A Review:

Epidemiology and Management of *Varroa* Mite

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The rewiew contains the available literature in the light of *Varroa* mite epidemic and its management in the world considering the aspects like; impact of management technique on the honeybee colony members, their biology, mode of action, disease level, efficacy of dose applied, release of active in gradient in per unit of time, use of individual or integrated method, their compatability and efficacy, resistance to insecticides etc.The physical environment as, temperature, season, location where bees were reared, hygiene of the hive, space for application and threshold levels etc. affecting the methods for their suitability.

Varroa mite, a serious pest of honeybees attacks as an ectoparasite present in different parts of the world in localized virulent species or strains except Australian continent has created a threat to honeybee industry. In India, the mite epidemic had been a matter of little concern till 2005. Due to its outbreak in recent years' up to 20 per cent dwindling of colonies has been reported in various parts of the country (Kumar and Surender, 2005). Beekeeping scientists around the world have evaluated and reported different management or control techniques but these become unfeasible in other continents or locations. Though, the chemical control measures proved better but persistence of residues in bee products, unsuitability to hived bees have been reported as the major drawback. The botanicals, biotechnical/ behavioral methods, integrated management techniques have been devised in the different countries. The objective of the paper considering the seriousness of the pest is to compile the varroa mite related knowledge and reports in a summarized way to devise the most practical management technique (may be an integration) for particular location.

Morphology and distribution:

Oudemans, 1904 described *Varroa jacobsoni*, based on 4 female mites found on *Apis indica* (=*cerana*) from Semarang, Java. Delfinado-Baker and Aggarwal, 1974 recorded a new species as *Varroa underwoodi* while collecting samples for *Varroa jacobsoni* in *Apis cerana* colonies from Nepal. Delaplane, 2001 reported *V. jacobsoni*, a crytic species (as a complex of atleast two species) as *V. destructor* with different genotypes but Korean genotype, a most virulent genotype. Delfinado-Baker and Houck, 1989 recorded significant variations in thirteen morphological characters among mites of *Apis cerana* and *A. mellifera* in *Varroa jacobsoni* collected from 17 countries and named them as geographical strains. The genus *Varroa* was defined in detail with the description of nymphal stages and males as it comprises of two species as, *jacobsoni* and *underwoodi* with *Apis cerana* as the original honeybee host (Delfinado-Baker, 1984). Matheson (1995) listed the strains from 49 countries of *Varroa jacobsoni* outside Asia by review of literature. The most pandemic strain was identified as *Varroa destructor* in Europe for the first time with its resistance to synthetically prepared substances (Hovorka and Hascik, 2004).

Biology:

Delfinado-Baker and Aggarwal, 1974 described unique smaller size having long female lateral marginal setae radiating outwards and feeding on bee brood as the major distinguishing characters of *Varroa underwoodi*. Naim and Bisht, 1987 reported that mites live on worker and drone bees under the abdominal sclerites and occasionally under thorax to feed on haemolymph, larvae and pupae. Female lays upto 12 eggs in worker while upto 21 eggs in drone cell. Males develop in 6-7 days and females in 8-9 days. Mites live in temperate region upto 2 months and a colony may have 3000 to 11000 mites. Ifantidis, 1983 recorded ontogenetic aspects of varroa mite in *Apis mellifera* honeybees; female mite lay atleast 7 eggs in drone cell and 6 in woker cell, egg laying starts after invading cell after 6 hours which were laid after an interval of 30 minutes. It lasts in 7.5 day in female and 5.5 days in male. Boot *et al.*, 1995 reported that on 2nd day 4% of varroa mite climbed on bees and

spent maximum of 23 -days on bees. 8-12% mites did not reproduce offspring 4-4.4% with 1.2-1.3% viable daughters and 8-10% male. Zaid and Ghonlemy during 1992 reported that Folbex treatment caused queen mortality. Trouiler *et al.*, 1992 developed the semiochemical basis for the different esters secreted by the drone as well as the worker larvae which were more in drone cells hence preferred drone brood. Boecking *et al.*, 1993 reported the more grooming behaviour for resistance against *Varroa* mite in Africanised, European and *Apis cerana* than *A. mellifera* honeybees and felt a need for selection and breeding programmes. Chen *et al.*, 1995 reported higher dose of formic acid led to less egg laying and reduction in feed uptake. Gatien and Currie, 1995 have studied the mite population dynamics, colony survival, management and chemical control. Soko, 1996 has reported the adverse effects on oviposition and mortality of worker and queen bees by the use of Fluvarol 250 mg per strip against varroa control. Nedic *et al.*, 2002 recommended cupric gluconate salt 11.4 ml/kg in sugar syrup in Yugoslvia resulting median inhibition of parasite development without apparent impact on bees. Bassiouny *et al.*, 2004 reported above 0.26 mites/bee and 0.12 mites /bee approximately as economic injury and economic threshold levels for *Varroa destructor*.

