as an agonist of the α-2 adrenergic receptor which is a G protein-coupled receptor located in post-synaptic adrenergic neurons [41]. Coumaphos, an organophosphate pesticide, inhibits the activity of acetylcholinesterase enzyme (AChE), which hydrolysis acetylcholine (ACh) into choline and acetic acid. Drugs containing coumaphos are successfully used worldwide to control both Varroa and bee lice infections in honey bees [43].

Pyrethroids such as flumethrin and fluvalinate are highly effective in Varroa control and act on neural function by inhibiting the Varroa mite voltage-gated sodium channel [14]. The use of synthetic drugs for controlling the parasitic mites leads to the development of drug-resistant mites.The acaricides residues in the beehives as a result of treatment and these synthetic compounds distort the image of pure honey [12].

Providing new treatments for Varroa control is becoming very important. The most widely used biopesticides in the fight against Varroa are organic acids. Organic acids do not pose negative effects on the population of the queen, adult bee, and offspring in the colony provided their use at appropriate time and dosage [11]. Formic acid (HCOOH) is the first of a homologous series of organic acids. The use of formic acid in conjunction with integrated control systems can maintain the population of Varroa at the desired level, confirmed as a part of integrated control in many countries [38]. The volatile nature of formic acid is used in the control of Varroa. Its efficacy requires slow evaporation; therefore, the efficacy of formic acid depends on weather conditions, season of application, volume of the evaporation container, and the distance between container and hatching cells. Formic acid is successful when the air temperature is between 10ºC and 25ºC [9]. Even though application of formic acid using spray method is more effective, rapid evaporation increases the toxic effects of formic acid. Consequently, application of formic acid gel can be used to reduce the risk of toxicity [19].

Lactic acid is used as a better choice for controlling honey bee mites. Like other drugs used in classical treatment, organic acids should be applied in early spring or late autumn when honey is not present in the hive. Otherwise, the evaporation of these acids leaves a sour taste when honey is consumed. Another drawback of using lactic acid in mite control is the precise dosage required in order to kill a high percentage of mites. Therefore, the dosage should be well adjusted to avoid high bee mortality [5,36]. Oxalic acid (H2C2O4), an organic compound found in many plants, is one of the natural products widely used as an alternative therapy of Varroa. More than one application can increase the death of bees and may slow down the growth of colony in the next spring [31].

Plant-Based Control

Varroa mites have developed resistance to a wide range of synthetic acaricides due to the misuse and overuse thus decreasing the effectiveness of these synthetic acaricides [6]. Natural treatments consisting of organic acids and plant extracts are an emerging alternative cure in controlling honey bee mites. Essential oils, highly volatile compounds are plant products found in only specific parts or in all parts of a plant. It has been reported that many essential oils and their components are alternative to synthetic acaricides for control of Varroa mites [4,15]. Beekeepers use essential oils obtained from the market for acaricidal properties. About 15 plant species with acaricidal properties are used directly or by mixing with each other. Essentials oils are inexpensive, safe and free of adverse side effects when used properly. However, their standardization is very difficult during application [29,39].

The most common essential oils used in mite control are cinnamon oil (*Cinnamomum cassia*), citronella oil (*Cymbopogon nardus*), eucalyptus oil (*Eucalyptus globulus*), peppermint oil (*Mentha piperita*), rosemary oil (*Rosmarinus officinalis*), spearmint oil (*Mentha spicata*), tea tree oil (*Melaleuca alternifolia*), wintergreen oil (*Gaultheria procumbens*), neem oil (*Azadirachta indica*), thyme oil (*Thymus vulgaris*) and lemongrass oil (*Cymbopogon citratus*) [15,27,32,42]. The most commonly used components are eucalyptol, menthol, thymol, camphor, citronellal and citral [15,17,26,34]. These plant-based substances should be used together with other integrated control methods against mites. The single application of essential oils is often insufficient in the control of Varroa mites [4,33].

Biological Control

Biological control methods have been developed to control *V. destructor* without the use of chemicals. Biological Varroa control methods include the use of the bee's biology. Desirable properties of bees selected to form a mite resistant colony include higher hygienic and grooming activities, shorter post-capping periods, low attractiveness of the brood to mites, and low mite fecundity factors. The selection and establishment of resistant colonies are the best and cheapest methods for the control of Varroosis [25].

As a biotechnological approach, the "trapping comb method" has been used successfully. The principle is to remove the sealed honey bee comb hatching mites from the colonies, which can be highly effective due to the uneven distribution between the brood mites and bee mites. Most applications focus solely on the removal of the drone brood, which can be eliminated without a negative impact on colony size or honey production [37].

