Dottorato per il Sistema Agro-alimentare

ciclo XXXII

S.S.D: AGR/11

Utilizzi innovativi di molecole naturali o di sintesi per la lotta agli insetti infestanti

Coordinatore: Ch.mo Prof. Marco Trevisan

Tesi di Dottorato di: **Dr.ssa Olga Chiesa**
Matricola: 4612267

Tutor: Prof. Emanuele Mazzoni

Anno Accademico 2018/2019

Abstract

Gli insetti possono generare problematiche in ambito urbano, merceologico e agronomico. La presente tesi raccoglie i risultati preliminari di tre progetti di ricerca, ognuno riguardante uno dei sopraccitati aspetti. Ognuno dei progetti è vincolato da accordi di segretezza in virtù delle potenzialità brevettuali dei risultati ottenuti.

Per l'ambito urbano, la ricerca è stata condotta all'interno di un progetto nazionale del Ministero dell'Industria che prevedeva lo sviluppo di prodotti tessili ingegnerizzati per conferire protezione contro gli insetti e in particolare contro *Aedes albopictus*.

Per l'ambito merceologico, la ricerca è stata sviluppata in collaborazione con una importante azienda alimentare italiana per contrastare le infestazioni di *Plodia interpunctella* in confezioni di praline a base di cioccolato.

Per l'ambito agronomico, la ricerca ha visto la collaborazione in una impresa britannica orientata a produrre prodotti insetticidi di origine naturale. Il progetto di ricerca si è focalizzato nei confronti di *Myzus persicae* al fine di individuare nuove molecole a minor impatto ambientale che possano essere utilizzate con successo contro specie che molto spesso risultano di difficile controllo a causa dei fenomeni di resistenza agli insetticidi che si sono selezionati nel tempo.

L'esigenza, trasversale a tutti i progetti, è quella di selezionare molecole a minor impatto ambientale rispetto a quelle tradizionali ma con proprietà insetticida e/o repellente paragonabili o superiori a quelle utilizzate ad oggi contro gli insetti oggetto dello studio.

Abstract

Insects can generate problems in urban, storage and agronomic fields. This work collects the preliminary results of three research projects, each one regarding the above-mentioned arguments. Each projects is protected by secret agreement for the potential creation of patents related to the obtained results.

For urban field, the research was carried out in the framework a national project funded by the Italian Ministry of Industry. The project involved the development of textile products engineered to confer protection against insects and in particular against *Aedes albopictus*.

For store product field, the research was carried out in collaboration with an important Italian food company to counter the infestations of *Plodia interpunctella* using repellent molecules.

For agronomic field, the research was developed in collaboration with a British company oriented to produce insecticides of natural origin. The project was focused on *Myzus persicae*, in order to identify new molecules with a lower environmental impact that could be successfully employed against species which are difficult to control due to resistance phenomena.

The aim, transversal to all projects, is to select molecules with a lower environmental impact than traditional ones but with insecticidal and/or repellent properties comparable (or superior) to those used currently against the insects object of the study.

SOMMARIO

BIBLIOGRAFIA

Abbott, W. S. (1925). A method of computing the effectiveness of an insecticide. *Journal of economic Entomology*, *18*(2), 265-267.

Abdel-Mohdy, F. A., Fouda, M. M., Rehan, M. F., & Aly, A. S. (2008). Repellency of controlled-release treated cotton fabrics based on cypermethrin and prallethrin. *Carbohydrate polymers*, 73(1), 92-97.

Ahmad, M. (2007). Insecticide resistance mechanisms and their management in *Helicoverpa armigera* (Hübner) – A review. *Journal of Agricultural Research*, *45*(4), 319-335.

Alphey, L. (2014). Genetic control of mosquitoes. *Annual review of entomology*, *59*.

Andersen, A. N., Blum, M. S., & Jones, T. H. (1991). Venom alkaloids in Monomorium “rothsteini” Forel repel other ants: is this the secret to success by Monomorium in Australian ant communities?. *Oecologia*, *88*(2), 157-160.

Anderson, P., & Löfqvist, J. (1996). Asymmetric oviposition behaviour and the influence of larval competition in the two pyralid moths *Ephestia kuehniella* and *Plodia interpunctella*. *Oikos Journal*, 47-56.

Araújo, L. U., Grabe-Guimarães, A., Mosqueira, V. C. F., Carneiro, C. M., & Silva-Barcellos, N. M. (2010). Profile of wound healing process induced by allantoin. *Acta Cirurgica Brasileira*, 25(5), 460-461.

Ardanuy, M., Faccini, M., Amantia, D., Aubouy, L., & Borja, G. (2014). Preparation of durable insecticide cotton fabrics through sol–gel treatment with permethrin. *Surface and coatings technology*, *239*, 132-137.

Asidi, A. N., N'Guessan, R., Koffi, A. A., Curtis, C. F., Hougard, J. M., Chandre, F., Corbel, V., Darriet, F., Zaim, M. & Rowland, M. W. (2005). Experimental hut evaluation of bednets treated with an organophosphate (chlorpyrifos-methyl) or a pyrethroid (lambdacyhalothrin) alone and in combination against insecticide-resistant *Anopheles gambiae* and *Culex quinquefasciatus* mosquitoes. *Malaria journal*, *4*(1), 25.

Ayvaz, A., Sagdic, O., Karaborklu, S., & Ozturk, I. (2010). Insecticidal activity of the essential oils from different plants against three stored-product insects. *Journal of Insect Science*, *10*(1), 21.

Ayvaz, A., & Yilmaz, S. (2015). Ionizing radiation disinfestation treatments against pest insects. *Evolution of ionizing radiation research*, 235-258.

Baird, M., Jones, O., & Long, M. (2016). Novel Insecticidal Soap-an old dog with new tricks. *International Pest Control*, *58*(5), 260.

Balestrino, F., Puggioli, A., Gilles, J. R., & Bellini, R. (2014). Validation of a new larval rearing unit for *Aedes albopictus* (Diptera: Culicidae) mass rearing. *PloS one*, *9*(3), e91914.

Baliota, G., Rumbos, I.C., & Athanassiou, G.C. (2018). From lethality to mortality: exploring the “grey area” of knockdown as an efficacy indicator of different insecticides against major storage insects using a lethality index. *Journal of pest science*, *91*(4), 1371-1380.

Bantz, A., Camon, J., Froger, J. A., Goven, D., & Raymond, V. (2018). Exposure to sublethal doses of insecticide and their effects on insects at cellular and physiological levels. *Current opinion in insect science*, *30*, 73-78.

