Overview Regarding the Bioactivity of *Agastache foeniculum* and *Nepeta cataria* Species

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Bulletin UASVM Animal Science and Biotechnologies 72(1) / 2015

Print ISSN 1843-5262; Electronic ISSN 1843-536X

DOI:10.15835/buasvmcn-asb:10591

Abstract

In this study, we summarize the recent advances on chemical composition and bioactivity of giant hyssop (*Agastache foeniculum* (Pursh) Kuntze) and catnip (*Nepeta cataria* L.). Extracts from giant hyssop and catnip have a significant bioactivity, antibacterial and antioxidant activity (Suschke *et al.*, 2007; Zielińska and Matkowski, 2014; Mihaylova *et al.*, 2013). This literature review wants to emphasize the value of these two plants and the opportunity of using them to obtain bioactive extracts with applicability in beekeeping for different pest control. Different parts of the mentioned plants were used for the determination of active principles from macerates and essential oils. Spectrophotometric methods as well as high performance liquid chromatography and gas chromatography are generally used for determination of bioactive principles from the classes of polyphenols, flavonoids, carotenoids and aromatic acids. Remarkable results have been obtained using the essential oil from *Agastache foeniculum* as an insecticide for the control of pests like the Red flour beetle (*Tribolium castaneum* Herbst), Lesser grain borer (*Rhyzopertha dominica* F.), Mediterranean flour moth (*Ephestia kuehniella*) and the Indian meal moth (*Plodia interpunctella*) from the grain and food warehouses (Ebadollahi, 2011). The anti-microbial activity of catnip (*Nepeta cataria*) was proven in over five bacterial strains: *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus subtilis* (Bandh *et al.*, 2011).

Considering the results obtained and reported in the literature on the control of various pests and diseases, we consider appropriate to extend the research in the field of beekeeping as well, for a natural treatment of different bacterial diseases and pests.

Keywords: *Agastache foeniculum*, *Nepeta cataria*, anti-microbial, bio-insecticides

INTRODUCTION

In this study, we summarize the recent advances on chemical composition and bioactivity of aerial parts (leaves, stems and inflorescences) of giant hyssop (or blue giant hyssop, licorice mint) (*Agastache foeniculum* (Pursh) Kuntze) and catnip (*Nepeta cataria* L.). The genus *Agastache* includes 22 species of perennial aromatic medicinal herbs (Vogelmann, 1983). Although the study of the two species (*A. foeniculum* and *N. cataria*) has been carried out since 1945, for *Agastache* (Lint and Epling, 1945), and since 1941 for *Nepeta* (McElvain

et al., 1941; Walker cited by Woods and DuBuy, 1951), there is still much to be elucidated in the chemical composition of plants and their effects. Giant hyssop has been commercially cultivated as a source of nectar for honeybees (*Apis mellifera* L.) in Washington (Mayer *et al.*, 1982, cited by Widrlechner, 1992; Senechal, 1990; Ayers and Widrlechner, 1994; Fuentes-Granados *et al.*, 1998), because it excels at nectar production (Wilson *et al.*, 1992). Extracts from giant hyssop and catnip have a significant bioactivity, antibacterial and antioxidant activity (Mihaylova *et al.*, 2013; Zielińska and Matkowski, 2014).

This review covers the literature to summarize the main constituents from both aromatic and medicinal plants. *N. cataria* (Catnip) is the most famous *Nepeta* species, which has a long history of use as tea in Europe before real tea was imported from the orient (Herron, 2003). The flowering tips of the plant have also been used as a sedative drug (Newall *et al.*, 1996; Baser *et al.*, 2000). Some of the *Nepeta* species are used by bees as a source of pollen and nectar (Sammataro and Avitabile 1998, cited by Celenk *et al.*, 2008).

Catnip is a perennial herb with a considerable folkloric reputation (Marchei *et al.*, 2010). A diethyl ether extract of this plant has been shown to have antimicrobial activity against fungi and Gram-positive bacteria, have bacteriostatic and fungistatic properties (Bourrel *et al.*, 1993; Nostro *et al.*, 2001), and also with traditional uses that relate to the treatment of inflammation (Prescott *et al.*, 2011). *Catnip* produces predominantly nepetalactone, which is also known to comprise aphid sex pheromones and aphid parasitoid attractants. The availability of aphid sex pheromone components is now facilitating the development of new aphid pest control strategies, incorporating the use of other semiochemicals, particularly in the manipulation of populations of aphid parasitoids and aphid predators (Birkett and Pickett, 2003; Birkett *et al.*, 2010). Ameixa and Kindlmann (2012) have found a positive response regarding the aphid parasitoid *Aphidius colemani*, conducting research with a mixture of odors of synthetic and plant-extracted nepetalactone (a component of aphid sex pheromone) and (E)- β -farnesene (aphid alarm pheromone).