Chemical management:

Apistan, fluvalinate, flumethrin, bromopropylate, phenothiazine, chlorbenzylate, etc.:

Naim and Bisht, 1987 reported chemical control of *Varroa* as difficult because it is always associated with hosts, being obligatory parasites, hence mite specific measures should be opted. Phenothiazine and chlorrbenzylate may be used and stressed that elimination of this pest is not possible. Kumar *et al.*, 1994 reported amitraz and fluvalinate had no detrimental effects on brood and longeivity of adult bees of *Apis mellifera.* Loglio, 1994 in a meeting of the apiculture scientists to discuss the issues pertaining to resistence occurred to *Varroa* against Apistan formulations and stressed on a need to find out the alternate control measure while Accorti and Luti during 1994 have shown their worries due to *V. jacobsoni* resistant strains and reinfestation and distortion of results in Apistan and suggested the protocols. Delaplane, 1995 reported antibiotic terramycin improves body weight of bees with Apistan 2 strips as varroacide. Chen *et al.*, 1994 reported treatments of Gubitol (coumaphos) dust 0.3 and 1.0 g at an interval of 6-7 days resulted into 76.6 and 82.4 % in 2 days, respectively were effective for the mite control. Erdmann, 1993 found Folbex VA Neu (bromopropylate) or Perizin (coumaphos) as ineffective in Berlinwith no correlation between the parasite load and reduced honey yield, climate and upto the mite population of 2100/colony. Moosbeckhofer, 1994 recommended one treatment per year either of Apistan or Bayvarol for the control of varoosis in Austria. Greef *et al.*, 1994 reported Apistan use for varroa control during autamn and in spring with residues from 25- 95% in just 4 years and quantity of residues in honey upto 0.004 ppm. Barbattini *et al.*, 1994 reported formic acid applied 4 times at an interval of 7 days resulted in mean effectiveness from 29.6% and 62.3% (40 ml of 65% acid) applied through absorbent cardboard and in sponge cloth, respectively with residue on 11th day 150-500 ppm but harmless. Lodesani *et al.*, 1995, reported the average effectiveness of Apistan 2 strips for 22 days as 44.5%. Frilli *et al.*, 1992 compared the efficacy of coumaphos, fluvalinate, flumethrin against varroa in Italy and mean effectiveness was 97.9, 92.1, 99.7, respectively. Hameed and Singh, 1990 evaluated seven fumigants on *Apis cerana* colonies infested with *Varroa jacobsoni viz*. PCB, methyl salycilate were not feasible in mite control but caused bees to abscond. Dichlorvos led to 50% mite mortality and folbex upto 250% mite mortality. According to Ansary and Zoggby, 1992 simple application technique of Apistan (fluvalinate) was the most effective. Ivanov, 1993 reported synthetic pyrethroids as control measure. Sanford, 1995 recommended that fluvalinate should be used as Apistan instead of other formulations like Kiarstan and Mavrik. Use of other formulations resulted in resistance. Dufol *et al.*, 1995 recommended half dose of fluvalinate (Apistan) and Bayvarol (Flumethrin) for 28 days in colonies having sealed brood with 100% mite mortality. Coumaphos and its 3 derivatives fed to colonies in different concentrations of sugar syrup were the most effective and safe killing upto 100% mites than enolophosphate upto 94% which also increased bee mortality (Jedruszuk *et al.*,1994). Fleche *et al.*, 1996 reported Apistan, the commonly used varrocide but migratory beekeepers have also adopted Kiarstan on large scale.

Acids:

Radetzki, 1994 reported limited use of oxalic acid in Germany. However, its application on honeybees @.3% twice gave 93-99% control and residues were insoluble in beeswax. Frilli *et al.*, 1992 reported efficacy of powdered lactic and formic acids against *Varroa* as 41.4 and 47.1%, respectively. Zaid and Ghoniemy during 1992 evaluated the role of somechemical compounds lactic acid and oxalic acid alongwith Bayvarol and Apitol for controlling *Varroa jacobsoni*. Greatti and associates

during 1993 reported that 40 ml of 65% of formic acid was the most effective against *Varroa* with a control of 62% by cardboard or a sponge cloth soaked 4 times in a week in *Apis meelifera* honeybees. Wilson and Collins (1993) reported formic acid (65%) as good measure but it becomes ineffective during temperate climate. Kraus and Berg, 1994 applied lactic acid 15.5% @ 8 ml /comb side with dosage gun and found mite mortality of 94.2 to 99.8% without side effects as compared to coumaphos. Rademacher and his associates during 1995 used formic acid 60% @ 85g of through Becker type applicator and mortality during July and September was 85 and 96%, respectively without mortality of queens and bees. Imdorf *et al.*, 1995 developed the Kramer method for the application of formic acid, lactic acid, oxalic acid in Switzerland. Mutinelli *et al.*,1994 documented 65% formic acid applied at week interval caused 89.6- 94.3% during the second half of August and if after 3 days upto 3 months could control mites upto 96.6%.without side effects on honeybees. Chen *et al.*, 1995 reported formic acid @ 6 ml / day of.on the top bars of the frames for honeybees in Taiwan. Rademacher *et al.*, 1995 applied average daily 17.5 g of 60% formic acid in Germany and recoded maximum mite mortality of 99.8% with no effects on queens. Gatien and Currie, 1995 reported that formic acid becomes ineffective at higher infestation levels. They categorized the chemicals according to their efficacy in order of Apistan, Perizin followed by formic acid. Shoreit and Omar,1995 reported lactic and oxalic acid both 0.1% in sugar syrup @ 250 ml/colony at 5 day intervals which successfully controlled the varroa mite population in Egypt. Underwood and Currie, 2003 applied formic acid in different concentrations and intervals and reported that doses of 0.08 and 0.16 mg/litre were effective to kill mites at all temperature conditions above 5 ^{0} C. Uderwood and Currie, 2004 suggested that in winter months the colonies should be treated with formic acid in small compartments which was feasible and effective also and reduced the *Nosema apis* spores and *Varroa destructor*. Satta *et al.*, 2005 reported gradual release of formic acid as autumnal treatment in gel packets and impregnated paperwick as most suitable against *Varroa destructor*. Squaras *et al.*, 2001 reported formic acid in gel matrix under autumnal conditions with 92% mite control without side effects on queen, brood or adult honeybees.