Barbosa, W. F., De Meyer, L., Guedes, R. N. C., & Smagghe, G. (2015). Lethal and sublethal effects of azadirachtin on the bumblebee *Bombus terrestris* (Hymenoptera: Apidae). *Ecotoxicology*, *24*(1), 130-142.

Barlow, F., & Hadaway, A. B. (1975). The insecticidal activity of some synthetic pyrethroids against mosquitoes and flies. *Pest Articles & News Summaries (PANS)*, 21(3), 233-238.

Barratt, B. I. P., Moran, V. C., Bigler, F., & Van Lenteren, J. C. (2018). The status of biological control and recommendations for improving uptake for the future. *BioControl*, *63*(1), 155-167.

Basal, G., Altıok, D., & Bayraktar, O. (2010). Antibacterial properties of silk fibroin/chitosan blend films loaded with plant extract. *Fibers and Polymers*, *11*(1), 21-27.

Bass, C., Puinean, A. M., Zimmer, C. T., Denholm, I., Field, L. M., Foster, S. P., Gutbrod, O., Nauen, R., Slater, R., & Williamson, M. S. (2014). The evolution of insecticide resistance in the peach potato aphid, *Myzus persicae*. *Insect biochemistry and molecular biology*, *51*, 41-51.

Bass, C., Denholm, I., Williamson, M. S., & Nauen, R. (2015). The global status of insect resistance to neonicotinoid insecticides. *Pesticide biochemistry and physiology*, *121*, 78-87.

Batikian, C. M., Lu, A., Watanabe, K., Pitt, J., & Gersberg, R. M. (2019). Temporal pattern in levels of the neonicotinoid insecticide, imidacloprid, in an urban stream. *Chemosphere*, *223*, 83-90.

Battilani, P., Camardo Leggieri, M., Giorni, P. (2016) La prevenzione delle micotossine in un contesto di difesa sostenibile. Milano: Edagricole, *Difesa sostenibile delle colture*, 281- 297.

Bayramzadeh, N., & Pourmirza, A. A. (2018). Combined Impacts of Two Type's Cold Storage and Microwave Radiation on Stored Products Insects and Wheat Seed Viability. *Egyptian Academic Journal of Biological Sciences. A, Entomology*, *5*(2), 121-129.

Benelli, G., Bedini, S., Cosci, F., Toniolo, C., Conti, B., & Nicoletti, M. (2015). Larvicidal and ovideterrent properties of neem oil and fractions against the filariasis vector *Aedes albopictus* (Diptera: Culicidae): a bioactivity survey across production sites. *Parasitology research*, *114*(1), 227-236.

Benelli, G., Canale, A., Toniolo, C., Higuchi, A., Murugan, K., Pavela, R., & Nicoletti, M. (2017). Neem (Azadirachta indica): towards the ideal insecticide?. *Natural product research*, *31*(4), 369-386.

Berenbaum, M. C. (1985). The expected effect of a combination of agents: the general solution. *Journal of Theoretical Biology*, *114*(3), 413-431.

Berenbaum, M., & Neal, J. J. (1985). Synergism between myristicin and xanthotoxin, a naturally cooccurring plant toxicant. *Journal of Chemical Ecology*, *11*(10), 1349-1358.

Berger, A., Degenkolb, T., Vilcinskas, A., & Schöller, M. (2017). Evaluating the combination of a parasitoid and a predator for biological control of seed beetles (Chrysomelidae: Bruchinae) in stored beans. *Journal of stored products research*, *74*, 22-26.

Bernardes, R. C., Tomé, H. V., Barbosa, W. F., Guedes, R. N., & Lima, M. A. P. (2017). Azadirachtin-induced antifeeding in Neotropical stingless bees. *Apidologie*, *48*(3), 275-285.

Bezzar-Bendjazia, R., Kilani-Morakchi, S., & Aribi, N. (2016). Larval exposure to azadirachtin affects fitness and oviposition site preference of *Drosophila melanogaster*. *Pesticide biochemistry and physiology*, *133*, 85-90.

Bhattacharyya, A., Bhaumik, A., Rani, P. U., Mandal, S., & Epidi, T. T. (2010). Nano-particles - A recent approach to insect pest control. *African Journal of Biotechnology*, *9*(24), 3489-3493.

Bingham, G., Strode, C., Tran, L., Khoa, P. T., & Jamet, H. P. (2011). Can piperonyl butoxide enhance the efficacy of pyrethroids against pyrethroid-resistant *Aedes aegypti*?. *Tropical Medicine & International Health*, *16*(4), 492-500.

Black, W. C., Alphey, L., & James, A. A. (2011). Why RIDL is not SIT. *Trends in Parasitology*, 27(8), 362-370. doi:10.1016/j.pt.2011.04.004

Blackman, R. L. (1972). The inheritance of life-cycle differences in *Myzus persicae* (Sulz.)(Hem., Aphididae). *Bulletin of Entomological Research*, *62*(2), 281-294.

Boh, B., & Knez, E. (2006). Microencapsulation of essential oils and phase change materials for applications in textile products. *Indian Journal of Fibre and Textile Research*, 31: 72-82.

Boots, M. (2000). Kinship and cannibalism in the Indian meal moth, *Plodia interpunctella*: no evidence of kin discrimination. *Evolutionary Ecology Research*, *2*(1), 119-128.

Boppré, M. (1986). Insects pharmacophagously utilizing defensive plant chemicals (pyrrolizidine alkaloids). *Naturwissenschaften*, *73*(1), 17-26.

Borror, D. J., Triplehorn, C. A., & Johnson, N. F. (1989). An introduction to the study of insects (VI ed.). Philadelphia: Saunders College Publishing.

Bougherra, H. H., Bedini, S., Flamini, G., Cosci, F., Belhamel, K., & Conti, B. (2015). Pistacia lentiscus essential oil has repellent effect against three major insect pests of pasta. *Industrial Crops and Products*, *63*, 249-255.

Boulahbel, B., Aribi, N., Kilani-Morakchi, S., & Soltani, N. (2015). Insecticidal activity of azadirachtin on *Drosophila melanogaster* and recovery of normal status by exogenous 20-hydroxyecdysone. *African Entomology*, *23*(1), 224-234.

Boyer, S., Zhang, H., & Lempérière, G. (2012). A review of control methods and resistance mechanisms in stored-product insects. *Bulletin of entomological research*, *102*(2), 213-229.

Bradshaw, C. J., Leroy, B., Bellard, C., Roiz, D., Albert, C., Fournier, A., Babet-Massin, M., Salles, J., Simard, F., & Courchamp, F. (2016). Massive yet grossly underestimated global costs of invasive insects. *Nature communications*, *7*, 12986.