This literature review wants to emphasize the value of these two plants and the opportunity of using them to obtain bioactive extracts with applicability in beekeeping, for different pest control.

MATERIALS AND METHODS

Different parts of the mentioned plants were used for the determination of active principles from macerates and essential oils (Nykänen *et al.*, 1989). Spectrophotometric methods as well as high performance liquid chromatography and gas chromatography is generally used for the determination of bioactive principles from the classes of polyphenols, flavonoids, carotenoids

and aromatic acids (Vogelmann, 1984; Tisserand and Young, 2014).

Essential oil from aerial parts of giant hyssop was isolated by the hydrodistillation with Clevenger apparatus, and its chemical composition was studied by gas chromatography mass spectrometry (Shakhnoza and Glushenkova, 2012; Srifi *et al.*, 2012; Zielińska and Matkowski, 2014). The chemical composition of *catnip* essential oils can be determined by GC-MS on an apolar stationary phase by comparison of the characteristic fragmentation patterns with those of the Wiley 275L database. Essential oils were then fractionated by column chromatography packed with silica gel (Heuskin *et al.*, 2009; Ganzera *et al.*, 2001).

To determine the potential crop protection value of *Nepeta cataria* essential oils, the repellent activity of the oils was assessed using a four-way olfactometer assay, with both oils showing strong repellent effects (Peterson and Coats, 2001; Schultz *et al.*, 2004; Webb and Russell, 2007; Birkett *et al.*, 2010). Nepetalactones were analyzed by reversed-phase HPLC coupled with UV and MS detection. The linearity range for Z, E-nepetalactone was determined as 0.00655-0.655 mg/mL with a correlation coefficient of 0.9999, and the linearity range of E, Z-nepetalactone was found to be 0.00228-0.456 mg/mL with a correlation coefficient of 0.9999, under UV detection at 228 nm. The linearity ranges were from 0.00164 to 0.0328 mg/mL, with a correlation coefficient of 0.9999, for Z, E-nepetalactone and 0.00114-0.0228 mg/mL, with a correlation coefficient of 0.9999, for E, Z-nepetalactone by MS detection with selected ion monitoring of ion peak *m/z* 167. The MS detection was found to be more sensitive than UV detection and this method was validated as simple, reliable and sensitive for catnip nepetalactone analysis (Wang *et al.*, 2007).

Nostro *et al.* (2000) used two methods of extraction from *N. cataria*. In method A, a known amount of 50 g powdered drug (which was sequentially extracted at room temperature with petroleum ether (30°C, 50°C), dichloromethane, dichloromethane: methanol (9:1) and methanol (Arebalo and Mitchell, 1984; Chalchat and Lamy, 1997). The four extracts were concentrated to dryness using a rotary evaporator at 40°C. In method B, a known amount of 50 g powdered drug was extracted as reported by Al-Sarraj *et*

al. (1985), cited by Nostro *et al.*, 2000. The drug was suspended in enough distilled water to form a homogeneous suspension. The mixture was adjusted to pH 2.0 with HCl (1 N) and then incubated at 37°C for 30 min in a shaking water-bath. The mixture was then neutralized with NaOH (1 N) to pH 7.0, filtered, extracted with diethyl ether and concentrated to dryness. The remaining aqueous extract was lyophilized. All solvents were purchased from Merck (Milan, Italy). The method B proved to be more efficient in extracting the active compounds and this could be ascribed to the acidified aqueous environment, which promotes an easy extraction.

RESULTS AND DISCUSSION

To *Agastache*, in addition to the main components (phenylpropanoids, terpenoids and essential oils) there are many other such biocompounds: phenolic compounds (non-volatile metabolites), such as caffeic acid derivatives (especially rosmarinic acid) flavones and flavone glycosides (like acacetin, tilianin, agastachoside, and a rare dimeric malonyl flavone -agastachin) (Zielińska and Matkowski, 2014). Well, from aerial parts of *agastache* two unique lignans -agastenol and agastinol were isolated. Among terpenoids is noted: triterpenoids of oleanane-type -maslinic acid, oleanolic acid and β -amyrin-, ursane-type - ursolic acid, corosolic acid and α -amyrin-, and typical plant sterols (abietane-type oxidized diterpenes - e.g., agastaquinone, agastol, and others (Zielińska and Matkowski, 2014).

In the essential oil from *Agastache foeniculum* were identified over 50 compounds, which were isolated. Only ten constituents, however, accounted for more than 0.1%. In this essential oil prevailing, were the methyl chavicol (87.5%) (Omidbaigi and Sefidkon, 2003) to (91-95%) (Mazza and Kiehn, 1992) and limonene (2.4%) (Omidbaigi and Sefidkon, 2003) to (3.6-3.9%) (Mallavarapu *et al.*, 2004), 1,8-cineole (2.0%) and globulol (1.4%) (Omidbaigi and Sefidkon, 2003) as the major constituents. Other components of the essential oil are: monoterpenes, sesquiterpenes, oxygenated monoterpenes, oxygenated sesquiterpenes, camphene, myrcene and phenolics among others (Wilson *et al.*, 1992; Yashika *et al.*, 2013).

