



UNIVERSITAT DE  
BARCELONA

## Estudios dirigidos a la ecología química de insectos plaga mediante semioquímicos

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# ***BIBLIOGRAFÍA***

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- Acín P, Carrascal M, Abián J, Guerrero A, Quero C. Expression of differential antennal proteins in males and females of an important crop pest, *Sesamia nonagrioides*. *Insect Biochem. Mol. Biol.* 2009, 39: 11-19.
- Agarwal M, Walia S, Dhingra S, Khambay BPS. Insect growth inhibition, antifeedant and antifungal activity of compounds isolated/derived from *Zingiber officinale* Roscoe (ginger) rhizomes. *Pest Manag. Sci.* 2001, 57: 289-300.
- Albans KR, Baker R, Jones OT, Jutsum AR, Turnbull MD. Inhibition of response of *Heliothis virescens* to its natural pheromone by antipheromones. *Crop Prot.* 1984, 3: 501-506.
- Altner H, Routil C, Loftus R. The structure of bimodal chemo-, thermo-, and hygrosensitive sensilla on the antenna of *Locusta migratoria*. *Cell Tissue Res.* 1981, 215: 289-308.
- Amer A, Mehlhorn H. Repellency effect of forty-one essential oils against *Aedes*, *Anopheles*, and *Culex* mosquitoes. *Parasitol. Res.* 2006, 99: 478-490.
- Anderson P, Hansson BS, Nilsson U, Han Q, Sjöholm, Skals N, Anton S. Increased behavioral and neuronal sensitivity to sex pheromone after brief odor experience in a moth. *Chem. Senses* 2007, 32: 483-491.
- Anderson P, Hilker M, Hansson BS, Bombosch S, Klein B, Schildknecht H. Oviposition deterring components in larval frass of *Spodoptera littoralis* (Boisd.)(Lepidoptera: Noctuidae): A behavioural and electrophysiological evaluation. *J. Insect Physiol.* 1993, 39: 129-137.
- Anderson P, Sadek MM, Hansson BS. Pre-exposure modulates attraction to sex pheromone in a moth. *Chem. Senses* 2003, 28: 285-291.
- Ansari MA, Vasudevan P, Tandon M, Razdan RK. Larvicidal and mosquito repellent action of peppermint (*Mentha piperita*) oil. *Biores. Technol.* 2000, 71: 267-271.
- Anton S, Dufour MC, Gadenne C. Plasticity of olfactory-guided behaviour and its neurobiological basis: Lessons from moths and locusts. *Entomol. Exp. Appl.* 2007, 123: 1-11.
- Antonatos SA, Emmanuel NG, Fantinou AA. Effect of temperature and species of plant on the consumption of leaves by three species of Orthoptera under laboratory conditions. *Eur. J. Entomol.* 2013, 110: 605-610.
- Antony B, Fujii T, Moto K, Matsumoto S, Fukuzawa M, Nakano R, Tatsuki S, Ishikawa Y. Pheromone-gland-specific fatty acyl-reductase in the adzuki bean borer, *Ostrinia scapulalis* (Lepidoptera: Crambidae). *Insect Biochem. Mol. Biol.* 2009, 39: 90-95.
- Arata AA. Perspectivas del uso de plaguicidas: Historia, situación actual y necesidades futuras. En: *Plaguicidas, Salud y Ambiente*. Albert, LA (eds.). Centro Panamericano de Ecología Humana y Salud, México D.F. 1986: 314-325.

- Araújo ECC, Silveira ER, Lima MAS, Andrade M, de Andrade IL, Lima MAA. Insecticidal activity and chemical composition of volatile oils from *Hyptis martiusii* Benth. J. Agric. Food Chem. 2003, 51: 3760–3762.
- Arias Giralda A, Cobos-Suárez JM, Martín Bernal E, Morales Agacino E, Sopeña Mañas, JM. ADENDA: La langosta mediterránea, *Doclostaurus maroccanus* (Thunberg). Bol. San. Veg. Plagas, 1993, 19:1-11.