Brodeur, J., Hajek, A. E., Heimpel, G. E., Sloggett, J. J., Mackauer, M., Pell, J. K., & Völkl, W. (2017). Predators, parasitoids and pathogens. *Aphids as Crop Pests, 2nd ed.; van Emden, HF, Harrington, R., Eds*, 225-261.

Brown, P. M. J., Adriaens, T., Bathon, H., Cuppen, J., Goldarazena, A., Hägg, T., Kenis, M., KlausnitzerI, B. E. M., Kovář, I., Loomans, A. J. M., Majerus, M. E. N., Nedved, O., Pedersen, J., Rabitsch W., Roy, H. E., TernoisI, V., Zakharov, I. A. & Roy D. B. (2007). *Harmonia axyridis* in Europe: spread and distribution of a non-native coccinellid. In *From Biological Control to Invasion: the Ladybird Harmonia axyridis as a Model Species* (pp. 5-21). Springer, Dordrecht.

Brown, P. M. J., Frost, R., Doberski, J., Sparks, T., Harrington, R., & Roy, H. E. (2011). Decline in native ladybirds in response to the arrival of *Harmonia axyridis*: Early evidence from England. *Ecological Entomology*, 36(2), 231-240. doi:10.1111/j.1365-2311.2011.01264.x

Brumby, A. M., & Richardson, H. E. (2005). Using *Drosophila melanogaster* to map human cancer pathways. *Nature Reviews Cancer*, *5*(8), 626.

Bukhari, T., Takken, W., Githeko, A. K., & Koenraadt, C. J. (2011). Efficacy of aquatain, a monomolecular film, for the control of malaria vectors in rice paddies. *PLoS One*, *6*(6), e21713.

Cagri, A., Ustunol, Z., & Ryser, E. T. (2004). Antimicrobial edible films and coatings. *Journal of food protection*, *67*(4), 833-848.

Chung, S. K., Seo, J. Y., Lim, J. H., Park, H. H., Yea, M. J., & Park, H. J. (2013). Microencapsulation of essential oil for insect repellent in food packaging system. *Journal of food science*, *78*(5), E709-E714.

Collison, E. J., Hird, H., Tyler, C. R., & Cresswell, J. E. (2018). Effects of neonicotinoid exposure on molecular and physiological indicators of honey bee immunocompetence. *Apidologie*, *49*(2), 196-208.

Conti, B., Canale, A., Bertoli, A., Gozzini, F., & Pistelli, L. (2010). Essential oil composition and larvicidal activity of six Mediterranean aromatic plants against the mosquito *Aedes albopictus* (Diptera: Culicidae). *Parasitology research*, *107*(6), 1455-1461.

Conti, B., Benelli, G., Flamini, G., Cioni, P. L., Profeti, R., Ceccarini, L., Macchia, M., & Canale, A. (2012). Larvicidal and repellent activity of *Hyptis suaveolens* (Lamiaceae) essential oil against the mosquito *Aedes albopictus* Skuse (Diptera: Culicidae). *Parasitology research*, 110(5), 2013-2021.

Copping, L. G., & Menn, J. J. (2000). Biopesticides: a review of their action, applications and efficacy. *Pest Management Science: formerly Pesticide Science*, *56*(8), 651-676.

Corbet, S. A. (1973). Oviposition pheromone in larval mandibular glands of *Ephestia kuehniella*. *Nature*, *243*(5409), 537-538.

Cravedi, P., & Bolchi Serini, G. (1981). Gli afidi del pesco conoscerli e riconoscerli. *Pubblicazione del C.N.R.*, "Stampa la Garangola", Padova.

Curtis, C. F., Myamba, J., & Wilkes, T. J. (1992). Various pyrethroids on bednets and curtains. *Memórias do Instituto Oswaldo Cruz*, *87*, 363-370.

Dadzie, S. K., Chabi, J., Asafu-Adjaye, A., Owusu-Akrofi, O., Baffoe-Wilmot, A., Malm, K., Bart-Plange, C., Coleman, S., Appawu, M. A. & Boakye, D. A. (2017). Evaluation of piperonyl butoxide in enhancing the efficacy of pyrethroid insecticides against resistant *Anopheles gambiae* sl in Ghana. *Malaria journal*, *16*(1), 342.

Dar, M. A., Kaushik, G., & Chiu, J. F. V. (2020). Pollution status and biodegradation of organophosphate pesticides in the environment. In *Abatement of Environmental Pollutants* (pp. 25-66). Elsevier.

de Miranda, J. R., & Nazzi, F. (2019). Multiple stressors, neonicotinoid insecticides and bee declines. Science. Volume: 356, Number: 6345, pp Letters.

De Moraes, C. M., Mescher, M. C., & Tumlinson, J. H. (2001). Caterpillar-induced nocturnal plant volatiles repel conspecific females. *Nature*, *410*(6828), 577.

Deletre, E., Martin, T., Campagne, P., Bourguet, D., Cadin, A., Menut, C., Bonafos, R., & Chandre, F. (2013). Repellent, irritant and toxic effects of 20 plant extracts on adults of the malaria vector *Anopheles gambiae* mosquito. *PloS one*, 8(12), e82103.

Deletre, E., Chandre, F., Williams, L., Duménil, C., Menut, C., & Martin, T. (2015). Electrophysiological and behavioral characterization of bioactive compounds of the Thymus vulgaris, Cymbopogon winterianus, Cuminum cyminum and Cinnamomum zeylanicum essential oils against Anopheles gambiae and prospects for their use as bednet treatments. *Parasites & vectors*, 8(1), 316.

Dhiman, S., & Veer, V. (2014). Culminating anti-malaria efforts at long lasting insecticidal net?. *Journal of infection and public health*, *7*(6), 457-464.

Dowd, P. F., Smith, C. M., & Sparks, T. C. (1983). Detoxification of plant toxins by insects. *Insect Biochemistry*, *13*(5), 453-468.

Dowd, P. F. (1992). Detoxification of mycotoxins by insects. ACS Symposium Series, Vol. 505. *Molecular Mechanisms of Insecticide Resistance*, Chapter 21 pp 264-275.

Drago, A., Simonato, G., Vettore, S., Martini, S., Di Regalbono, A. F., & Cassini, R. (2017). Field trial to evaluate two different procedures for monitoring the efficacy of Aquatain® against *Culex pipiens* and *Aedes albopictus* in catch basins. *Journal of the American Mosquito Control Association*, 33(4), 318-323. doi:10.2987/17-6682.1

Ellakiya, K., Yasodha, P., Justin, C. G. L., & Kumar, V. A. (2019). Neuropeptides as Novel Insecticidal Agents. *International Journal of Current Microbiology and Applied Sciences*, *8*(2).