Remarkable results have been obtained in use of the essential oil from *Agastache foeniculum* as an insecticide for the control of pests like the Red flour

beetle (*Tribolium castaneum* Herbst), Lesser grain borer (*Rhyzopertha dominica* F.), Mediterranean flour moth (*Ephestia kuehniella*) and the Indian meal moth (*Plodia interpunctella*) from the grain and food warehouses (Ebadollahi, 2011). *A. foeniculum* oil revealed a strong toxicity (strong larvicidal potential) against the *T. castaneum* larvae, but also decreased the activity of esterase and GST besides reducing total carbohydrate, lipid and protein contents. Results showed that the mortality of larvae was dose-dependent and increasing concentrations of the essential oil exacerbate mortality. Probit analysis showed that LC50 and LC90 values were calculated as 8.022% and 80.152%, respectively (Ebadollahi *et al.*, 2013). Lopez *et al.* (cited by Ebadollahi *et al.*, 2013) reported estragole as an example of toxic compounds that are active against insect pests. The toxicity of *A. foeniculum* essential oil against red flour beetle, *Tribolium castaneum* (Herbst) and lesser grain borer *Rhyzopertha dominica* (F.) was evaluated by fumigation (Ebadollahi, 2011; Zielińska and Matkowski, 2014).

In a study by Nafziger and Fadamiro (2011) with giant hyssop as nectar sources for the parasitoid wasp, *Microplitis croceipes* (Hymenoptera: Braconidae), found significantly increased female longevity and numerically increased male longevity with honey from this plant. However, giant hyssops are not good nectar sources for the wasp (Nafziger and Fadamiro, 2011).

Some of the effects of induced plant protection *Herba Agastache* and inflorescences are: antimicrobial, antiviral, antimutagenic, antiproliferative, antiatherogenic, cytotoxic to cancer cell, anti-nociceptive, anti-inflammatory, antioxidant, relaxant activity on the contractions and others (Yashika *et al.*, 2012; Zielińska and Matkowski, 2014; Sánchez-Recillas *et al.*, 2014).

The presence of Nasonov pheromone components in the floral aroma of particular populations of *Agastache* could bias bee preference and might be useful as a tool for researchers to select attractive types (Wilson *et al.*, 1992). One component of the headspace of *A. foeniculum*, bornyl acetate, has been shown to stimulate the antennae of honeybees (Thiery *et al.*, 1990, cited by Wilson, 1992), but this olfactory stimulation has not been correlated with attractiveness. Among the 27 compounds identified of *Nepeta cataria* essential oil, four major components

were noted: 1,8-cineole (21.00%), α -humulene (14.44%), α -pinene (10.43%) and geranyl acetate (8.21%) (Peterson *et al.*, 2002; Morteza-Semnani and Saeedi, 2004; Gilani *et al.*, 2009; Javidnia *et al.*, 2002).

The antimicrobial activity of aerial parts of *Nepeta cataria* was assayed against five bacterial strains *Staphylococcus aureus*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Escherichia coli* and *Bacillus subtilis*. Two fungal strains, *Aspergillus flavus* and *Candida albicans* were also used to evaluate anti-fungal activity (Adiguzel *et al.*, 2009; Bandh *et al.*, 2011). Also, Nestorović *et al.* (2010) observed and evaluated the antimicrobial activity of methanol extracts from *Nepeta*, assayed against eight bacterial and eight fungal species. All the tested extracts showed significant antibacterial and strong antifungal activity.

The research done by Zenasni *et al.* (2008) shows that *Escherichia coli* and *Staphylococcus aureus* are more sensitive than *Pseudomonas aeruginosa* to essential oil from the *Nepeta* genus ($p < 0.001$). The research made by Zhu *et al.* (2014), found more than 98% inhibition of stable fly larval *Stomoxys calcitrans* (Diptera: Muscidae) growth and female oviposition was observed in larval and oviposition media treated with encapsulated catnip oil (0.5 μ g). Further, dose-response tests showed that as little as 0.1 μ g of encapsulated catnip oil provided more than 85% oviposition deterrence. Encapsulated catnip oil also exhibited antibacterial activity, supporting the hypothesis that its inhibition of larval growth may be based on its killing of the bacteria on which larvae feed. The use of encapsulated catnip oil can provide an alternative control strategy for stable fly management (Zenasni *et al.*, 2008; Bandh *et al.*, 2011; Zhu *et al.*, 2014).

Pavela (2005) tested *Nepeta cataria* essential oils for insecticidal activity against larvae *Spodoptera littoralis*, which were highly toxic, with $LC_{50} \leq 10.0$ ml/m³.