Smoke:

Chorbinski and Tomaezeweka, 1994 reported the side effects of Warrosekt, a smoke of malathion a.i. on enzymes activity and its double dose led to bee mortality upto 32% under field and laboratory conditions in Poland. Hameed and Singh, 1990 reported 40% mite mortality with sulphur but tobacco smoke caused deleterious effects on bees.

Strips, tags, aerosols and tablets:

Clark, 1994 suggested Apistan strips application as the simplest method. Imdorf *et al.*,1995, placing one vermiculite tablet (5*9*1 cm) on the upper part of bood combs for 3-4 weaks twice at optimum temperature with efficacy upto 95% and no residues were detected Wilson and Collins, 1994 reported new acaricide, YT-1601 and YT-1103 treated in USA for 28 days, killed 91.3 and 99.9% of mites, respectively without any side effect on bees. Plastic slow release device (Tag) was used in 1-4 tags/ colony. Jelinski *et al.*, 1994 have recommended plastic strips containing 50-250 mg of fluvalinate, 100 mg of malathion, 200 mg of amitraz in different combinations or alone and the higher doses in combination resulted into 95.4-100% mite mortality in Poland. Garra and Scoza 1993 treated infested colonies with 1, 2 or 3 Apistan strips for 8 weeks but did not find any significant difference in mite mortality. They emphasized that the number of strips varied in different localities. Wilson and Collins (1993) recomended for infested colonies with 2 strips of Apistan for 45 days, Miticur for 4-5 months and formic acid 65% thrice in a week. Byeung and Kang, 1995 reported relative efficacy of Bayvarol strips during autamn and spring was 92.7 and 93.7%, respectively. Hoopingarner, 1995 reported heavy winter loss due to late autamn. Apistan strips application hence should be used during early autamn. Imdorf *et al.*,1995 recommended Apilife VAR in Switzerland. Vesely *et al.*, 1995 reported 97.3% mite mortality with Acrinathrin (asynthetic pyrethroid) as 2 strips of 1.5mg a.i. in 50000 colonies in Czech Republic. Currie, 1995 reported the use of Queentabs (fluvalinate impregnated plastic strips) for 7 days against the varroa with a control up to 99% but it also affected workers and may be applied for 3 days only. Richer *et al.*, 1995 and Floris *et al.*, 1995 reported in severally mite infested honeybee colonies, Apistan and Apistan strips for one week for control the mites. Lensky *et al.*, 1996 reported fluvalinate inserts in brood nests for 6 weeks during March- April, as effective mite control measure. Haupt *et al.*, 1996 reported Bayvarol strips containing 3.6 mg protect bee colonies from late summer collapses and may be used once in a year against these mites while Perizin @ 0.064% with 50% control. According to Luganskii and Kiochko, 1994 the aerosol fumigation with Varrozen T J tablets having two active ingredients was effective and safe. Ali *et al.*, 2003 recommended alternative delivery method after evaluating three concentrations of

tebufenpyrid (17.5, 15 and 12.5%) in strip formulation for varroa mite control.

Adulteration in bee products, impact on bees and resistence of chemicals to mite:

Wallner, 1995 reported that the commonly used acaricides like fluvalinate and flumethrin against varroa can easily accumulate in beeswax as well as in honey and suggested their restricted use in Germany. Marien, 1995 reported that since 1988, the Apistan had been in use in Italy but resistance was apparent in spring 1994 and has also reported up to 100 mites in monthly treated colonies. Vandame *et al.*, 1995 reviewed the descriptive phenomenon of resistance to acaricides against *Varroa jacobsoni* and especially the failure of fluvalinate treatments in Italy. Vesely *et al.*, 1995 detected residues upto 0.1 mg/ kg of Acrinathrin (asynthetic pyrethroid) applied as 2 strips of 1.5 mg a.i Stehr *et al.*,1996 reported residues of Folvex VA Neu upto 0.3 mg/ kg in bee products. Richer *et al.*, 1995 reported that a colony can tolerate upto 5g of Apistan without any side effect. Soko, 1996 has reported Fluvarol 250 mg per strip used for varroa which control resulted into mortality of worker and queen bees and the adverse effects on oviposition.

Botanicals:

Calderone and Spiwak, 1994 reported the efficacy of plant products in a block of 25*25*5mm on florist material like thymol blend (18g each of thymol, eucalyptol, menthol and camphor) Linalool 18g as four pieces of these florist blocks. Thymol blend (96.7), linalool (27.5) and 4.4% for control in USA. Palmeri, 1995 studied the efficacy of *Tussilago farfara* as 2 and 4 g/hive thrice at weak interval and Apistan used and recoded 22.92-25.22 % mite control in Italy. Imdorf *et al.*, 1995 reported 100% *Varroa* mites control in caged honeybees in laboratory with thymol 5-15µg/l, menthol 20-60µg/l, camphor 50-150µg/l, and eucalyptol without bee mortality except eucalyptol in Switzerland. Lodesani *et al.*, 1995 reported Apilife (thymol 76%, eucalyptol 16.4%, menthol and camphor each 3.8%) as very effective. Imdorf *et al.*, 1995 recommended Apilife VAR (thymol 76%, eucalyptol 16.4%, menthol and camphor each 3.8%) in Switzerland against varroa mite. Frilli *et al.*, 1992 reported the efficacy of thymol upto 95%. Colin *et al.*, 1994 developed a method for characterizating the biological activity of essential oils like Thyme, Salvia and Chenopodium against *Varroa* and found acutely toxic in aerosol form to varroa which gave control upto 95.4% and prevented pupal parasitization in honeybee. Zaid and Ghonlemy, 1993 evaluated the powders from the flowers of warmwood (*Artemisia cinae*) and the seeds of cumin against *Varroa* mite during winters, reduced infestation level upto 9-12% and were safe to bees. Imdorf *et al.*, 1994 evaluated plant products, Apilife-Var available as (5*9*1 cm) piece impregnated with 20 g mixture of 76% thymol, 16.4% of eucalyptol, 3.8% each of menthol, camphor with 95% mite mortality in only single chambered colonies. Quedzuweit during 1994 reported insignificant effect of marjoram treated wax combs provided to the colonies against varroa mite. Kraus and Page, 1995 provided the vegetable oils to honeybees by different methods and found that oils in patties can increase the brood with varroa control up to 38.41%. Liu and Ward, 1995 documented Margosam O @ 3ml effective for control of *Acarapis woodi* but for *Varroa* control, results were inconclusive due to its high reinfestation rates. Greatti *et al.*, 1996 evaluated the product containing sulphur 33%, garlic 44% and pepper along with ethanol treated twice against the varroa mite and it resulted into the dwindling of the colonies. Gregore and Jelenc 1996 reported that the plates impregnated with Apilife VAR (74% thymol, 16% eucalyptol, 3.3% camphor, 3.7% menthol) inserted into the hives after honey harvesting controlled 2/3rd of mites as compared with Apistan (96%). Lensky *et al.*, 1996 reported thymol 10% to control mites up to 70% while thymol 30% was harmful to the bees. Mutinelli *et al.*, 1996 documented Apilife VAR containing thymol, menthol, eucalyptol and camphor along with other three organic acids *viz*. formic, oxalic, lactic acids, applied in various doses and formulations and their relative efficacy was worked out against varroa mite with very low mite mortality. Fries, 1997 reported the advantages of organic products like; efficiency, labour, cost and disadvantages of chemicals as residues and resistance and stressed the use of organic substances. Baggio *et al.*, 2004 evaluated three thymol based products namely Apilife VAR, Apigaurd and Thymovar and Apilife VAR in Italy and found the highest varroa mite control of 94.7% without any relavant side effect on bees while Thymovar showed partial results. Floris *et al.* (2004) found that Apilife VAR gave 74% and Apigaurd with 90.4% mite control and observed the negative effects of thymol due to its fat solubility. Shappard *et al.*, 2003 reported sucrose octanoate esters derived from the natural plant leaves against *Varroa destructor* as a benign compound safe and effective. Dimetry *et al.*,2005 used five formulations of plant extracts containing neem, vapcomic chloroform extract, citrullus seeds and powder and with alcohol and found control up to 94%. Burns *et al.*, 2005 compared the effectiveness of Exomite and thymol combinations and reported low population of mites initially but latter were ineffective due to gradual build

up. Ariana *et al.*, 2002 evaluated the plant essences of thymol, savory, rosemary, marjoram, dillsun and lavender @ 2 and 1 g. (w/w) and reported thyme, savory and spearmint having acaricidal properties.

Biotechnical:

Erdmann, 1993 suggested drone brood removal. Imdorf *et al.*, 1995 recommended the removal of drone brood and formation of nuclei. Brodsgaard *et al.*, 1994 used biotechnical methods like, drone brood removal, trapping combs, heat treatment of brood (4h to 44 ^{0} C) with lactic and formic acid. Heat treatment with drone brood removal was sufficient but considering difficulty of these methods hence autamn treatment with lactic acid or formic acid was recommended. Lavagnino and Marletto, 1995 reported drone brood removal from the colonies was effective and should be used during few months of year. Clark, 1995 reported the use of sticky papers along with the Apistan strips and formic acid for the control of *Varroa* as well as the *Acarapis woodi* mites. Gatien and Currie, 1995 suggested the artificial swarming, nucleus fusion which can control mites up to 50%. Fleche *et al.*, 1996 reported comb replacement and requeening the brood diseases *viz.* EFB, AFB, fungal have reduced from 40% to 28%. Nguyen *et al.*, 1996 adopted the manipulation methods *viz*. trapping varroa in drone brood cells, maintaining broodlessness, destroying brood after last honey harvest, caging queens. These methods helped in managing these mites in Vietnam. Spivak, 1996 reported hygiene as very important for varroa management and suggested that infested larvae must be taken out immediately. Calis *et al.*, 1996 adopted the drone brood trapping and creating broodlessness which could result in 93% varroa mite control. Thomas, 1997 has opined the resistance developed by varroa mite and stressed to manage it by alternate methods of drone brood killing, nulei making, developing resistant queens and using formic acid with winter treatment of oxalic acid resulting in 96-99% varroa mite control. Sammataro *et al.*, 2004.followed the integrated *Varroa* control strategies as the use of mite tolerant queen stock, screen inserts T-02 strips and has observed that the location of the apiaries has the effects on the colony development.Puskadiya *et al.*, 2003 reported nuclei method during the post spring season as effective to manage *Varroa destructor* but as an unique tactis can not be recommended.

Biological:

Tsagou *et al.*, 2004 reported that the bacterial strains of *Bacillus* sp. and three unidentified species of family Micrococaceae could control the mite up to 57% with lethal endotoxins and exotoxins to mite. Benoit *et al.*, 2004 reported the fungal spores present on the body of female mite and bees are almost the same but do not have any implication in biological control of *Varroa* mite but *Aspergillus flavus* may have the application in *Varroa* control. Peng *et al.*, 2002 cosidering resistance to fluvalinate, alternative management with fungus, *Hirsutella thompsonii* which has lethal time to kill 50% mites as 52-97 hours but its efficacy need to be studied largely in bee hives. Kanga *et al.*, 2002 reported *Hirsutella thompsonii* Fisher and *Metarrhizium anisopliae* Metachinkoff as biocontrol agents of varroa mite with LT 90 as 4.16 and 5.85 days, respectively @ 1.1*10 3 conidia mm(-2) having significant virulence against varroa mite and also recommended their use as promising avenues in integrated management of *Varroa destructo.* Kanga *et al.*, 2003 compared the efficacy of fungus, *Metarrhizium anisopliae* with tau- fluvalinate and reported that the fungus took 3-4 days after conidia were applied in dust and strip form and were found as effective as Apistan.