Elvira, S., Williams, T., & Caballero, P. (2010). Juvenile hormone analog technology: effects on larval cannibalism and the production of *Spodoptera exigua* (Lepidoptera: Noctuidae) ucleopolyhedrovirus. *Journal of economic entomology*, *103*(3), 577-582.

Faulde, M. K., Albiez, G., & Nehring, O. (2010). Insecticidal, acaricidal and repellent effects of DEET-and IR3535-impregnated bed nets using a novel long-lasting polymer-coating technique. *Parasitology research*, *106*(4), 957-965.

Feyereisen, R. (1995). Molecular biology of insecticide resistance. *Toxicology letters*, *82*, 83-90.

Finney, D. J. (1971). Probit analysis, Cambridge University Press. *Cambridge, UK*.

Flores, H. A., & O'Neill, S. L. (2018). Controlling vector-borne diseases by releasing modified mosquitoes. *Nature Reviews Microbiology*, *16*(8), 508.

Fontaine, S., Caddoux, L., & Micoud, A. (2013). Methods for characterising resistance to carbamates, pyrethroids and neonicotinoids in *Myzus persicae*. *Euro Reference*, *9*, 19-23.

Gallai, N., Salles, J. M., Settele, J., & Vaissière, B. E. (2009). Economic valuation of the vulnerability of world agriculture confronted with pollinator decline. *Ecological economics*, *68*(3), 810-821.

Galun, R., Ben-Eliahu, M. N., Ben-Tamar, D., & Simkin, J. (1980). Long-term protection of animals from tsetse bites through controlled-release repellents. In *Isotope and radiation research on animal diseases and their vectors* (pp. 207-217). International Atomic Energy Agency.

Germinara, G. S., De Cristofaro, A., & Rotundo, G. (2015). Repellents effectively disrupt the olfactory orientation of *Sitophilus granarius* to wheat kernels. *Journal of pest science*, *88*(4), 675-684.

Graf, J. F. (1993). The role of insect growth regulators in arthropod control. *Parasitology Today*, *9*(12), 471-474.

Grdiša, M., Carović-Stanko, K., Kolak, I., & Šatović, Z. (2009). Morphological and biochemical diversity of Dalmatian pyrethrum (*Tanacetum cinerariifolium* (Trevir.) Sch. Bip.). *Agriculturae Conspectus Scientificus*, *74*(2), 73-80.

Gregory, T. R. (2005). The evolution of the genome, ed. T.R. Gregory. New York, *Elsevier Academic Press*.

Grieco, J. P., Achee, N. L., Sardelis, M. R., Chauhan, K. R., & Roberts, D. R. (2005). A Novel High-Throughput Screening System to Evaluate the Behavioral Response of Adult Mosquitoes to Chemicals1. *Journal of the American Mosquito Control Association*, *21*(4), 404-412.

Grout, T. G. (2015). The status of citrus IPM in South Africa. *Acta Horticulturae*, 1065, 1091-1095.

Gullan, P. J., & Cranston, P. S. (2014). The insects: an outline of entomology (ed. V). JohnWiley & Sons, Ltd, The Atrium, Southern Gate, Chichester,West Sussex, PO19 8SQ, UK.

Gupta, R. C., Mukherjee, I. R. M., Doss, R. B., Malik, J. K., & Milatovic, D. (2017). Organophosphates and carbamates. In *Reproductive and Developmental Toxicology* (pp. 609-631). https://doi.org/10.1016/B978-0-12-804239-7.00035-4. Academic Press.

Gurr, G. M., & You, M. (2016). Conservation biological control of pests in the molecular era: new opportunities to address old constraints. *Frontiers in plant science*, *6*, 1255.

Hagstrum, D., Klejdysz, T., Subramanyam, B., & Nawrot, J. (2013). Atlas of stored–product Insects and Mites. AACC International. *Inc. USA, St. Paul, Minnesota*.

Hallman, G. J., & Denlinger, D. L. (2019). Temperature sensitivity in insects and application in integrated pest management. Routledge, Taylor & Francis Group, New York.

Han, P., Velasco-Hernández, M. C., Ramirez-Romero, R., & Desneux, N. (2016). Behavioral effects of insect-resistant genetically modified crops on phytophagous and beneficial arthropods: a review. *Journal of pest science*, *89*(4), 859-883.

Han, Y., Jin, H., Guo, W., Jin, J., Li, Y., Tao, Y., & Fang, S. (2017). Translocation and Distribution of Imidacloprid in Tobacco with Two Application Methods. *Agricultural Science & Technology*, *18*(2), 344-376.

Hebeish, A., Hamdy, I. A., El-Sawy, S. M., & Abdel-Mohdy, F. A. (2010). Preparation of durable insect repellent cotton fabric through treatment with a finishing formulation containing cypermethrin. *The Journal of The Textile Institute*, *101*(7), 627-634.

Hebeish, A., El-Sawy, S. M., Ragaei, M., Hamdy, I. A., El-Bisi, M. K., & Abdel-Mohdy, F. A. (2014). New textiles of biocidal activity by introduce insecticide in cotton-poly (GMA) copolymer containing β-Cd. *Carbohydrate polymers*, *99*, 208-217.

Hemingway, J. (1995). Efficacy of etofenprox against insecticide susceptible and resistant mosquito strains containing characterized resistance mechanisms. *Medical and veterinary entomology*, *9*(4), 423-426.

Hemingway, J. (2014). The role of vector control in stopping the transmission of malaria: threats and opportunities. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *369*(1645), 20130431.

Hogsette, J. A., Nalli, A., & Foil, L. D. (2008). Evaluation of different insecticides and fabric types for development of treated targets for stable fly (Diptera: Muscidae) control. *Journal of economic entomology*, *101*(3), 1034-1038.

Hou, X., Fields, P., & Taylor, W. (2004). The effect of repellents on penetration into packaging by stored-product insects. *Journal of Stored Products Research*, *40*(1), 47-54.

House, J. (2019). Modes of Eating and Phased Routinisation: Insect-Based Food Practices in the Netherlands. *Sociology*, *53*(3), 451-467.

Huang, T. H., Tien, N. Y., & Luo, Y. P. (2015). An in vitro bioassay for the quantitative evaluation of mosquito repellents against *Stegomyia aegypti* (=*Aedes aegypti*) mosquitoes using a novel cocktail meal. *Medical and veterinary entomology*, 29(3), 238-244.

Jahn, A., Kim, S. Y., Choi, J. H., Kim, D. D., Ahn, Y. J., Yong, C. S., & Kim, J. S. (2010). A bioassay for mosquito repellency against *Aedes aegypti*: method validation and bioactivities of DEET analogues. *Journal of Pharmacy and Pharmacology*, *62*(1), 91-97.