Pollen trap is a device made of plastic or metal placed in or under the hive entrance where bees returning from the field can hardly pass. At the entrance of the hive, the bees passing through the holes in the pollen traps leave the load of pollen, Varroa mites get trapped in most cases, separated from the bees, and fall from the trap screen. A study on the efficacy of pollen traps for controlling Varroa (*V. destructor*) showed that using pollen traps alone increased mite capture over control, and colonies with pollen traps produced higher honey yields than those without pollen traps. This method alone is not highly effective; however, it is useful to apply together with other methods [18].

Wire cage and drawer bottom application are Varroa control methods based on inserting a collection tray to hold any mites falling. Approximately 20% of adult mites in recently mature bees will fall to the bottom of the hive within the first three days. In order to catch the falling mites, a deep removable tray to the bottom board of hives and a wire grid where bees cannot pass but Varroa mites can pass is placed on the top of the tray. The mites fall under the wire cage failing to cross over to the bees and die of cold and starvation. The deep tray is not a stand-alone treatment to control mite populations, they must be used in conjunction with other mite control treatments [7,8].

Other biological methods include work-intensive applications like heat treatment. Varroa mites are more sensitive to temperatures above 34ºC than bee larvae and pupae. The optimal temperature for development of the mites is between 32.5 and 33.4°C. The reproduction ability of female mites is significantly reduced at temperatures above 36.5 °C, and mites above 38°C die without reproduction [44]. This method seems to be impractical in commercial beekeeping.

Colony management techniques provide many advantages in combating the mites. Varroa mites prefer to drone brood. The ability of young queen bees to lay low ratio of unfertilized eggs provide to reduce the number of drone brood thereby depressing the number of Varroa mites in the hive [8]. Especially when the queen replacement is mixed with other Varroa combat methods, the bees will not only be successful in the fight against Varroa but will also have the young queen bee for the coming season. When sufficient autumn feeding is made in the Requeen colonies, the production of the brood in the colonies can be increased and the colonies can be overwintered successfully [30]. Also, limiting the drone production by removing the drone brood areas on the honeycomb is a method of reducing the number of Varroa mites and can serve as a valuable component in an integrated pest management program for control of Varroa mites [35].

Entomopathogenic fungi have been used for the biological control of pests as environmentally friendly alternatives to chemical insecticides [16]. Entomopathogenic fungi such as *Metarhizium anisopliae* (MetschinkoV; Deuteromycetes: Hyphomycetes), *Hirsutella thompsonii* can infect insects and mites including *V. destructor* through specialized spores and grow within the hemocoel and soft tissues of the host, killing the hosts. Moreover, no residue was seen in the honey in addition to no undesirable effects on worker bees especially the queen bees. Microbial control with fungi can be a useful component of an integrated pest management program for controlling Varroa mites [21,22].

Conclusion

Several chemicals like coumaphos, fluvalinate have been widely used for control of Varroa mites. The alternative strategies against the use of the chemicals with residual and resistance problems are organic acids, plant products, biological control, and mechanical methods. However, no method alone is successful in Varroa control. Using these methods together in an integrated pest management strategy for control of Varroa mites can improve treatment success. Also, economic losses can be reduced by being treated more effectively, avoiding excessive chemical use and residual problems in bee products.

References

[1] A. Ayan and O.S. Aldemir. Genetic characterization of *Varroa destructor (*Family: Varroidae) prevalent in honeybees (*Apis mellifera*) in the province of Aydın in Turkey. MAKÜ Sag. Bil. Enst. Derg 6 (1): 26-32. (2018).

[2] A. Ayan, K. Ural, O.S. Aldemir and H. Tutun. Determination of the Genetic Characterization of *Varroa destructor* (Family: Varroidae) Collected from Honey Bees *Apis mellifera* (Hymenoptera, Apidae) in the Province of Van in Turkey. MAKÜ Sag. Bil. Enst. Derg 5 (2): 78-84. (2017b).

[3] A. Ayan, O.S. Aldemir and Z. Selamoglu, Z. Analysis of COI Gene Region of *Varroa destructor* in Honey Bees (*Apis mellifera*) in Province of Siirt. TJVR 1 (1): 20-23 (2017a).

[4] A. Imdorf, S. Bogdanov, R.I. Ochoa and N.W. Calderone.Use of essential oils for the control of *Varroa jacobsoni* Oud. in honey bee colonies. Apidologie, 30 (2-3): 209-228 (1999).

[5] B. Kraus and S. Berg. Effect of a lactic acid treatment during winter in temperate climate upon *Varroa jacobsoni* Oud. and the bee (*Apis mellifera* L.) colony. Exp. Appl. Acarol 18 (8): 459-468 (1994).

[6] D. Sammataro, P. Untalan, F. Guerrero and J. Finley. The resistance of varroa mites (Acari: Varroidae) to acaricides and the presence of esterase. Int. J. AcarIol 31 (1): 67-74 (2005).