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REFERENCES

Accorti, M. and Luti, F. (1994). Control problems in varroosis: reinfestation, resistance and effectiveness of acaricides. *Apicoltura,* **9** : 147-161

Ali, M., Macedo, P., Wu, J. and Ellis, M. (2003). Evaluation of three concentrations of tebufenpyrid for the control of *Varroa destructor*. *J. Economic Entomol.,* **96** (2) : 259-263.

Ansary, O. and Zoggby, F. (1992). Comparative studies of varroa mites control using the three different acaricides, Apitol, Folbex VA and Apistan. *Alexandria J. Agric. Res.*, **37** (3) : 277-291.

Ariana, A., Ebadi, R. and Tehmasbi, G. (2002). Laboratory evaluation of some plant essences to control *Varroa destructor*. *Experimental Applied Acarology,* **27** (4) : 319-321

Baggio, A., Acculeo, P., Nanetti, A., Marinelli, E. and Mutinelli, F. (2004). Field trials with different thymol based products for the control of varroosis. *American Bee J.*, **144** (5) : 395-400.

Barbattini, R., Greatti, M., Agaro, M. Sabatini, A.., Colombo, R. and Marcazzan, G.L. (1994). Use of formic acid to control *Varroa*; verification of its efficacy and residues in honey. *Ape-Nostra-Amica,* **16**(4): 4-9.

Bassiouny, E., Gomau, A., Banby, E. and Ali, M. (2004). Approximated damage threshold level for varroa mite *Varroa destructor* inhabiting honeybee colonies. *Annals Apicultural Sci., Cairo,* **46**(2): 787-792.

Benoit, J., Yoder, J., Sammataro, D. and Zettler, L. (2004). Mycoflora and fungal vector capacity of the parasitic mite *Varroa destructor* (Mesostigmata; Varroidae) in honeybee colonies. *Internat. J. Acarology*, **30** (2): 103-106.

Boecking, O., Rath, W. and Drescher, W. (1993). Grooming and removal behaviour- strategies of *Apis mellifera* and *Apis cerana* bees against *Varroa jacobsoni*.

Boot, W.J., Callis, J. and Beetsma, J. (1995). Does time spent on adult bees affect the reproductive succes of varroa mite. *Entomologia- Experimentalis-et-Applicata*, **75**(1) :1-7.

Brodsgaard, C., Hansen, H. and Matheson, A. (1994). *New perspectives on varroa*..ed. :101-105 pp

Burns, R., Hayes, G., Westervelt, D. and Diaz, J. (2005). Florida test of Exosect Reg., Exomite TM Apis system for control of varroa mites *American Bee J.*, **145** (4): 305-307.

Byeung, K. and Kang, S. (1995). Studies on efficacy of Bayvarol against the mite (*Varroa jacobsoni*) and safety of Bayvarol in honeybees. *Korean J. Vet. Clinical Medicine*, **12** (1): 99-108.

Calderone, N. and Spiwak, M. (1994). Plant extracts for the control of the parasitic mite *V. jacobsoni* in the colonies of western honeybee. *J. Economic Entomol.*, **88**(5): 1211-1215.

Calis, J., Boot, W., Beetama, J., Eijode, J., Ruijter, A. and Steen, J. (1996). Trapping *Varroa jacobsoni* in drone brood combs of *Apis mellifera* in broodless colonies. *Apidologie*, **27**(4): 295-296.

Chen, Y., Chen, P., Hsu, E., Ho, K.K., Chen, Y.W.,Chen, P.L., Hsu, E.L. and Ho, K.K. (1994). The effect of coumaphos on *Varroa jacobsoni* and its influence on honeybee colony. *Chinese J. Entomol.*, 14(3):353-360

Chen, Y., Horng, I. and Ho, K. (1995). The effect of formic acid on *Varroa jacobsoni* and the honeybee colony. *Chinese J. Entomol.*, **15**(4): 287-294.

Chorbinski, P. and Tomaezeweka, B. (1994). The activity in the selected enzymes in the epithelial cells of the honey bee mid gut after application of Warrosekt. *Pszczelnicze,-Zeszyty-Naukowe*, **38**: 5-15.

Clark, A. (1994). Control of Varroa mites in British Columbia with either formic acid or Apistan. *American Bee J.*, **134** (12): 829.

Clark, K. (1995). Field trials for recommendations to control *Varroa* mites. Canadian Honey Council Research Symposium. 9-12 pp.

Colin, M., Claverella, F., Colina, G., Belzunces, P. and Matheson, A. (1994). *New perspectives on varroa*. Ed. :109-114 pp

Currie, R. (1995). Fluvalinate Queentabs: efficacy against varroa mite and impact on honeybee queen performance. Canadian Honey Council Research Symposium. pp 28-29.

Delaplane, K. (1995). Effects of terramycin antibiotic and Apistan acaricide on colonies of honeybees infested with *Varroa jacobsoni*.Rewiew of varroa mite infesting honeybees infested with *Varroa jacobsoni. J. Economic Entomol.*, **88** (5) : 1206-1210

Delaplane, K. (2001). Varroa destructor: Revolution in the making. Aguest editorial. *Bee World*, **82**(4): 157-159.