Jayaraj, R., Megha, P., & Sreedev, P. (2016). Organochlorine pesticides, their toxic effects on living organisms and their fate in the environment. *Interdisciplinary toxicology*, *9*(3-4), 90-100.

Jo, H. J., Park, K. M., Na, J. H., Min, S. C., Park, K. H., Chang, P. S., & Han, J. (2015). Development of anti-insect food packaging film containing a polyvinyl alcohol and cinnamon oil emulsion at a pilot plant scale. *Journal of stored products research*, *61*, 114-118.

Karahroodi, Z. R., Moharramipour, S., & Rahbarpour, A. (2009). Investigated repellency effect of some essential oils of 17 native medicinal plants on adults *Plodia interpunctella*. *American-Eurasian Journal of Sustainable Agriculture*, *3*(2), 181-184.

Kim, I. H., Han, J., Na, J. H., Chang, P. S., Chung, M. S., Park, K. H., & Min, S. C. (2013). Insect-resistant food packaging film development using cinnamon oil and microencapsulation technologies. *Journal of food science*, *78*(2), E229-E237.

Kim, Y. H., Issa, M. S., Cooper, A. M., & Zhu, K. Y. (2015). RNA interference: applications and advances in insect toxicology and insect pest management. *Pesticide Biochemistry and Physiology*, *120*, 109-117.

Kitau, J., Oxborough, R., Matowo, J., Mosha, F., Magesa, S. M., & Rowland, M. (2014). Indoor residual spraying with microencapsulated DEET repellent (N,N-diethyl-m-toluamide) for control of *Anopheles arabiensis* and *Culex quinquefasciatus*. *Parasites & vectors*, *7*(1), 446.

Kole, R. K., Satpathi, C., Chowdhury, A., Ghosh, M. R., & Adityachaudhury, N. (1992). Isolation of amorpholone, a potent rotenoid insecticide from *Tephrosia candida*. *Journal of agricultural and food chemistry*, *40*(7), 1208-1210.

Kumar, P. M., Murugan, K., Kovendan, K., Subramaniam, J., & Amaresan, D. (2012). Mosquito larvicidal and pupicidal efficacy of *Solanum xanthocarpum* (Family: Solanaceae) leaf extract and bacterial insecticide, *Bacillus thuringiensis*, against *Culex quinquefasciatus* Say (Diptera: Culicidae). *Parasitology research*, *110*(6), 2541-2550.

Kunte, N., McGraw, E., Bell, S., Held, D. & Avila, L. A. (2020), Prospects, challenges and current status of RNAi through insect feeding. *Pest Management Science*, 76: 26-41. doi:10.1002/ps.5588

Leighton, T., Marks, E., & Leighton, F. (1981). Pesticides: insecticides and fungicides are chitin synthesis inhibitors. *Science*, *213*(4510), 905-907.

Lengeler, C. (2004). Insecticide-treated bed nets and curtains for preventing malaria. *Cochrane Database of systematic reviews*, (2), 1-46.

Li, X., Schuler, M. A., & Berenbaum, M. R. (2007). Molecular mechanisms of metabolic resistance to synthetic and natural xenobiotics. *Annual Review of Entomology*, *52*, 231-253.

Lichtenstein, E. P., Schulz, K. R., Skrentny, R. F., & Tsukano, Y. (1966). Toxicity and Fate of Insecticide Residues in Water: Insecticide Residues in Water After Direct Applications or by Leaching of Agricultural Soil. *Archives of Environmental Health: An International Journal*, *12*(2), 199-212.

Limonta, L., Savoldelli, S., Suss, L., & Locatelli, D. P. (2016). Pest detected in packed food: ten years of analysis. *Italian Journal of Food Science, 28: 440-447*.

Lindblade, K. A., Dotson, E., Hawley, W. A., Bayoh, N., Williamson, J., Mount, D., Olang, G., Vulule, J., Slutsker, L., & Gimnig, J. (2005). Evaluation of long-lasting insecticidal nets after 2 years of household use. *Tropical Medicine & International Health*, *10*(11), 1141-1150.

Lines, J. D., Myamba, J., & Curtis, C. F. (1987). Experimental hut trials of permethrin-impregnated mosquito nets and eave curtains against malaria vectors in Tanzania. *Medical and veterinary entomology*, *1*(1), 37-51.

Liška, A., Korunić, Z., Rozman, V., Halamić, J., Galović, I., Lucić, P., & Baličević, R. (2017). Efficacy of nine Croatian inert dusts against rice weevil *Sitophilus oryzae* L.(Coleoptera: Curculionidae) on wheat. *Emirates Journal of Food and Agriculture*, 485-494.

Liu, N., Xu, Q., Zhu, F., & Zhang, L. E. E. (2006). Pyrethroid resistance in mosquitoes. *Insect Science*, *13*(3), 159-166.

Liu, N., Li, M., Gong, Y., Liu, F., & Li, T. (2015). Cytochrome P450s – Their expression, regulation, and role in insecticide resistance. *Pesticide biochemistry and physiology*, *120*, 77-81.

Lo Nostro, P., Fratoni, L., Ridi, F., & Baglioni, P. (2003). Surface treatments on Tencel fabric: Grafting with β-cyclodextrin. *Journal of applied polymer science*, *88*(3), 706-715.

Main, A. R., Webb, E. B., Goyne, K. W., & Mengel, D. (2018). Neonicotinoid insecticides negatively affect performance measures of non-target terrestrial arthropods: a meta-analysis. *Ecological applications*, *28*(5), 1232-1244.

Masetti, A., Magagnoli, S., Lami, F., Lanzoni, A., & Burgio, G. (2018). Long term changes in the communities of native ladybirds in Northern Italy: Impact of the invasive species *Harmonia axyridis* (pallas). *Biocontrol*, 63(5), 665-675.

Mayer, M. S. & McLaughlin, J. R. (1991). Handbook of insect pheromones and sex attractants. CRC Press, Boca Raton, Ann Arbor, Boston, pp. 1083.

Mazzoni, E., & Cravedi, P. (2012). La resistenza agli insetticidi dell'afide *Myzus persicae* (Sulzer). Atti accademia nazionale di Entomologia, Anno LX, 2012: 187-192

Mazzoni, E., Panini, M., Manicardi, G., Cassanelli, S., Duso, C., Butturini, A., Pasqualini, E., Ioriatti, C., & Civolani, S. (2012). Stato della resistenza in Italia: insetticidi e acaricidi. In *La resistenza ai prodotti fitosanitari: una sfida per la moderna protezione integrata delle colture*. Presentazione orale, Convegno AIPP, Roma, 21 giugno 2012.