- Ashour MB, Hammock BD. Substituted trifluoroketones as potent selective inhibitors of mammalian carboxylesterases. Biochem. Pharmacol. 1987, 36: 1869–1879.
- Atanassov A, Shearer PW, Hamilton GC. Peach pest management programs impact beneficial fauna abundance and *Grapholita molesta* (Lepidoptera: Tortricidae) egg parasitism and predation. Environ. Entomol. 2003, 32: 780-788.
- Atanassov A, Shearer PW, Hamilton G, Polk D. Development and implementation of a reduced risk peach arthropod management program in New Jersey. J. Econ. Entomol. 2002, 95: 803-812.
- Attygalle AB, Jham GN, Svatos A, Frighetto RTS, Vilela EF, Ferrara FA, Uchóa-Fernandes MA, Meinwald J. (3E,8Z,11Z)-3,8,11-tetradecatrienyl acetate, a sex attractant for the tomato pest *Scrobipalpaloides absoluta* (Lepidoptera: Gelechiidae). Bioorg. Med. Chem. 1996, 4: 305-314.
- Attygalle AB, Jham GN, Svatos A, Frighetto RTS, Frighetto RTS, Meinwald J, Vilela EF, Ferrara FA, Uchóa-Fernandes MA. Microscale, random reduction: Application to the characterization of (3E,8Z,11Z)-3,8,11-Tetradecatrienyl acetate, a new Lepidopteran sex-pheromone. Tetrahedron Lett. 1995, 36: 5471–5474.
- Avilla J, Bosch D, Escudero-Colomar LA, Sarasúa MJ. Manzano, peral y melocotonero. En Control Biológico de Plagas Agrícolas. Jacas JA, Urbaneja A (eds). Phytoma 2008: 349-365.
- Awmack CS, Leather SR. Host plant quality and fecundity in herbivorous insects. Annu. Rev. Entomol. 2002, 47: 817-844.
- Bagamboula CF, Uyttendaele M, Debevere J. Inhibitory effect of thyme and basil essential oils, carvacrol, thymol, estragol, linalool and *p*-cymene towards *Shigella sonnei* and *S. flexneri*. Food Microbiol. 2004, 21: 33-42.
- Baker TC, Linn CE. Wind tunnels in pheromone research. En: Techniques in Pheromone Research. Miller TA (eds). Springer Verlag, New York. 1984: 74-110.
- Baker TC, Meyer W, Roelofs WL. Sex pheromone dosage and blend specificity of response by Oriental fruit moth males. Entomol. Exp. Appl. 1981, 30: 269-279.
- Baldacchino F, Pizza M, Moleas T, Di Gioia S. Prove di contenimento di *Doclostaurus maroccanus* (Orthoptera, Acrididae) con *Metarhizium anisopliae* var. *Acridum* (Ascomycotina, Hypocreales). Inf. Fitopatol. 2004, 54: 35-40.

- Baldacchino F, Sciarretta A, Addante R. Evaluating the spatial distribution of *Dociostaurus maroccanus* egg pods using different sampling designs. *Bull. Insectol.* 2012, 65: 223-231.
- Barbosa FS, Leite GLD, Alves SM, Nascimento AF, D'Avila VDA, Costa CA. Insecticide effects of *Ruta graveolens*, *Copaifera langsdorffii* and *Chenopodium ambrosioides* against pests and natural enemies in commercial tomato plantation. *Acta Sci. Agron.* 2011, 33: 37-43.
- Barea FD. Caracterización espacio-temporal de *Grapholita molesta* (Lepidoptera: Tortricidae) mediante métodos geoestadísticos y sistemas de información geográfica. Tesis doctoral, Universidad de la República, 2012.
- Barrozo RB, Jarriault D, Deisig N, Gemeno C, Monsempes C, Lucas P, Gadenne C, Anton S. Mating-induced differential coding of plant odour and sex pheromone in a male moth. *Eur. J. Neurosci.* 2011, 33: 1841-50.
- Batish D, Singh H, Kohli R, Kaur S. *Eucalyptus* essential oil as a natural pesticide. *Forest Ecol. Manag.* 2008, 256: 2166-2174.