Delfinado-Baker, M. (1984). The nymphal stages and males of Varroa jacobsoni Oudemans, a parasite of honeybees. *Internat. J. Acarology*, **10** : 75-80.

Delfinado-Baker, M. and Aggarwal, K. (1974). A new *Varroa* (Acari: Varroidae) from the nest of *Apis rerana* (Apidae). *Internat. J. Acarology*, **13**(4): 233-237.

Delfinado-Baker, M. and Houck, M.A. (1989). Geographic variation in *Varroa jacobsoni* (Acari.: Varroidae): application of multivariate morphometric techniques. *Apidologie*, **20**: 345-358.

Dimetry, N., Wahab, E. and Zakaria, M. (2005). Effective control of varroa mite *Varroa destructor* infecting honeybee colonies *Apis mellifera* L. by some natural products. Bulletin of Faculty of Agriculture, *Cairo University*, **56** (2) : 295-308.

Dufol, M., Manera, C., Martiner, A., Acedo, C. and Gracia, M. (1995). Field trials of treatment against *Varroa jacobsoni* using fluvalinate and flumethrin strips in honey bee colonies containing sealed brood. *J. Apicultural Res.*, **34** (3) : 147-152.

Erdmann, E. (1993). Epidemiological investigations on varroosis in Berlin with special consideration of the Berlin prevention and treatment programme. 98 pp.

Fleche, C., Faucon, J., Brajnudel, P. and Palveroni, G. (1996). RESAN; Analysis of results for 1994. *Sante de L Abeille*, **152**: 75-84.

Floris, I., Prota, R., Cabras, F. and Lampis, A. (1995). Recent data on guided control of varroosis with Apistan. *Apitalia*, **22** (7/8) : 23-28.

Floris, I., Satta, A., Cabras, F., Garau, V. and Angioni, A. (2004). Comparison between two thymol formulations in the control of *Varroa destructor* : effectiveness, persistence and residues. *J. Economic Entomol.*, **97**(2): 187-191

Frilli, F., Milani, N., Barbattini, R., Greatti, M., Chiesa, F,, Iob, M., Aparo, M., and Prota, R. (1992). The effectiveness of various acaricides in the control of *Varroa jacobsoni* and their tolerance by the honeybees. Proceedings of 'The current state and development of research in Apiculture", Sessari, Italy, pp. 59-77

Fries, I. (1997). Organic control of varroa. Varroa- fight- the – mite.1997: 16-21.

Garra, C. and Scoza, F. (1993). Evaluation of 10% fluvalinate to control varroatosis in Mexico. *American Bee J.*, **133** (12) :864-865.

Gatien, F.and Currie, R. (1995). Effectiveness of control measures for the varroa mite. *Canadian Honey Council Res. Symposium*, pp. 3-8.

Greatti, M., Barbattini, R. and Aparo, M. (1993). Treatment of varroosis. Formic acid as a control method against *Varroa jacobsoni*. *Obiettivi-e-Documenti-Veterineri*, **14** (6) : 37-43.

Greatti, M., Barbettini, R. and Aparo, M. (1996). Efficacy of a product containing sulphur, garlic and pepper against the *Varroa jacobsoni* and its tolerance by *Apis mellifera*. *Selezione Veterinaria*, **1** : 9-20.

Greef, M., Eael, L. and Laere, O. (1994). Determination of fluvalinate residues in Belgian honey and beeswax. *Allgemeine-Deutsche-Imkerzeitung*, **28** (7): 7-8.

Gregore, A. and Jelenc, J. (1996). Control of *Varroa jacobsoni* Oud. in honeybee colonies using Apilife-VAR. Zbornik *Veterinarake Facultata Universe Ljubljana*, **33** (2) : 231-235.

Hameed, S. and Singh, B. (1990). Effectiveness of various fumigants against *Varroa jacobsoni* mites in *Apis cerana indica* F. colonies. *J. Entomological Res.*, **14** (1) : 75-77.

Haupt, W., Ribbeck, R., Will, R. and Hartzsch, K. (1996). Experience in application of bayvarol strip in various beehives controlling varroatosis under field conditions. *Berliner- und-Munchener- Tierarzliche- Wochenschrift.*, **109** (6/7) : 232-234, 236-238.

Hoopingarner, R. (1995). The time of fall treatment with Apistan and winter survival of honeybee colonies. *American Bee J*., **135** (8) : 535-536.

Hovorka, F. and Hascik, J. (2004). An alternative way of treatment of bee colonies against *Varroa destructor* using formic acid. *Slovensky Veterinersky Casopis*, **29** (3) : 40-42.

Ifantidis, M. (1983). Ontogenesis of the mite *Varroa jacobsoni* in worker and drone honeybee brood cells. *J. Apicultural Res.*, **22** (3) : 200-206.

Imdorf, A., Kilchenmann, V., Bogdanov, S., Bachofen, B. and Baretta, C. (1995). Toxic effects of thymol, menthol and eucalyptol on *Varroa*. *Apidologie*, **26**(1): 27-31.

Imdorf, A., Bogdanov, S., Kilchenmann, V. and Maquelin, C. (1995). Apilife VAR; a new varroacide with thymol as the main ingredient. *Bee World*, **76**(2): 77-83.

Imdorf, A., Charriere, J., Maquelin, C., Kilchenmann, V. and Bachofen, B. (1995). Alternative varroa treatments. *Schweizerische Bienen Zeitung*, **118** (8) : 450-459.

Imdorf, A., Bogdanov, S., Kilchenmann, V., and Maquelin, C. (1994). Apilife-VAR- a varroa treatment substance with thymol as the active ingredient.*Schweizerische-Bienen-Zeitung*, **117** (6) : 326-333.