McGeoch, M. A. (1998). The selection, testing and application of terrestrial insects as bioindicators. *Biological reviews*, *73*(2), 181-201.

Menze, B. D., Riveron, J. M., Ibrahim, S. S., Irving, H., Antonio-Nkondjio, C., Awono-Ambene, P. H., & Wondji, C. S. (2016). Multiple insecticide resistance in the malaria vector *Anopheles funestus* from Northern Cameroon is mediated by metabolic resistance alongside potential target site insensitivity mutations. *PloS one*, *11*(10), e0163261.

Misof, B., Liu, S., Meusemann, K., Peters, R. S., Donath, A., Mayer, C., Frandsen, P. B., Ware, J., Flouri, T., Beutel, R. G., *et al.*, Zhou, X. (2014). Phylogenomics resolves the timing and pattern of insect evolution. *Science* 346:763 - 767.

Moretti, M. D., Sanna-Passino, G., Demontis, S., & Bazzoni, E. (2002). Essential oil formulations useful as a new tool for insect pest control. Springer, *AAPS PharmSciTech*, *3*(2), 64-74.

Mossadegh, M. S. (1980). Inter-and intra-specific effects of the mandibular gland secretion of larvae of the Indian-meal moth, *Plodia interpunctella*. *Physiological Entomology*, *5*(2), 165-173.

Muthukrishnan, S., Merzendorfer, H., Arakane, Y., & Yang, Q. (2016). Chitin metabolic pathways in insects and their regulation. In *Extracellular composite matrices in arthropods* (pp. 31-65). Springer, Cham.

Naqqash, M. N., Gökçe, A., Bakhsh, A., & Salim, M. (2016). Insecticide resistance and its molecular basis in urban insect pests. *Parasitology research*, *115*(4), 1363-1373.

Nauen, R., & Bretschneider, T. (2002). New modes of action of insecticides. *Pesticide Outlook*, *13*(6), 241-245.

Nerio, L. S., Olivero-Verbel, J., & Stashenko, E. (2010). Repellent activity of essential oils: a review. *Bioresource technology*, *101*(1), 372-378.

Nielsen, C., Agrawal, A. A., & Hajek, A. E. (2010). Ants defend aphids against lethal disease. *Biology Letters*, 6(2), 205-208. doi:10.1098/rsbl.2009.0743

Nordlund, D. A., & Lewis, W. J. (1976). Terminology of chemical releasing stimuli in intraspecific and interspecific interactions. *Journal of Chemical Ecology*, *2*(2), 211-220.

Ogendo, J. O., Kostyukovsky, M., Ravid, U., Matasyoh, J. C., Deng, A. L., Omolo, E. O., Kariuki, S. T. & Shaaya, E. (2008). Bioactivity of *Ocimum gratissimum* L. oil and two of its constituents against five insect pests attacking stored food products. *Journal of Stored Products Research*, *44*(4), 328-334.

Pagani, M., Savoldelli, S., & Schiaparelli, A. (2010). Manuale pratico per il monitoraggio e riconoscimento degli insetti infestanti le industrie alimentari: Diptera, Coleoptera, Hymenoptera, Cenni sugli acari delle derrate (Vol.2). *A.N.I.D., Edizioni Sinergitech Soc. Coop.*, 150 pp.

Panini, M., Dradi, D., Marani, G., Butturini, A., & Mazzoni, E. (2014). Detecting the presence of target-site resistance to neonicotinoids and pyrethroids in Italian populations of *Myzus persicae*. *Pest management science*, *70*(6), 931-938.

Panini, M., Anaclerio, M., Puggioni, V., Mazzoni, E., (2014b) Resistenze “target-site” in popolazioni italiane dell’afide verde del pesco (*Myzus persicae*). Relazione in XXIV Congresso Nazionale Italiano di Entomologia - Riassunti delle comunicazioni orali, (Orosei, 09-14 June 2014), ISE-CNR, Sassari: 154-155.

Panini, M., Anaclerio, M., Puggioni, V., Stagnati, L., Nauen, R., & Mazzoni, E. (2015). Presence and impact of allelic variations of two alternative s-kdr mutations, M918T and M918L, in the voltage-gated sodium channel of the green peach aphid *Myzus persicae*. *Pest management science*, *71*(6), 878-884.

Panini, M. (2015b). Characterisation of insecticide resistance mechanisms in italian populations of the green peach aphid *Myzus persicae* (Sulzer). PhD Dissertation, Università Cattolica del Sacro Cuore, XXVII ciclo, a.a. 2013/14, Piacenza, [http://hdl.handle.net/10280/6071].

Panini, M., Manicardi, G. C., Moores, G. D., & Mazzoni, E. (2016). An overview of the main pathways of metabolic resistance in insects. *Invertebrate Survival Journal*, *13*(1), 326-335.

Panneerselvam, C., Murugan, K., Kovendan, K., & Kumar, P. M. (2012). Mosquito larvicidal, pupicidal, adulticidal, and repellent activity of *Artemisia nilagirica* (Family: Compositae) against *Anopheles stephensi* and *Aedes aegypti*. *Parasitology research*, *111*(6), 2241-2251.

Pedigo, L. P., & Higley, L. G. (1992). The economic injury level concept and environmental quality: a new perspective. *American Entomologist*, *38*(1), 12-21.

Pedigo, L. P., & Rice, M. E. (2014). *Entomology and pest management* (VI ed.). Long Grove, Illinois: Waveland Press.

Pereira, A. E., Souza, D., Zukoff, S. N., Meinke, L. J., & Siegfried, B. D. (2017). Cross-resistance and synergism bioassays suggest multiple mechanisms of pyrethroid resistance in western corn rootworm populations. *PloS one*, *12*(6), e0179311.

Perich, M. J., Rocha, O., Castro, L., Alfaro, W., Platt, K. B., Solano, T. & Rowley, A. (2003). Evaluation of the efficacy of lambda-cyhalothrin applied by three spray application methods for emergency control of *Aedes aegypti* in Costa Rica. *Journal of the American Mosquito Control Association* 19(1): 58 – 62.

Phillips, T. W., & Throne, J. E. (2010). Biorational approaches to managing stored-product insects. *Annual review of entomology*, 55: 375-397.

Pisa, L. W., Amaral-Rogers, V., Belzunces, L. P., Bonmatin, J. M., Downs, C. A., Goulson, D., Kreutzweiser, D. P., Krupke, C., Liess, M., McField, M., Morrissey, C. A., Noome, D. A., Settele, J., Simon-Delso, N., Stark, J. D., Van der Sluijs, J. P., Van Dyck, H. & Wiemers, M. (2015). Effects of neonicotinoids and fipronil on non-target invertebrates. *Environmental Science and Pollution Research*, *22*(1), 68-102.