[7] D. Somerville and D. Collins. Screened bottom boards.Rural Industries Research and Development Corporation. Access link: [https://www.agrifutures.com.au/wp-content/uploads/publications/14-061.pdf] Access time: 14.09.2019 (2014).

[8] E. Akyol and A. Korkmaz. Biological methods to control of the *Varroa destructor*. Uludag Bee J 6 (2): 62-67 (2006).

[9] E. Akyol and D. Özkök.The Use of Organic Acids for Varroa Control. Uludag Bee J 5 (4): 167-174 (2005).

[10] E. Akyol and H. Yeninar. Controlling *Varroa destructor* (Acari: Varroidae) in honeybee *Apis mellifera* (Hymenoptera: Apidae) colonies by using Thymovar® and BeeVital®. Ital. J. Anim. Sci7 (2): 237-242 (2008).

[11] E. Akyol and H. Yeninar. Use of oxalic acid to control *Varroa destructor* in honeybee (*Apismellifera* L.) colonies. Turk. J. Vet. Anim. Sci 33 (4): 285-288 (2009).

[12] E. Tihelka. Effects of synthetic and organic acaricides on honey bee health: a review. Slov. Vet. Res 55 (2): 119-40 (2018).

[13] G.V. Amdam, K. Hartfelder, K. Norberg, A. Hagen and S.W. Omholt. Altered physiology in worker honey bees (Hymenoptera: Apidae) infested with the mite Varroa destructor (Acari: Varroidae): a factor in colony loss during overwintering? J. Econ. Entomol 97 (3): 741-747 (2004).

[14] H. Thompson, R. Ball, M. Brown and M. Bew. *Varroa destructor* resistance to pyrethroid treatments in the United Kingdom. Bull. Insectology 56 (1): 175-184. (2003).

[15] H. Tutun, N. Koç, A. Kart. Plant Essential Oils Used Against Some Bee Diseases TURJAF 6 (1): 34-45 (2018).

[16] H. Zhao, B. Lovett and W. Fang. Genetically engineering entomopathogenic fungi. Adv. Genet 94: 137-163 (2016).

[17] H.A. Gashout and E. Guzmán-Novoa. Acute toxicity of essential oils and other natural compounds to the parasitic mite, *Varroa destructor* and to larval and adult worker honey bees (*Apis mellifera* L.). J. Apic. Res 48 (4): 263-269. (2009).

[18] I. Cakmak, L. Aydin, S. Camazine and H. Wells. Pollen traps and walnut-leaf smoke for Varroa control. Am. Bee. J 142 (5): 367-370 (2002).

[19] J.A. Skinner, J.P. Parkman and M.D. Studer. Evaluation of honey bee miticides, including temporal and thermal effects on formic acid gel vapours, in the central south-eastern USA. J. Apic. Res 40 (3-4): 81-89 (2001).

[20] J.D. Evans. Diverse origins of tetracycline resistance in the honey bee bacterial pathogen *Paenibacillus larvae*. J. Invertebr. Pathol 83 (1): 46-50 (2003).

[21] L.H. Kanga, R.R. James and D.G. Boucias. *Hirsutella thompsonii* and *Metarhizium anisopliae* as potential microbial control agents of *Varroa destructor*, a honey bee parasite. J. Invertebr. Pathol 81 (3): 175-184 (2002).

[22] L.H. Kanga, W.A. Jones and C. Gracia. Efficacy of strips coated with *Metarhizium anisopliae* for control of *Varroa destructor* (Acari: Varroidae) in honey bee colonies in Texas and Florida. Exp. Appl. Acarol 40 (3-4): 249 (2006).

[23] M. Reyes-Quintanaa, L.G. Espinosa-Montaño, D. Prieto-Merlos, G. Koleoglua, T. Petukhovaa, A. Correa-Benítez and E. Guzman-Novoa. Impact of *Varroa destructor* and deformed wing virus on emergence, cellular immunity, wing integrity and survivorship of Africanized honey bees in Mexico J. Invertebr. Pathol 164: 43-48 (2019).

[24] M. Shen, X. Yang, D. Cox-Foster and L. Cui.The role of varroa mites in infections of Kashmir bee virus (KBV) and deformed wing virus (DWV) in honey bees. Virol 342 (1): 141-149 (2005).

[25] M. Zemene, B. Bogale, S. Derso, S. Belete, S. Melaku and H.A. Hailu. Review on Varroa Mites of Honey Bees. AJE 8 (3): 150-159 (2015).

[26] M.D. Ellis and F.P. Baxendale. Toxicity of seven monoterpenoids to tracheal mites (Acari: Tarsonemidae) and their honey bee (Hymenoptera: Apidae) hosts when applied as fumigants. J. Econ. Entomol 90 (5): 1087-1091 (1997).