- Bawin T, Collard F, De Backer L, Yarou BB, Compère P, Francis F, Verheggen FJ. Structure and distribution of the sensilla of the antennae of *Tuta absoluta* (Lepidoptera: Gelechiidae). *Micron*, 2017, 96: 16-28.
- Benton R, Vannice KS, Vosshall LB. An essential role for a CD36-related receptor in pheromone detection in *Drosophila*. *Nature*, 2007, 450: 289-293.
- Benzi V, Stefanazzi N, Ferrero A. Bioactivity of essential oils from leaves and fruits of agueribay (*Schinus molle* L.) in the rice weevil (*Sitophilus oryzae* L.). *Chilean J. Agric. Res.* 2009, 9: 154-159.
- Bio-Rad Laboratories, I., RC-DC Protein Assay, Instruction Manual, 2007.
- Birch MC. Responses of both sexes of *Trichoplusia ni* (Lepidoptera: Noctuidae) to virgin females and to synthetic pheromone. *Ecol. Entomol.* 1977, 2: 99-104.
- Blenau W, Rademacher E, Baumann A. Plant essential oils and formamidines as insecticides/acaricides: What are the molecular targets? *Apidologie*, 2012, 43: 334-347.
- Bohbot J, Sobrio F, Lucas P, Nagnan-Le Meillour P. Functional characterization of new class of odorant-binding proteins in the moth *Mamestra brassicae*. *Biochem. Biophys. Res. Commun.* 1998, 253: 489-494.
- Briand L, Swasdipan N, Nespoulous C, Bezirard V, Blon F, Huet JC, Ebert P, Penollet JC. Characterization of a chemosensory protein (ASP3c) from honeybee (*Apis mellifera* L.) as a brood pheromone carrier. *Eur. J. Biochem.* 2002, 269: 4586-4596.
- Butenandt A, Beckmann R, Stamm D, Hecker E. Über der sexual-lockstoff des seidenspinners *Bombyx mori*. Reindarstellung und konstitutionsermittlung. *Zeit. Naturforsch.* 1959, 14: 283-284.

- Casanova A, Pinto-Morente R, Carrascal M, Abian J. Large-scale filter-aided sample preparation method for the analysis of the ubiquitinome. *Anal. Chem.* 2017, 89: 3840-3846.
- Callahan FE, Vogt RG, Tucker ML, Dickens JC, Mattoo AK. High level expression of “male specific” pheromone binding proteins (PBPs) in the antennae of female noctuid moths. *Insect Biochem. Molec. Biol.* 2000, 30: 507-514.
- Carraher C, Authier A, Steinwender B, Newcomb RD. Sequence comparisons of odorant receptors among tortricid moths reveals different rates of molecular evolution among family members. *PLoS ONE*, 2012, 7: e38391.
- Chapman PJ, Lienk SE. Tortricid fauna of apple in New York (Lepidoptera: Tortricidae); including an account of apples' occurrence in the state, especially as a naturalized plant. Special Publication March 1971, New York State Agric. Exp. Station, Cornell University, Geneva.
- Chegini SG, Abbasipour H. Chemical composition and insecticidal effects of the essential oil of cardamom, *Elettaria cardamomum* on the tomato leaf miner, *Tuta absoluta*. *Toxin. Rev.* 2017, 36: 12-17.
- Coelho MCF, França FH. Biologia e quetotaxia da larva e descrição da pupa e adulto da traça-do-tomateiro. *Pes. Agropec. Bras.* 1987, 22: 129-135.
- Colpo JF, Jahnke SM, Füller TN. Potencial inseticida de óleos de origem vegetal sobre *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae). *Rev. Bras. Plantas Med.* 2014, 16: 182-188.
- Conti B, Canale A, Bertoli A, Gozzini F, Pistelli L. Essential oil composition and larvicidal activity of six Mediterranean aromatic plants against the mosquito *Aedes albopictus* (Diptera: Culicidae). *Parasitol. Res.* 2010, 107: 1455-1461.