Pitarokili, D., Michaelakis, A., Koliopoulos, G., Giatropoulos, A., & Tzakou, O. (2011). Chemical composition, larvicidal evaluation, and adult repellency of endemic Greek Thymus essential oils against the mosquito vector of West Nile virus. *Parasitology research*, *109*(2), 425-430.

Potts, R., Clarke, R. M., Oldfield, S. E., Wood, L. K., de Ibarra, N. H., & Cresswell, J. E. (2018). The effect of dietary neonicotinoid pesticides on non-flight thermogenesis in worker bumblebees (*Bombus terrestris*). *Journal of insect physiology*, *104*, 33-39.

Proniuk, S., Liederer, B. M., Dixon, S. E., Rein, J. A., Kallen, M. A., & Blanchard, J. (2002). Topical formulation studies with DEET (N,N-diethyl-3-methylbenzamide) and cyclodextrins. *Journal of pharmaceutical sciences*, *91*(1), 101-110.

Puggioni, V., Chiesa, O., Panini, M., & Mazzoni, E. (2017). Qualitative Sybr Green real-time detection of single nucleotide polymorphisms responsible for target-site resistance in insect pests: the example of *Myzus persicae* and *Musca domestica*. *Bulletin of entomological research*, *107*(1), 96-105.

Rafinejad, J., Vatandoost, H., Nikpoor, F., Abai, M. R., Shaeghi, M., Duchen, S., & Rafi, F. (2008). Effect of washing on the bio-efficacy of insecticide-treated nets (ITNs) and long-lasting insecticidal nets (LLINs) against main malaria vector *Anopheles stephensi* by three bioassay methods. *Journal of vector borne diseases*, *45*(2), 143.

Rajkumar, S., & Jebanesan, A. (2005). Scientific Note Oviposition deterrent and skin repellent activities of *Solanum trilobatum* leaf extract against the malarial vector *Anopheles stephensi*. *Journal of Insect Science*, *5*(1).

Ramasamy, R., Rajan, R., & Velmurugan, R. (2014). Development of mosquito repellent fabrics using *Vitex negundo* loaded nanoparticles. *Malaya Journal of Bio-sciences*, *1*(1), 19-23.

Rees, D. P., Subramanyam, B., & Hagstrum, D. W. (1996). Integrated management of insects in stored products. New York, Marcel Dekker.

Reid, M. C., & McKenzie, F. E. (2016). The contribution of agricultural insecticide use to increasing insecticide resistance in African malaria vectors. *Malaria journal*, *15*(1), 107.

Rharrabe, K., Sayah, F., & Marion-Poll, F. (2011). Gustatory perception of phytoecdysteroids in *Plodia interpunctella* larvae. *Entomologia experimentalis et applicata*, *138*(1), 33-39.

Rinkevich, F. D., Du, Y., & Dong, K. (2013). Diversity and convergence of sodium channel mutations involved in resistance to pyrethroids. *Pesticide biochemistry and physiology*, *106*(3), 93-100.

Riudavets, J., Salas, I., & Pons, M. J. (2007). Damage characteristics produced by insect pests in packaging film. *Journal of stored products research*, *43*(4), 564-570.

Robb, E. L., & Baker, M. B. (2019). Organophosphate Toxicity. In *StatPearls [Internet]*. Treasure Island (FL): StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK470430/.

Roberts, D. R., Chareonviriyaphap, T., Harlan, H. H., & Hshieh, P. (1997). Methods of testing and analyzing excito-repellency responses of malaria vectors to insecticides. *Journal of the American Mosquito Control Association*, *13*(1), 13-17.

Rodrigues, S. N., Fernandes, I., Martins, I. M., Mata, V. G., Barreiro, F., & Rodrigues, A. E. (2008). Microencapsulation of limonene for textile application. *Industrial & Engineering Chemistry Research*, *47*(12), 4142-4147.

Romi, R., Lo Nostro, P., Bocci, E., Ridi, F., & Baglioni, P. (2005). Bioengineering of a cellulosic fabric for insecticide delivery via grafted cyclodextrin. *Biotechnology progress*, *21*(6), 1724-1730.

Rozman, V., Kalinović, I., & Korunić, Z. (2007). Toxicity of naturally occurring compounds of Lamiaceae and Lauraceae to three stored-product insects. *Journal of Stored Products Research*, *43*(4), 349-355.

Rozman, V., Korunić, Z., Halamić, J., Liška, A., Baličević, R., Galović, I., & Lucić, P. (2018). The three-year development of new natural insecticide formulations based on inert dusts and botanicals in Croatia. *IOBC/WPRS bulletin*, *130*, 61-67.

Rusch, A., Bommarco, R., & Ekbom, B. (2017). Conservation biological control in agricultural landscapes. In *Advances in Botanical Research* (Vol. 81, pp. 333-360). Academic Press.

Saddiq, B., Abbas, N., Shad, S. A., Aslam, M., & Afzal, M. B. S. (2016). Deltamethrin resistance in the cotton mealybug, *Phenacoccus solenopsis* Tinsley: cross-resistance to other insecticides, fitness cost analysis and realized heritability. *Phytoparasitica*, *44*(1), 83-90.

Semmler, M., Abdel-Ghaffar, F., Schmidt, J., & Mehlhorn, H. (2014). Evaluation of biological and chemical insect repellents and their potential adverse effects. *Parasitology research*, *113*(1), 185-188.

Shahba, A. F., Halawa, O., Ragaei, M., & Hashem, M. (2011). Development of longer-lasting insect repellence cellulosic based curtain fabrics. *Material Science and Applications*, *2*(3), 200-208.

Singh, G., & Suri, K. S. (2017). Potential of insect growth regulators in insect pest management. *Theory and Practice of Integrated Pest Management*. Scientific Publishers, Jodhpur, pp. 110-119.

Slater, R., Paul, V. L., Andrews, M., Garbay, M., & Camblin, P. (2012). Identifying the presence of neonicotinoid resistant peach-potato aphid (*Myzus persicae*) in the peach-growing regions of southern France and northern Spain. *Pest management science*, *68*(4), 634-638.

Solomon, B., Sahle, F. F., Gebre-Mariam, T., Asres, K., & Neubert, R. H. H. (2012). Microencapsulation of citronella oil for mosquito-repellent application: Formulation and in vitro permeation studies. *European Journal of Pharmaceutics and Biopharmaceutics*, 80(1), 61-66.

Soltani-Mazouni, N., Hami, M., & Gramdi, H. (2012). Sublethal effects of methoxyfenozide on reproduction of the Mediterranean flour moth, *Ephestia Kuehniella* Zeller. *Invertebrate reproduction & development*, *56*(2), 157-163.