Ivanov, Y. (1993). Effectiveness of different forms of amitraz and synthetic pyrethroids against varroa mites and effects of these preparations on the activity of bees. *Sel'skokhozyalstvennaya Biologiya*, **2** : 130-136.

Jedruszuk, A., Wael, L. and Laere, O. (1994). Laboratory study on the varroacidal efficacy and toxicity for bees of certain substances used in sugar syrup. *Bulletin of the Veterinary Institute in Puawy*, **38** (2) : 119-123.

Jelinski, M., Jedruszuk, A. Kostecki, R. and Matheson, A. (1994). Studies on the usefulness of different varroa control substances incorporated in plastic carriers. New perspectives on varroa, 85-86 pp.

Kanga, L., James, R. and Boucias, D. (2002). *Hirsutella thompsonii* and *Metarrhizium anisopliae* as potential microbial control agents of *Varroa destructor*, a honeybee parasite. *J. Invertebrate Pathol.*, **81**(3): 175-184.

Kanga, L., Jones, W. and James, R. (2003). Field trials using the fungal pathogen, *Metarrhizium anisopliae* to control the ectoparasitic mite *Varroa destructor* in honeybees, *Apis mellifera* colonies. *J. Economic Entomol.*, **96**(4): 1091-1099.

Kraus, B. and Berg, S. (1994). Effect of lactic acid treatment during winter in temperate climate upon *Varroa jacobsoni* Oud. and the bee (*Apis mellifera* L.) colony. *Experimental & Applied Acarology*, **18** (8): 459-468.

Kraus, B. and Page, R. (1995). Effect of vegetable oil on *Varroa jacobsoni* and honeybee colonies. *Bee Sci*., **31**(4): 157-161.

Kumar, A. and Surender, K.S. (2005). Varroasis in *Apis mellifera* Linn. colonies in Kangra valley of Himachal Pradesh.*Insect Environment*, **11**(3) : 131.

Kumar, A., Sharma, S., Kashyap, N.,Srivastva, S. and Raj, D. (1994). Effect of Amitraz and fluvalinate on brood and longeivity of adult *Apis mellifera* L. bees (Hymenoptera, Apidae). *Uttar Pradesh J. Zoology*, **14** (2) : 151-155.

Lavagnino, P. and Marletto, F. (1995). The effect of periodical drone brood removal on varroaosis development in Liguria. *Apicoltore Moderno*, **84** (2): 77-82.

Lensky, Y., Sisbezki, Y., Gal, H., Gerson, U. and Dechmani, U. (1996). Integrated control of varroa mite- (Varroa jacobsoni Oud.). in *Apis mellifera* colonies in Thailand. Final Report. 1996, 96.

Liu, T. and Ward, I. (1995). Control of tracheal mites, *Acarapis woodi* Rennie, and the mite *Varroa jacobsoni* Oud., with neem extract, Canadian Honey Council Research Symposium. pp 116-137.

Lodesani, M., Colombo, M. and Spreafico, M. (1995). Ineffectiveness of Apistan R treatment against mite Varroa in several districts of Lombardy (Italy). *Bee World*, **76**(2): 77-83.

Loglio, G. (1994). Effectiveness of Apistan and the resistance occurred in *Varroa* in Italy A meeting of new varroa control policies *Apicoltore-Moderno*, **85**(2): 67-69.

Luganskii, S. and Kiochko, R. (1994). Some aspects of the application of medicated smoke aerosols against *Varroa*. *Problemy- Veterinersol- Sanitari-I- Ekologii*, **93**(2): 40-42.

Marien, J. (1995). Controlling varroosis by temperature treatment with an Apitherm heater.*Deutsches Biesen J.,* **3**(5): 37-38.

Matheson, A. (1995). First documented findings of Varroa jacobsoni outside its presumed natural range. *Apiacta,* **30**(11): 1-8.

Moosbeckhofer, R. (1994). Individual or coordinated control-several years, experience of using pyrethroid strips for the control of varoosis in Austria. *Allgemeine- Deutsche-Imkerzeitung,* **28**(10): 6-11.

Mutinelli, F., Cremasco, S. and Irsara, A. (1994). Formic acid in control of varroatosis; a practical approach. *J. Veterinary Medicine,* **41**(7-8): 433-440.

Mutinelli, F., Cremasco, S., Irsara, A., Nanetti, A. and Massi, S. (1996). Organic acids and Apilife VAR in the control of varroosis in Italy. *Apicoltore Moderno,* **87**(3): 99-104.

Naim, M. and Bisht, B. (1987). A review on mites as pests of honeybees. *Indian Bee J.,* **49**: 54-57.

Nedic, N., Mladenovic, M., Popskovic, D., Georgijev, A. and Mirjanic, G. (2002).The influence of cupric gluconate on keeping down *Varroa jacobsoni* Biotechnology in Animal Husbandary, **18** (5/6): 329-332.

Nguyen, V., Nguyen, T., Lwong, H. and Boot, W. (1996). Biotechnical manipulatios used in Vietnam to control Varroa jacobsoni and Tropilaelaps claraeae in colonies of Apis mellifera. *Bee Sci.,* **4**(1): 11-13.

Oudemans, A. (1904). On a new genus and species of parasite. Acari. Notes. *Leyden. Mus.,* **24** : 216-222.

Palmeri, V. (1995). Studies on the efficacy of products of *Tussilago farfara* against *Varroa jacobsoni*. *Apicoltore Moderno,* **86**(2) :67-75.

Peng, E., Zhou, E. and Hoyo, A. (2002). Virulence and time of infection of the fungus, *Hirsutella thompsonii* on the honeybee ectoparsitic mite, *Varroa destructor*. *J. Invertebrate Pathol.,* **81** (3) : 185-195.