By commercial cultivation of the catmint *Nepeta cataria* (Lamiaceae), the lactone (II) can be isolated by industrial scale steam distillation and converted to the lactol (I) by inexpensive chemical means (Birkett & Pickett, 2003). Birkett *et al.* (2011) obtained results which suggest that although the nepetalactone isomers have the potential to be used in human and livestock protection against major pathogen vectors, intact,

i.e. un-fractionated, *Nepeta* sp. oils offer potentially greater protection, due to the presence of both nepetalactone isomers and other components such as (*E*)-(1*R*,9*S*)-caryophyllene.

Extracts of catnip were found to inhibit calcineurin; an important regulator of T-cell mediated inflammation that has received little attention in ethnopharmacological research. Calcineurin inhibition should be considered as a potential mode of action when investigating the immunomodulatory activity of caffeoyl phenylethanoid glycoside contained in catnip (Prescott *et al.*, 2011). It has also been found that iridodial is a key intermediate in the biosynthesis of nepetalactone (Bellesia *et al.*, 1984). *Nepeta cataria*, is also known to repel other ectoparasites affecting human and animal health (Kim *et al.*, 2003; Khan *et al.*, 2012). Zhu *et al.* (2009) successfully conducted catnip repellency tests on two fly species (stable flies and houseflies), including toxicity studies in humans to *N. cataria* products applied by oral, dermal and inhalation tests evaluating the eye and skin sensitivity. Bernardi *et al.* (2011) found through his research with catnip in rats improved male rat sexual

Fig. 1. Plant-defence compounds 'attracting' parasitoids and 'repelling' aphids could be activated by naturally occurring small lipophilic molecules (SLM) identified from (A) pest-damaged or (B) nonhost plants (Pickett *et al.*, 2012).

activity. The repellent mechanism could be activated by naturally occurring small lipophilic molecules (SLMs) identified from pest-damaged or non-host plants, as shown in *Figure 1* (A and B, respectively) (Pickett *et al.*, 2012).

Birkett *et al.* (2010)'s findings illustrate that *Nepeta cataria* possess a diverse range of high value secondary metabolites, and also highlight their potential to be developed as renewable feed stocks for the production of repellents for the use of economically important crop pests, as well as for the production of sex pheromones and natural enemy attractants. Further studies are underway to investigate their potential for use as part of a novel strategy for dust mite control, based on deployment of repellent and attractant semiochemicals in a push-pull strategy (Cook *et al.*, 2007, cited by Khan *et al.*, 2012), which could incorporate attractive pull components such as the recently identified aggregation pheromone (Skelton *et al.*, 2010, cited by Khan *et al.*, 2012).

Polsomboon *et al.* (2008) made experiments, which showed that catnip oil has strong irritant and repellent actions on mosquito test populations as indicated by the comparatively low escape time. Catnip oil and its major constituent compounds, nepetalactone, act not only as effective feeding and oviposition repellents, but also have a strong spatial repellency. The *in vitro* blood-feeding assay has proven to be a useful screening tool for discovering novel repellents for stable flies. Field trials conducted on cattle of two catnip oil formulations found these gave 5–6 h of protection against stable flies. Formulating catnip oil to meet USDA organic standards may also have promise as a method for stable fly control in organic dairy farms (Bissinger *et al.*, 2010; Zhu *et al.*, 2012).

CONCLUSION

Biotechnological and molecular studies have focused on *in vitro* propagation and enhancing the biosynthesis of bioactive metabolites in cell or organ cultures, as well as on the expression of genes involved in phenolic biosynthesis (Zielińska and Matkowski, 2014).

Nepeta cataria possesses spasmolytic and myorelaxant activities mediated possibly through dual inhibition of calcium channels and PDE, which may explain its traditional use in colic, diarrhea, cough and asthma (Gilani *et al.*, 2009).

The use of essential oils in the control of veterinary ectoparasites is an exciting area, which holds huge potential for the future. However, extensive field trials, standardization of components, standardization of extraction techniques, standardization of experimental design, mammalian toxicology profiling and excipient development, as well as further investigation into the residual activities and length of shelf life of these oils are all required before their potential can be fully explored (Ellse and Wall, 2014).

The results regarding the identified and isolated active principles from catnip and their antimicrobial effects encourage further research for their usage in the cosmetic and food industry, as viable and safe alternatives to synthetic antimicrobial products. Considering the results obtained and reported in the literature in the control of various pests and diseases, we consider appropriate to extend the research also in the field of beekeeping, for natural treatment of different bacterial diseases and pests. We consider appropriate, to extend further the research on the utility of the two plants on the health of bees and their honey production.

Acknowledgements. This paper was published under the frame of European Social Fund, Human Resources Development Operational Programme 2007-2013, project no. POSDRU/159/1.5/S/132765.