Sparks, T. C., & Nauen, R. (2015). IRAC: Mode of action classification and insecticide resistance management. *Pesticide biochemistry and physiology*, *121*, 122-128.

Stenberg, J. A. (2017). A conceptual framework for integrated pest management. *Trends in plant science*, *22*(9), 759-769.

Suganthi, A., Bhuvaneswari, K., & Ramya, M. (2018). Determination of neonicotinoid insecticide residues in sugarcane juice using LC-MS/MS. *Food chemistry*, *241*, 275-280.

Sukumaran, D., Sharma, A. K., Wasu, Y. H., Pandey, P., & Tyagi, V. (2014). Knockdown and repellent effect of permethrin-impregnated army uniform cloth against *Aedes aegypti* after different cycles of washings. *Parasitology research*, *113*(5), 1739-1747.

Sylvester, E. S. (1954). Insectary life history and apterous instar morphology of *Myzus persicae* (Sulzer) (Homoptera, Aphidae). *Annals of the Entomological Society of America*, *47*(3), 397-406.

Traboulsi, A. F., Taoubi, K., El-Haj, S., Bessiere, J. M., & Rammal, S. (2002). Insecticidal properties of essential plant oils against the mosquito *Culex pipiens molestus* (Diptera: Culicidae). *Pest Management Science*, *58*(5), 491-495.

Trematerra, P. (2011). Riflessioni sui feromoni degli insetti infestanti le derrate alimentari. *Atti Accademia Nazionale Italiana di Entomologia*, *59*, 83-89.

Trematerra, P. (2016). Entomologia urbana applicata. Animali infestanti o molesti e loro gestione. *Aracne editrice int.le S.r.l.*, Ariccia, pp1–189.

Trifković, K. T., Milašinović, N. Z., Djordjević, V. B., Krušić, M. T. K., Knežević-Jugović, Z. D., Nedović, V. A., & Bugarski, B. M. (2014). Chitosan microbeads for encapsulation of thyme (*Thymus serpyllum* L.) polyphenols. *Carbohydrate polymers*, *111*, 901-907.

Tripathi, A. K., Upadhyay, S., Bhuiyan, M., & Bhattacharya, P. R. (2009). A review on prospects of essential oils as biopesticide in insect-pest management. *Journal of Pharmacognosy and phytotherapy*, *1*(5), 52-63.

Tunaz, H., & Uygun, N. (2004). Insect growth regulators for insect pest control. *Turkish Journal of Agriculture and Forestry*, *28*(6), 377-387.

Tunç, I., Berger, B. M., Erler, F., & Dağlı, F. (2000). Ovicidal activity of essential oils from five plants against two stored-product insects. *Journal of Stored Products Research*, *36*(2), 161-168.

Unsal, S., & Sart, H. (2018). Effects of NeemAzal-T/S chitin synthesis inhibitör (CSI) activity against *Galleria mellonella* (L)(Lepidoptera: Pyralidae). *Fresenius Environmental Bulletin*, *27*(10), 7090-7098.

Van Lenteren, J. C. (1990). A century of biological control in West Europe. *Experimental and Applied Entomology, Dutch Entomological Society, Amsterdam*, 3-12.

Varona, S., Kareth, S., Martín, Á., & Cocero, M. J. (2010). Formulation of lavandin essential oil with biopolymers by PGSS for application as biocide in ecological agriculture. *The Journal of Supercritical Fluids*, *54*(3), 369-377.

Visser, J. H., & Thiery, D. (1986). Effects of feeding experience on the odour-conditioned anemotaxes of Colorado potato beetles. *Entomologia experimentalis et applicata*, *42*(2), 198-200.

Walentowska, J., & Foksowicz-Flaczyk, J. (2013). Thyme essential oil for antimicrobial protection of natural textiles. *International Biodeterioration & Biodegradation*, *84*, 407-411.

Whalon, M. E., Mota-Sanchez, D., & Hollingworth, R. M. (2008). Global pesticide resistance in Arthropods. *Center for Agriculture and Bioscience International (CABI)*, Oxfordshire, UK.

Wijayaratne, L. K. W., Arthur, F. H., & Whyard, S. (2018). Methoprene and control of stored-product insects. *Journal of Stored Products Research*, *76*, 161-169.

World Health Organization (1995). Supplies for monitoring insecticide resistance in disease vectors: Procedures and conditions (No. WHO/MAL/95.1073). Geneva: World Health Organization.

World Health Organization. (2009). Guidelines for efficacy testing of mosquito repellents for human skin (No. WHO/HTM/NTD/WHOPES/2009.4). Geneva: World Health Organization.

World Health Organization. (2016). Test procedures for insecticide resistance monitoring in malaria vector mosquitoes. Geneva: World Health Organization.

Wu, X. Q., Huang, J., Wang, M. Z., Zhang, Z., Li, X. L., Yang, X. L., & Tobe, S. S. (2016). Synthesis, bioactivity and functional evaluation of linker-modified allatostatin analogs as potential insect growth regulators. *Chinese Chemical Letters*, *27*(4), 559-562.

Xue, R. D., Barnard, D. R., & Ali, A. (2001). Laboratory and field evaluation of insect repellents as oviposition deterrents against the mosquito *Aedes albopictus*. *Medical and veterinary entomology*, *15*(2), 126-131.

Yahouédo, G. A., Chandre, F., Rossignol, M., Ginibre, C., Balabanidou, V., Mendez, N. G. A., Pigeon, O., Vontas, J., & Cornelie, S. (2017). Contributions of cuticle permeability and enzyme detoxification to pyrethroid resistance in the major malaria vector *Anopheles gambiae*. *Scientific reports*, *7*(1), 11091.

Yencho, G. C., Cohen, M. B., & Byrne, P. F. (2000). Applications of tagging and mapping insect resistance loci in plants. *Annual Review of Entomology*, *45*(1), 393-422.

Zhang, J., Liu, H., Sun, Z., Xie, J., Zhong, G., & Yi, X. (2017). Azadirachtin induced apoptosis in the prothoracic gland in *Bombyx mori* and a pronounced Ca2+ release effect in Sf9 cells. *International journal of biological sciences*, *13*(12), 1532.

Zhu, F., Lavine, L., O'Neal, S., Lavine, M., Foss, C., & Walsh, D. (2016). Insecticide resistance and management strategies in urban ecosystems. *Insects*, *7*(1), 2.

Zvereva, E. L., & Kozlov, M. V. (2016). The costs and effectiveness of chemical defenses in herbivorous insects: a meta-analysis. *Ecological Monographs*, *86*(1), 107-124.