Puskadiya, Z., Florijencic, T., Boskovic, J., Mijic, F. and Ozimec, S. (2003). Efficiency of forming nucleus colonies in order to decrease population of *Varroa destructor* in bee hives. *Apiculture Scientific and Professional Review,* **9** (2): 74-77.

Quedzuweit, K. (1994). Examination of oil of marjoram treatment for the control of varroosis under field conditions. Bediopungen: 115.

Rademacher, E., Polaczek, B. and Schricker, B. (1995). Control of varroosis using formic acid in applicator-II. *Pszczellicze Zeszyty Naukowe,* **39** (11): 133-142.

Radetzki, T. (1994). Oxalic acid, another organic acid for *Varroa* treatment. *Allgemeine-Deutsche-Imkerzeitung,* **28**(12): 11-15.

Richer, F., Conte, L. amd Collin, D. (1995). Therapeutic efficacy of a new formulation (Apivar) intended for the treatment of varroosis of the honeybee. *Abeille de Franze et 1 Apiculteur,* **807** : 373-374.

Sammataro, D., Hoffman, O., Wardell, G., Finley, J. and Ostiguy, U. (2004). Testing a combination of control tactics to manage *Varroa destructor* populations in honeybee colonies. *Internat. J. Acarology,* **30**(1): 71-76.

Sanford, M. (1995). Use it right or lose it. *Apis,* **13**(5): 1-5.

Satta, A., Floris, J., Squras, M., Cahras, P., Garau, V. and Melis, M. (2005). Formic acid –based treatments for control of *Varroa destructor* in a Mediterranian area. *J. Economic Entomol.,* **98** (2): 267-273.

Shappard, W., Gardner, M., Hasher, S., Kehkonen, B., Meixner, M. and Strange, J. (2003). Use of sucrose octanoate esters to control the parasitic honeybee mite *Varroa destructor*. *American Bee J.,* **143**(12): 982-985.

Shoreit, M. and Omar, M. (1995). The effect of lactic and oxalic acids on controlling varroatosis in honeybee colonies. *Assiut J. Agricu. Sci.,* **26** (2) : 145-152.

Soko, R. (1996). Influence of long term persistence of Fluvarol (fluvalinate) in a honeybee hive. *Medycyna Weterynaryjna,* **52** (11): 718-720.

Spivak, M. (1996). Response of hygienic honeybees to *Varroa jacobsoni* mites. *Resistent- Pest –Management,* **8**(1): 42-44.

Stehr, C., Wachendorfer, G. and Seeger, B. (1996). Gas chromatographic testing for residues of bromopropylate in honey, wax and propolis after its use for controlling *Varroa jacobsoni* mites. *Tierarzliche Umschau,* **51**(4): 249-254

Squaras, M., Hoyo, D., Palacio, M., Ruffinango, S. and Bdascarrasbure, E. (2001). A new product with formic acid for *Varroa jacobsoni* control in Argentina. 1. Efficacy. *J-Vet-Med-B-Infect-Dia-Vet- Public_Health,* **48**(1): 11-14..

Thomas, H. (1997). Practical aspects of alternative varroa control methods. *Varroa- fight- the –mite,*1997: 22-30.

Trouiler, J., Arnold, G. Chappe, B. Conte, V. and Masson, C. (1992). Semiochemical basis of infestation of honey bee brood by *Varroa jacobsoni*. *J. Chemical Ecology,* **18**(11): 2041-2053.

Tsagou, V., LIanou, A., Lazarakis, D., Emmarouel, N. and Aggelis, D. (2004). Newly isolated bacterial strains belonging to Bacilliaceae (*Bacillus* sp.) and micrococcaceae accelerate the death of honey bee mite *Varroa destructor* (*V. jacobsoni*), in laboratory assays. *Biotechnology Letters,* **26** (6) : 529-532.

Underwood, R. and Currie, R. (2003).The effects of temperature and dose of formic acid on treatment efficacy against *Varroa destructor*, a parasite of *Apis mellifera*. *Exoerimental & Applied Acarology,* **29** (3/4): 303-313.

Underwood, R. and Currie, R. (2004). Indoor winter fumigation of *Apis mellifera* colonies infested with *Varroa destructor* with formic acid is a potential control alternative in northern climates. *J. Economic Entomol.,* **97**(2): 177-186.

Vandame, R., Colin, M., Belzunces, L. and, J. (1995). Resistance of varroa to fluvalinate.*Carnets- du- CARI*: **146** (5-11).

Vesely, V., Malonova, H. and Titera, D. (1995). Acrinathrin, an effective varroacide and its residues in stores, honey and wax. *Apidologie*, **26** (4) : 321-322.

Wilson, T. and Collins, A. (1993). Falure of formic acid to control *Varroa jacobsoni* in hot climate. *American Bee J.,* **133** (12) : 871.

Wilson, W. and Collins, A.M. (1994). New miticides for varroa control. *American Bee J.*, **134**(12): 839.

Wallner, H. (1995).The use of varroacides and their influence on the quality of bee products. *American Bee J.*, **139** (12): 817-821.

Zaid, M. and Ghoniemy, A. (1992). Evaluation of the role of somechemical compounds for controlling *Varroa jacobsoni* Oudemans in Egypt. *J. Agric. Res.,* **17**(3):1465-1470.

Zaid, M. and Ghonlemy, A. (1993). Evaluation of the role of two natural substances for controlling *Varroa jacobsoni* infesting honeybee colonies. *Egyptian J. Appl. Sci.*, **8** (2): 295-300.

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