REFERENCES

1. Adiguzel A, H Ozer, M Sokmen, M Gulluce, A Sokmen, H Kilic, F Sahin, O Baris (2009). Antimicrobial and antioxidant activity of the essential oil and methanol extract of *Nepeta cataria*. Polish Journal of Microbiology, Vol. 58, Issue 1, 69-76.
2. Ameixa OMCC and P Kindlmann (2012). Effect of synthetic and plant-extracted aphid pheromones on the behaviour of *Aphidius colemani*. J Applied Entomology, 136(4): 292-301.
3. Arebalo RE, ED Mitchell Jr (1984). Cellular distribution of 3-hydroxy-3-methylglutaryl coenzyme A reductase and mevalonate kinase in leaves of *Nepeta cataria*. Phytochemistry, Vol. 23, Issue 1, 13-18.
4. Ayers GS, and MP Widrlechner (1994). The genus *Agastache* as bee forage: a historical perspective. American Bee Journal (USA), Vol. 134, Issue 5.
5. Bandh SA, AN Kamili, BA Ganai, BA Lone & S Saleem (2011). Evaluation of antimicrobial activity of aqueous extracts of *Nepeta cataria*. J Pharm Res, 4(9), 3141-3142.

6. Baser KHC, N Kirimer, M Kurkcuoglu, B Demirci (2000). **Essential Oils of *Nepeta* Species Growing in Turkey.** Chemistry of Natural Compounds. Vol. 36, Issue 4, 356-359.
7. Bellesia F, R Grandi, UM Pagnoni, A Pinetti, R Trave (1984). Biosynthesis of nepetalactone in *Nepeta cataria*. Phytochemistry, Vol. 23, Issue 1, 83-87.
8. Bernardi Maria Martha, Thiago Berti Kirsten, João Henrique Ghilardi Lago, Tatiana Marisis Giovani, Cristina de Oliveira Massoco (2011). *Nepeta cataria* var. *citriodora* (Becker) increases penile erection in rats. Journal of Ethnopharmacology, Vol. 137, Issue 3, 1318-1322.
9. Birkett MA, JA Pickett (2003). Aphid sex pheromones: from discovery to commercial production. Phytochemistry, Vol. 62, Issue 5, 651-656.
10. Birkett MA, TJA Bruce, JA Pickett (2010). Repellent activity of *Nepeta grandiflora* and *Nepeta clarkei* (Lamiaceae) against the cereal aphid, *Sitobion avenae* (Homoptera: Aphididae). Phytochemistry Letters, Volume 3, Issue 3, 139-142.
11. Birkett MA, A Hassanali, S Hoglund, J Pettersson, JA Pickett (2011). Repellent activity of catmint, *Nepeta cataria*, and iridoid nepetalactone isomers against Afro-tropical mosquitoes, ixodid ticks and red poultry mites. Phytochemistry, Vol. 72, 109-114.
12. Bissinger Brooke W and RM Roe (2010). Tick repellents: past, present, and future. Pesticide biochemistry and physiology, Vol. 96, Issue 2, 63-79.
13. Bourrel C, F Perineau, G Michel & JM Bessiere (1993). Catnip (*Nepeta cataria* L.) essential oil: analysis of chemical constituents, bacteriostatic and fungistatic properties. Journal of Essential Oil Research, Vol. 5, Issue 2, 159-167.
14. Chalchat Jean-Claude and Jacques Lamy (1997). Chemical composition of the essential oil isolated from wild catnip *Nepeta cataria* L. cv. *citriodora* from the Drôme region of France. Journal of Essential Oil Research, Vol. 9, Issue 5, 527-532.
15. Celenk Sevcan, Tuncay Dirmenci, Hulusi Malyer (2008). A palynological study of the genus *Nepeta* L. (Lamiaceae). Plant Systematics and Evolution, Vol. 276, Issue 1-2, 105-123.
16. Ebadollahi A, M Safaralizadeh, A Pourmirza, S Gheibi (2010). Toxicity of Essential Oil of *Agastache foeniculum* (Pursh) Kuntze to *Oryzaephilus surinamensis* L. and *Lasioderma serricorne* F. Journal of Plant Protection Research, Vol. 50, Issue 2, 215-219.