- CPAGE, Catálogo de Publicaciones de la Administración General del Estado. Informes reuniones anuales de los Grupos de Trabajo Fitosanitario. Ministerio de Medio Ambiente y Medio Rural y Marino. 2004-2008.
- Crespo PH, Santiago-Álvarez C. Entomopathogenic fungi associated with natural populations of the Moroccan Locust *Dociostaurus maroccanus* (Thunberg) (Orthoptera: Gomphocerinae) and other Acridoidea in Spain. *Biocontrol Sci. Technol.* 1997, 7: 357-364.
- Cruz D, Eizaguirre M. Response to conspecific and heterospecific semiochemicals by *Sesamia nonagrioides* (L.) (Lepidoptera:Noctuidae) gravid females. *Bull. Entomol. Res.* 2015, 105: 347-354.
- De Cristofaro A, Ioriatti C, Molinari F, Pasqualini E, Anfora G, Germinara GS, Villa M, Rotundo G. Electrophysiological responses of codling moth, *Cydia pomonella* (L.) (Lepidoptera:Tortricidae), to codlemone and pear ester ethyl (E,Z)-2,4-decadienoate: Peripheral interactions in their perception and evidence for cells responding to both compounds. *Bull. Insect.* 2004, 57: 1-8.

- De Evert MBT, López VAG, de López MBR. Evaluación de extractos vegetales para el control de la palomilla del tomate *Tuta absoluta* (Meyrick) en condiciones de invernadero. *Inv. Agr.* 2015, 17: 138-142.
- De Jong R, Visser JH. Olfactory coding in the perception of semiochemicals. *J. Chem. Ecol.* 1988, 14: 2005-2018.
- De Moraes J, de Oliveira RN, Costa JP, Junior AL, de Sousa DP, Freitas RM, Allegretti SM, Pinto PL. Phytol, a diterpene alcohol from chlorophyll, as a drug against neglected tropical disease *Schistosomiasis mansoni*. *PLoS Negl. Trop. Dis.* 2014, 8: e2617.
- Del Mazo-Cancino A, Malo EA, Cruz-López L, Rojas JC. Diel periodicity and influence of age and mating in female sex pheromone titre in *Estigmene acrea* (Lep., Arctiidae). *J. Appl. Entomol.* 2004, 128: 459–463.
- Del Moral J. Discusión sobre la situación actual de la plaga de langosta (*Doclostaurus maroccanus* Thunb.) en Badajoz y resultados de un ensayo de insecticidas para su control. *Bol. San. Veg. Plagas* 1986, 12: 221-235.
- Del Moral J, Miguel-Lasobras EM, Álvarez IS, Muriel A, Pérez-Rojas F, Senero M. Toxicidad en aves (*Numida meleagris* L.) de insecticidas utilizados en el control de la langosta (*Doclostaurus maroccanus* Thunb.). *Bol. San. Veg. Plagas* 2005, 30: 635-648.
- Delisle J, Picimbon JF, Simard J. Regulation of pheromone inhibition in mated females of *Choristoneura fumiferana* and *C. rosaceana*. *J. Insect. Physiol.* 2000, 46: 913–921.
- Derbalah AS, Morse SZ, El-Samahy M. Some recent approaches to control *Tuta absoluta* in tomato under greenhouse conditions. *African Entomol.* 2012, 20: 27-34.
- Desneux N, Luna MG, Guillemaud T, Urbaneja A. The invasive South American tomato pinworm, *Tuta absoluta*, continues to spread in Afro-Eurasia and beyond: The new threat to tomato world production. *J Pest Sci.* 2011, 84: 403-408.
- Desneux N, Wajnberg E, Wyckhuys KAG, Burgio G, Arpaia S, Narváez-Vázquez CA, González-Cabrera J, Catalán D, Tabone E, Frandon J, Pizzol J, Poncet C, Cabello T, Urbaneja A. Biological invasion of European tomato crops by *Tuta absoluta*: Ecology, geographic expansion and prospects for biological control. *J. Pest Sci.* 2010, 83: 197–215.