[27] M.F. Hassan, F.A. Sally A.R. Margaret and A.Y. Zaki. Utilization of essential oils and chemical substance against Varroa mite, *Varroa destructor* Anderson and Trueman on two stocks of *Apis mellifera lamerkii* in Egypt. AJESA 2: 3-8 (2008).

[28] M.I. SmodisSkerl, M. Nakrst, L. Žvokelj and A. Gregorc. The acaricidal effect of flumethrin, oxalic acid and amitraz against *Varroa destructor* in honey bee (*Apis mellifera carnica*) colonies. Acta Vet. Brno 80 (1): 51-56 (2011).

[29] M.L. Umpiérrez, E. Santos, A. González and C. Rossini. Plant essential oils as potential control agents of varroatosis. Phytochem. Rev 10 (2): 227-244. (2011).

[30] M.M. Cengiz. Effectiveness of combining certain biotechnical methods with thymol treatment against *Varroa destructor* infestation. Afr. J. Agric. Res 13 (47): 2735-2740 (2018).

[31] N. Adjlane, E.O. Tarek and N. Haddad. Evaluation of oxalic acid treatments against the mite *Varroa destructor* and secondary effects on honey bees *Apis mellifera*. J. Arthropod-Borne Di 10 (4): 501 (2016).

[32] N. Damiani, L.B. Gende, P. Bailac, J.A. Marcangeli and M.J. Eguaras. Acaricidal and insecticidal activity of essential oils on *Varroa destructor* (Acari: Varroidae) and *Apis mellifera* (Hymenoptera: Apidae). Parasitol. Res 106 (1): 145-152 (2009).

[33] N. Islam, M. Amjad, S.E. Ehsan-ul-Haq and F. Naz. Management of *Varroa destructor* by essential oils and formic acid in *Apis mellifera* Linn. Colonies.J. Entomol. Zool. Stud 4 (6): 97-104 (2016).

[34] N.W. Calderone and M. Spivak. Plant extracts for control of parasitic mite *Varroa jacobsoni* (Acari: Varroidae) in colonies of the western honey bee (Hymenoptera: Apidae). J. Econ. Entomol 88: 1211-1215 (1995).

[35] N.W. Calderone. Evaluation of drone brood removal for management of *Varroa destructor* (Acari: Varroidae) in colonies of *Apis mellifera* (Hymenoptera: Apidae) in the northeastern United States. J. Econ. Entomol 98 (3): 645-650 (2005).

[36] O.S. Aldemir and S. Bakırcı. Bal Arısı Hastalıkları ve Zararlıları. Adnan Menderes Üniveresitesi Veteriner Fakültesi, Aydın, s 53-94 (2014).

[37] P. Rosenkranz, P. Aumeier and B. Ziegelmann.Biology and control of *Varroa destructor*. J. Invertebr. Pathol 103: S96-S119 (2010).

[38] P.J. Elzen, D. Westervelt and R. Lucas. Formic acid treatment for control of *Varroa destructor* (Mesostigmata: Varroidae) and safety to *Apismellifera* (Hymenoptera: Apidae) under southern United States conditions. J. Econ. Entomol 97 (5): 1509-1512. (2004).

[39] R. Bauer. Quality criteria and standardization of phytopharmaceuticals: Can acceptable drug standards be achieved? Drug Inf. J 32 (1): 101-110 (1998).

[40] R. Hussain, S. Farooq, M. Kalsoom and H.U. Rehman. Prevalence of *Varroa destructor* on honey bees hives in district Karak, Khyber Pakhtunkhwa, Pakistan. J. Entomol. Zool. Stud 6 (1): 169-171 (2018).

[41] S. Baron, R.A. Barrero, M. Black, M.I. Bellgard, E.M. van Dalen, J. Fourie and C. Maritz-Olivier. Differentially expressed genes in response to amitraz treatment suggests a proposed model of resistance to amitraz in R. decoloratus ticks. Int. J. Parasitol. Drugs Drug Resist 8 (3): 361-371. (2018).

[42] S. Ruffinengo, M. Eguaras, P. Bailac, J. Torres, M. Basualdo and M. Ponzi.Essential Oils in the control of *Varroa destructor*. An Evaluation in Laboratory. Proceedings of the 37th International Apicultural Congress, 28 October – 1 November 2001, Durban, South Africa, (November), 28-31 (2001).

[43] S.M. Williamson, C. Moffat, M. Gomersall, N. Saranzewa, C. Connolly and G.A. Wright. Exposure to acetylcholinesterase inhibitors alters the physiology and motor function of honeybees. Front. Physio l4: 13 (2013).

[44] Y. Le Conte, G. Arnold and P.H. Desenfant. Influence of brood temperature and hygrometry variations on the development of the honey bee ectoparasite *Varroa jacobsoni* (Mesostigmata: Varroidae). Environ. Entomol 19 (6): 1780-1785. (1990).