17. Ebadollahi Asgar (2011). Chemical constituents and toxicity of *Agastache foeniculum* (Pursh) Kuntze essential oil against two stored-product insect pests. Chilean J Agricultural Res, 71:2, 212-217.
18. Ebadollahi A, Khosravi R, Jalali-Sendi J, Honarmand P & Moayed-Amini R (2013). Toxicity and physiological effects of essential oil from *Agastache foeniculum* (Pursh) Kuntze against *Tribolium castaneum* Herbst (Coleoptera: Tenebrionidae) larvae. Ann Review & Res in Biology, 3: 649-658.
19. Ellse L and R Wall (2014). The use of essential oils in veterinary ectoparasite control: a review. Medical and Veterinary Entomology, Vol. 28, Issue 3, 233-243.
20. Fuentes-Granados RG and MP Widrlechner (1995). Diversity Among and Within Populations of *Agastache foeniculum*. Proceedings of the 14th North American Prairie Conference. Kansas State University, Manhattan, Kansas, Ed. D. Hartnett, 1-8.
21. Fuentes-Granados RG, MP Widrlechner and LA Wilson (1998). An overview of *Agastache* research. Journal of Herbs, Spices & Medicinal Plants, Vol. 6, Issue, 69-97.
22. Ganzera M, S Crockett, MR Tellez & IA Khan (2001). Determination of nepetalactone in *Nepeta cataria* by reversed phase high performance liquid chromatography. Die Pharmazie, 56(11), 896.
23. Gilani Anwar H, Abdul J Shah, Amina Zubair, Sana Khalid, Jawad Kiani, Amir Ahmed, Munawwer Rasheed, Viqar U Ahmad (2009). Chemical composition and mechanisms underlying the spasmolytic and bronchodilatory properties of the essential oil of *Nepeta cataria* L. Journal of Ethnopharmacology, Vol. 121, Issue 3, 405-411.
24. Herron Scott (2003). Catnip, *Nepeta cataria*, a morphological comparison of mutant and wild type specimens to gain an ethnobotanical perspective. Economic Botany, 57(1): 135-142.
25. Heuskin Stéphanie, Bruno Godin, Pascal Leroy, Quentin Capella, Jean-Paul Wathélet, François Verheggen, Eric Haubruge, Georges Lognay (2009). Fast gas chromatography characterisation of purified semiochemicals from essential oils of *Matricaria chamomilla* L. (Asteraceae) and *Nepeta cataria* L. (Lamiaceae). J. Chromatography A, Vol. 1216, Is 14, 2768-2775.
26. Javidnia K, R Miri, F Safavi, A Azarpira and A Shafiee (2002). Composition of the essential oil of *Nepeta persica* Boiss from Iran. Flavour and Fragrance J., Vol. 17, Issue 1, 20-22.
27. Khan MA, I. Jones, E Loza-Reyes, MM Cameron (2012). Interference in foraging behaviour of European and American house dust mites *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae* (Acari: Pyroglyphidae) by catmint, *Nepeta cataria* (Lamiaceae). Experimental and Applied Acarology, Vol. 57, Issue 1, 65-74.
28. Kim Soon-Il, Chan Park, Myung-Hee Ohh, Hyung-Chan Cho, Young-Joon Ahn (2003). Contact and fumigant activities of aromatic plant extracts and essential oils against *Lasioderma serricorne* (Coleoptera: Anobiidae). J. of Stored Products Research, Vol. 39, Issue 1, 2003, 11-19.
29. Lint Harold and Carl Epling (1945). A revision of *Agastache*. American Midland Naturalist, Vol. 33, No. 1, 207-230.
30. Mallavarapu GR, RN Kulkarni, K, Baskaran and S Ramesh (2004). The essential oil composition of anise hyssop grown in India. Flavour and Fragrance J., Vol. 19, Issue 4, 351-353.
31. Marchei P, S Diverio, N Falocci, J Fatjó, JL Ruiz-de-la-Torre, X Manteca (2010). The effect of *Nepeta cataria* on