- Diongue A, Yen TB, Lap PY. Bioassay studies on the effect of essential oils on the female Oriental fruit fly, *Bactrocera dorsalis* (Hendel) (Diptera: Tephritidae). *Pest Manag. Hort. Ecosys.* 2010, 16: 91-102.
- Domínguez A, Puigmartí M, Bosch MP, Rosell G, Crehuet R, Ortiz A, Quero C, Guerrero A. Synthesis, functional assays, electrophysiological activity and field tests of pheromone antagonists of the tomato leafminer, *Tuta absoluta*. *J. Agric. Food Chem.* 2016, 64: 3523-2532.
- Duportets L, Dufour MC, Couillaud F, Gadenne C. Biosynthetic activity of corpora allata growth of sex accessory glands and mating in the male moth *Agrotis ipsilon*. *J. Exp. Biol.* 1998, 201: 2425-2432.



- Durán I, Parrilla A, Feixas J, Guerrero A. Inhibition of antennal esterases of the Egyptian armyworm *Spodoptera littoralis* by trifluoromethyl ketones. *Bioorg. Med. Chem. Lett.* 1993, 3: 2593-2598.
- Edgecomb RS, Harth CE, Schneiderman AM. Regulation of feeding behavior in adult *Drosophila melanogaster* varies with feeding regime and nutritional state. *J. Exp. Biol.* 1994, 197: 215–35.
- Ehler LE. Integrated pest management (IPM): Definition, historical development and implementation, and the other IPM. *Pest Manag. Sci.* 2006, 62: 787-789.
- Enan E. Insecticidal activity of essential oils: Octopaminergic sites of action. *Comp. Biochem. Physiol.* 2001, 130: 325–337.
- Erler F, Ulug I, Yalcinkaya B. Repellent activity of five essential oils against *Culex pipiens*. *Fitoterapia* 2006, 77: 491–494.
- Espinosa F, Mora P, Espuny J, Nácher J. Evaluación de un activo proteómico como agente de control frente a araña roja (*Tetranychus urticae*). *Phytoma* 2010, 218. (<http://www.interempresas.net/Horticola/Articulos/122580-Evaluacion-de-un-activo-proteomico-como-agente-de-control-frente-a-arana-roja.html>).
- FAO, 2006. Lucha biológica contra las langostas. Nuevas armas en una guerra milenaria. (<http://www.fao.org/ag/locusts-CCA/en/1026/1029/index.html>).
- Felipe CFB, Fonsêca KS, Barbosa ALR, Bezerra JNS, Neto MA, França Fonteles MM, Barros Viana GS. Alterations in behavior and memory induced by the essential oil of *Zingiber officinale Roscoe* (ginger) in mice are cholinergic-dependent. *J. Med. Plants Res.* 2008, 2: 163-170.
- Feng L, Prestwich GD. Expression and characterization of lepidopteran general odorant binding protein. *Insect Biochem. Molec. Biol.* 1997, 27: 405-412.
- Ferez HJ, Seidelmann K. Pheromones in relation to aggregation and reproduction in desert locusts. *Physiol. Entomol.* 2003, 28: 11-18.
- Ferkovich SM, Mayer MS, Rutter RR. Sex pheromone of the cabbage looper: reactions with antennal proteins in vitro. *J. Insect Physiol.* 1973, 19: 2231-2243.
- Fuentes M, Orfao A. Nanotecnología en Proteómica: Microarrays de proteínas y nuevos sistemas de detección. Centro de Investigación del Cáncer/IBMCC (USAL/CSIC) y Departamento de Medicina y Servicio General de Citometría. Universidad de Salamanca. 2012. ([https://www.instituto-roche.es/biotecnologia/69/nanotecnologia\\_en\\_proteomica\\_microarrays\\_de\\_proteinas\\_y\\_nuevos\\_sistemas\\_de\\_deteccion](https://www.instituto-roche.es/biotecnologia/69/nanotecnologia_en_proteomica_microarrays_de_proteinas_y_nuevos_sistemas_de_deteccion)).
- Fürstenau B. Comunicación química intraespecífica de *Coroebus spp.* (Coleoptera: Buprestidae) y *Doclostaurus maroccanus* (Orthoptera: Acrididae), dos insectos plaga de la Península Ibérica. Tesis doctoral, Universitat de Barcelona. 2011.

- Fürstenau B, Muñoz L, Coca-Abia M, Rosell G, Guerrero A, Quero C. Phytal: A candidate sex pheromone component of the Moroccan locust *Dociostaurus maroccanus*. *ChemBioChem* 2013, 14: 1450-1459.
- Fuzeau-Braesch S, Genin E, Jullien R, Knowles E, Papin C. Composition and role of volatile substances in atmosphere surrounding two gregarious locusts, *Locusta migratoria* and *Schistocerca gregaria*. *J. Chem. Ecol.* 1988, 14: 1023-1033.
- Gadenne C, Barrozo RB, Anton S. Plasticity in insect olfaction: to smell or not to smell? *Annu. Rev. Entomol.* 2016, 61: 317-333.
- Gadenne C, Dufour MC, Anton S. Transient post-mating inhibition of behavioural and central nervous responses to sex pheromone in an insect. *Proc. R. Soc. Lond. B. Biol. Sci.* 2001, 268: 1631–1635.
- Gaire S, O’Connell M, Holguin FO, Amatya A, Bundy S, Romero A. Insecticidal properties of essential oils and some of their constituents on the Turkestan cockroach (Blattodea: Blattellidae). *J. Econ. Entomol.* 2017, 110: 584-592.
- Gelb MH, Svaren JP, Abeles RH. Fluoroketone inhibitors of hydrolytic enzymes. *Biochemistry* 1985, 24: 1813-1817.
- Giner M, Sans A, Riba M, Bosch D, Gago R, Rayo J, Rosell G, Guerrero A. Development and biological activity of a new antagonist of the pheromone of the codling moth *Cydia pomonella*. *J. Agric. Food Chem.* 2009, 57: 8514–8519.
- Giordani R, Regli P, Kaloustian J, Mikail C, Abou L, Portugal H. Antifungal effect of various essential oils against *Candida albicans*. Potentiation of antifungal action of Amphotericin B by essential oil from *Thymus vulgaris*. *Phytother. Res.* 2004, 18: 990-995.
- Gökçe A, Stelinski LL, Isaacs R, Whalon ME. Behavioural and electrophysiological responses of grape berry moth (Lep., Tortricidae) to selected plant extracts. *J. Appl. Entomol.* 2006, 130: 509-514.
- Gong ZJ, Zhou WW, Yu HZ, Mao CG, Zhang CX, Cheng JA, Zhu ZR. Cloning, expression and functional analysis of general odorant-binding protein 2 gene of the rice striped stem borer, *Chilo suppressalis* (Walker) (Lepidoptera: Pyralidae). *Insect Molec. Biol.* 2009, 18: 405-417.
- González-Cabrera J, Mollá O, Montón H, Urbaneja A. Efficacy of *Bacillus thuringiensis* (Berliner) in controlling the tomato borer, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *BioControl* 2011, 56: 71-80.
- González-Coloma A, Martín-Benito D, Mohamed N, García-Vallejo MC, Soria AC. Antifeedant effects and chemical composition of essential oils from different populations of *Lavandula luisieri* L. *Biochem. Syst. Ecol.* 2006, 34: 609–616.

- González L. Interferència en l'atracció a la feromona sexual de mascles de *Grapholita molesta* (Busck) per acció de derivats tipus metilcetona. Trabajo final de Máster. Universidad de Lleida (2014).
- Gordh G, Headrick DH. A dictionary of entomology. CABI Publishing, Wallingford, UK. 2001: 1032.
- Grant GG. Evidence for a male sex pheromone in the noctuid, *Trichoplusia ni*. Nature. 1970, 227:1345-1346.
- Groot AT, Visser JH. Influence of host plants on sexual communication in the herbivorous bug *Lygocoris pabulinus*. Chemoecology 2001, 11: 161-166.