- kittens' behavior. *Journal of Veterinary Behavior: Clinical Applications and Research*, Vol. 5, Issue 1, 50-51.
32. Massoco CO, MR Silva, SL Gorniak, MS Spinosa & MM Bernardi (1995). Behavioral effects of acute and long-term administration of catnip (*Nepeta cataria*) in mice. *Veterinary and human toxicology*, Vol. 37, Issue 6, 530-533.
 33. Mazza G, FA Kiehn (1992). Essential oil of *Agastache foeniculum*, a potential source of methyl chavicol. *Journal of Essential Oil Research*, Vol. 4, Issue 3, 295-299.
 34. McElvain M Samuel, Robert D Bright and Paul R Johnson (1941). The constituents of the volatile oil of catnip. I. Nepetalic acid, nepetalactone and related compounds. *Journal of the American Chemical Society* 63.6 (1941): 1558-1563.
 35. Mihaylova D, L Georgieva and A Pavlov (2013). In vitro antioxidant activity and phenolic composition of *Nepeta cataria* L. extracts. *Int. J.Agric.Sci.Technol*, Vol. 1, Issue 4, 74-79.
 36. Morteza-Semnani Katayoun and Madjid Saeedi (2004). Essential oils composition of *Nepeta cataria* L. and *Nepeta crassifolia* Boiss. and Buhse from Iran. *Journal of Essential Oil Bearing Plants*, Vol. 7, Issue 2, 120-124.
 37. Nafziger Timothy D Jr, Henry Y Fadamiro (2011). Suitability of some farmscaping plants as nectar sources for the parasitoid wasp, *Microplitis croceipes* (Hymenoptera: Braconidae): Effects on longevity and body nutrients. *Biological Control*, Vol. 56, Issue 3, 225-229.
 38. Nestorović Jasmina, Danijela Mišić, Branislav Šiler, Marina Soković, Jasmina Glamočlija, Ana Ćirić, Vuk Maksimović, Dragoljub Grubišić (2010). Nepetalactone content in shoot cultures of three endemic *Nepeta* species and the evaluation of their antimicrobial activity. *Fitoterapia*, Vol. 81, Issue 6, 621-626.
 39. Nostro A, MP Germanò, V D'Angelo, A Marino and MA Cannatelli (2000). Extraction methods and bioautography for evaluation of medicinal plant antimicrobial activity. *Letters in Applied Microbiology*, Vol. 30, Issue 5, 379-384.
 40. Nostro Antonia, Maria Angela Cannatelli, Giuseppe Crisafi, Vittorio Alonzo (2001). The effect of *Nepeta cataria* extract on adherence and enzyme production of *Staphylococcus aureus*. *International Journal of Antimicrobial Agents*, Volume 18, Issue 6, 583-585.
 41. Nykänen Irma, Yvonne Holm, and Raimo Hiltunen (1989). Composition of the Essential Oil of *Agastache foeniculum*. *Planta medica*, Vol. 55, Issue 3, 314-315.
 42. Omidbaigi R, F Sefidkon (2003). Essential Oil Composition of *Agastache foeniculum* cultivated in Iran. *Journal of Essential Oil Research*, Vol. 15, Issue 1, 52-53.
 43. Omidbaigi R, F Sefidkon (2004). Effect of sowing time on the essential oil content and composition of *Agastache foeniculum*. *J. of Essential Oil Bearing Plants*, Vol. 7, Issue 2, 190-194.
 44. Pavela Roman (2005). Insecticidal activity of some essential oils against larvae of *Spodoptera littoralis*. *Fitoterapia*, Vol. 76, Issues 7-8, 691-696.
 45. Peterson Chris and Joel Coats (2001). Insect repellents-past, present and future. *Pesticide Outlook*, Vol. 12, Issue 4, 154-158.
 46. Peterson CJ, LT Nemetz, LM Jones & JR Coats (2002). Behavioral activity of catnip (*Lamiaceae*) essential oil components to the German cockroach (*Blattodea: Blattellidae*). *Journal of Economic Entomology*, 95(2), 377-380.
 47. Pickett JA, GI Aradottir, GA Birkett, MA Bruce, TJ Chamberlain, K Khan, AOM Charles, ES Lesley and CM Woodcock (2012). Aspects of insect chemical ecology: exploitation of reception and detection as tools for deception of pests and beneficial insects. *Physiological Entomology*, Vol. 37, Issue 1, 2-9.
 48. Polsomboon S, JP Grieco, NL Achee, KR Chauhan, S Tanasinchayakul, J Pothikasikorn & T Chareonviriyaphap (2008). Behavioral responses of catnip (*Nepeta cataria*) by two species of mosquitoes, *Aedes aegypti* and *Anopheles harrisoni*, in Thailand. *Journal of the American Mosquito Control Association*, Vol. 24, Issue 4, 513-519.
 49. Prescott Thomas AK, Nigel C Veitch, Monique SJ Simmonds (2011). Direct inhibition of calcineurin by caffeoyl phenylethanoid glycosides from *Teucrium chamaedrys* and *Nepeta cataria*. *Journal of Ethnopharmacology*, Volume 137, Issue 3, 1306-1310.
 50. Sánchez-Recillas Amanda, Paul Mantecón-Reyes, Patricia Castillo-España, Rafael Villalobos -Molina, Maximiliano Ibarra-Barajas, Samuel Estrada-Soto (2014). Tracheal relaxation of five medicinal plants used in Mexico for the treatment of several diseases. *Asian Pacific Journal of Tropical Medicine*, Vol. 7, Issue 3, 179-183.
 51. Schultz G, E Simbro, J Belden, J Zhu & J Coats (2004). Catnip, *Nepeta cataria* (*Lamiales: Lamiaceae*) - a closer look: seasonal occurrence of nepetalactone isomers and comparative repellency of three terpenoids to insects. *Environmental entomology*, Vol. 33, Issue 6, 1562-1569.
 52. Senechal NP (1990). Evaluation of native perennial *Lamiaceae* as sources of nectar for honey bees. Doctoral dissertation, Iowa State University.
 53. Shakhnoza S Azimova, Anna I Glushenkova (2012). Lipids, Lipophilic Components and Essential Oils from Plant Sources. Ed. Springer London, ISBN 978-0-85729-322-0, 439.
 54. Sherry CJ, PS Hunter (1979). The effect of an ethanol extract of catnip (*Nepeta cataria*) on the behavior of the young chick. *Experientia*, Vol. 35, Issue 2, 237-238.
 55. Srifi A, B Rahmouni, El H Boudida, K Alaoui, Y Cherrah (2013). Étude phytochimique et activité antifongique in vitro des huiles essentielles de quatre espèces du genre *Nepeta* du Maroc. *Phytothérapie*. Vol. 11, Issue 3, 161-171.
 56. Suschke U, F Sporer, J Schneelee, HK Geiss & J Reichling (2007). Antibacterial and cytotoxic activity of *Nepeta cataria* L., *N. cataria* var. *citriodora* (Beck.) Balb. and *Melissa officinalis* L. essential oils. *Natural Product Communications*, Vol. 2, Issue 12, 1277-1286.