- Gu SH, Zhou JJ, Wang GR, Zhang YJ, Guo YY. Sex pheromone recognition and immunolocalization of three pheromone binding proteins in the black cutworm moth *Agrotis ipsilon*. Insect Biochem. Mol. Biol. 2013, 43: 237-251.
- Guerra PC, Molina Y, Yábar E, Gianoli E. Oviposition deterrence of shoots and essential oils of *Minthostachys spp.* (Lamiaceae) against the potato tuber moth. J. Appl. Entomol. 2007, 131: 134-138.
- Guerrero A. Feromonas sexuales de insectos. En: Insecticidas Biorracionales. Bellés X (ed.). Consejo Superior de Investigaciones Científicas (España) Madrid, 1988.
- Guerrero A, Rosell G. Biorational approaches for insect control by enzymatic inhibition. Curr. Med. Chem. 2005, 12: 461-469.
- Guerrieri F, Gemeno C, Monsempes C, Anton S, Jacquín-Joly E, Lucas P, Devaud JM. Experience-dependent modulation of antennal sensitivity and input to antennal lobes in male moths (*Spodoptera littoralis*) pre-exposed to sex pheromone. J. Exp. Biol. 2012, 215: 2334-2341.
- Guidobaldi F, Guerenstein PG. El sistema olfativo de los insectos. En: Rojas JC, Malo EA (eds.). Temas Selectos en Ecología Química de Insectos. Ecosur, Chiapas. 2012: 46-71.
- Guo H, Huang LQ, Pelosi P, Wang CZ. Three pheromone-binding proteins help segregation between two *Helicoverpa* species utilizing the same pheromone components. Insect Biochem. Mol. Biol. 2012, 42: 708-716.
- Hannour K, Boughdad A, Maataoui A, Bouchelta A. Chemical composition and toxicity of Moroccan *Rosmarinus officinalis* (Lamiaceae) essential oils against the potato tuber moth, *Phthorimaea operculella* (Zeller, 1873) Zeller (Lepidoptera, Gelechiidae). J. Mater. Environ. Sci. 2017, 8: 758-769.
- Hassanali A, Bashir MO. Insights for the management of different locust species from new findings on the chemical ecology of the desert locust. Int. J. Trop. Insect Sci. 1999, 19: 369-376.
- Hansson BS. A bug's smell—research into insect olfaction. Trends Neurosci. 2002, 25: 270-274.

- Hansson BS. Olfaction in lepidoptera. *Experientia*, 1995, 51: 1003-1027.
- Hansson BS, Ochieng SA, Grosmaître X, Anton S, Njagi PGN. Physiological responses and central nervous projections of antennal olfactory receptor neurons in the adult desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae). *J. Comp. Physiol. A*, 1996, 179: 157-167.
- Hapke C, Kirchert J, Dickler E, Zebitz CP. Combination of pheromone and an additive for the control of codling moth, *Cydia pomonella*. *IOBC WPRS Bulletin*, 2001, 24: 37-42.
- Harari AR, Zahavi T, Thiéry D. Fitness cost of pheromone production in signaling female moths. *Evolution* 2011, 65: 1572-1582.
- Hartlieb E, Rembold H. Behavioural response of female *Helicoverpa (Heliiothis) armigera* HB. (Lepidoptera: Noctuidae) moths to synthetic pigeonpea (*Cajanus cajan* L.) kairomone. *J. Chem. Ecol.* 1996, 22: 821–837.
- Heifetz Y, Voet H, Applebaum SW. Factors affecting behavioral phase transition in the desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera: Acrididae). *J. Chem. Ecol.* 1996, 22: 1717-1734.
- Hendrikse A, Vos-Bunnemyer E. Role of host plant stimuli in sexual behavior of small ermine moths (*Yponomeuta*). *Ecol. Entomol.* 1987, 12: 363–71.