57. Tisserand Robert, Rodney Young (2014). 13 - Essential oil profiles. Essential Oil Safety (Second Edition), Churchill Livingstone Elsevier, 187-482.
58. Vogelmann JE (1983). A biosystematic study of *Agastache* section *Agastache* (*Labiatae*) (Doctoral dissertation, Indiana University).
59. Vogelmann JE (1984). Flavonoids of *Agastache* section *Agastache*. Biochemical Systematics and Ecology. Vol. 12, Issue 4, 363-366.
60. Vogelmann JE (1985). Crossing relationships among North American and eastern Asian populations of *Agastache* sect. *Agastache* (*Labiatae*). Systematic Botany, Vol. 10, No. 4, 445-452.
61. Wang Mingfu, Ka-Wing Cheng, Qingli Wu and James E. Simon (2007). Quantification of nepetalactones in catnip (*Nepeta cataria* L.) by HPLC coupled with ultraviolet and mass spectrometric detection. Phytochemical analysis. Vol. 18, Issue 2, 157-160.
62. Widrlechner MP (1992). A field evaluation of native mint family plants as honey bee forage in Iowa. In Proceedings of the Twelfth North American Prairie Conference. University of Northern Iowa, Cedar Falls, 39-42.
63. Wilson LA, NP Senechal, MP Widrlechner (1992). Headspace analysis of the volatile oils of *Agastache*. *Journal of Agricultural and Food Chemistry*, Vol. 40, Issue 8, 1362-1366.
64. Woods MW and HG DuBuy (1951). Hereditary and Pathogenic Nature of Mutant Mitochondria in *Nepeta*. *Journal of the national Cancer Institute*. 1105-1151.
65. Yashika Bhalla, Vinay Kumar Gupta and Vikas Jaitak (2013). Anticancer activity of essential oils: a review. *Journal of the Science of Food and Agriculture*. Vol. 93, Issue 15, 3643-3653.
66. Zenasni L, H Boudida, A Hancali, A Boudhane, H Amzal, A Idrissi, A Aouad, Y Bakri & A Benjouad (2008). The essentials oils and antimicrobial activity of four *Nepeta* species from Morocco. *Journal of Medicinal Plants Research*, 2(5), 111-114.
67. Zhang Hui, Shanshan Lu, Jian Wu, Yi Jiang, Yingmin Lu, Huien Zhao (2014). Effect of substrate depth on 18 non-succulent herbaceous perennials for extensive green roofs in a region with a dry spring. *Ecological Engineering*, Vol. 71, 490-500.
68. Zhu J, X Zeng, T Liu, K Qian, Y Han, S Xue, B Tucker, G Schultz, J Coats, W Rowley & A Zhang (2006). Adult repellency and larvicidal activity of five plant essential oils against mosquitoes. *Journal of the American Mosquito Control Association*, 22(3), 515-522.
69. Zhu JJ, XP Zeng, D Berkebile, HJ Du, Y Tong and K Qian (2009). Efficacy and safety of catnip (*Nepeta cataria*) as a novel filth fly repellent. *Med and Vet Ent*, Vol. 23, Issue 3, 209-216.
70. Zhu JJ, DR Berkebile, CA Dunlap, A Zhang, D Boxler, K Tangtrakulwanich, RW Behle, F Baxendale and G Brewer (2012). Nepetalactones from essential oil of *Nepeta cataria* represent a stable fly feeding and oviposition repellent. *Medical and Veterinary Entomology*, Vol. 26, Issue 2, 131-138.
71. Zhu JJ, BJ Wienhold, J Wehrle, D Davis, H Chen, D Taylor, K Friesen and L Zurek (2014). Efficacy and longevity of newly developed catnip oil microcapsules against stable fly oviposition and larval growth. *Medical and Veterinary Entomology*, Vol. 28, Issue 2, 222-227.
72. Zielińska S and Matkowski A (2014). Phytochemistry and bioactivity of aromatic and medicinal plants from the genus *Agastache* (*Lamiaceae*). *Phytochem Rev.*, Vol. 13, 391-416.