- Hernández-Valladares M, Aasebø E, Mjaavatten O, Vaudel M, Bruserud Ø, Berven F, Selheim F. Reliable FASP-based procedures for optimal quantitative proteomic and phosphoproteomic analysis on samples from acute myeloid leukemia patients. *Biol. Proced. Online* 2016, 18: 13-23.
- Hickel ER, Vilela EF, De Lima JOG, Della Lucia MC. Comportamento de acasalamento de *Scrobipalpula absoluta*. *Pesq. Agropec. Bras.* 1991, 26: 827-835.
- Horowitz AR, Ellsworth PC, Ishaaya I. Biorational pest control—an overview. En: *Biorational Control of Arthropod Pests*. Ishaaya I, Horowitz A (eds.). Springer Netherlands. 2009: 1-20.
- Hu P, Wang j, Cui M, Tao J, Luo Y. Antennal transcriptome analysis of the Asian longhorned beetle *Anoplophora glabripennis*. *Sci. Rep.* 2016, 6: 26652.
- Hudaib M, Speroni E, Di Pietra AM, Cavrini V. GC/MS evaluation of thyme (*Thymus vulgaris* L.) oil composition and variations during the vegetative cycle. *J. Pharm. Biomed. Anal.* 2002, 29: 691-700.
- Hughes PR, Renwick JAA. Hormonal and host factors stimulating pheromone synthesis in female western pine beetles *Dendroctonus brevicomis*. *Physiol. Entomol.* 1977, 2: 289-92.
- Hummelbrunner LA, Isman MB. Acute, sublethal, antifeedant, and synergistic effects of monoterpenoid essential oil compounds on the tobacco cutworm, *Spodoptera litura* (Lep., Noctuidae). *J. Agric. Food Chem.* 2001, 49: 715-720.

- Hunter DM. Advances in the control of locust (Orthoptera: Acrididae) in Eastern Australia: From crop protection to preventive control. *Aust. J. Entomol.* 2004, 43: 293-303.
- Iannacone J, Lamas G. Efecto insecticida de cuatro extractos botánicos y del cartap sobre la polilla de la papa *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae), en el Perú. *Entomotropica* 2003, 18: 95-105.
- Ibrahim MA. Insecticidal, repellent and antimicrobial activity and phytotoxicity of essential oils: with special reference to limonene and its suitability for control of insect pests. *Agric. Food Sci. Finland* 2001, 10: 243-259.
- Inayatullah C, El Bashir S, Hassanali A. Sexual behavior and communication in the desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae): Sex pheromone in solitaria. *Environ. Entomol.* 1994, 23: 1544-1551.
- Isman MB. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annu. Rev. Entomol.* 2006, 51: 45-66.
- Isman MB, Miresmailli S, Machial C. Commercial opportunities for pesticides based on plant essential oils in agriculture, industry and consumer products. *Phytochem. Rev.* 2011, 10: 197-204.
- Isman MB. Plant essential oils as green pesticides for pest and disease management. *Agric. Appl. Green Chem.* 2004, 887: 41-51.
- Ivaldi-Sender C. Techniques simples pour un élevage permanent de la torteuse orientale, *Grapholita molesta* (Lepidoptera Tortricidae) sur milieu artificiel. *Ann. Zool. Ecol. Anim.* 1974, 6: 337-343.
- Jacquin-Joly E, Vogt RG, François MC, Nagnan-Le Meillour P. Functional and expression pattern analysis of chemosensory proteins expressed in antennae and pheromonal gland of *Mamestra brassicae*. *Chem. Senses* 2001, 26: 833-844.
- Jang EB. Effects of mating and accessory gland injections on olfactory-mediated behavior in the female Mediterranean fruit fly, *Ceratitis capitata*. *J. Insect Physiol.* 1995, 41: 705-710.
- Jia XJ, Wang HX, Yan ZG, Zhang MZ, Wei CH, Qin XC, Ji WR, Falabella P, Du YL. Antennal transcriptome and differential expression of olfactory genes in the yellow peach moth, *Conogethes punctiferalis* (Lepidoptera: Crambidae). *Sci. Rep.* 2016, 6: 29067.
- Jia YZ, Ze SZ, Yang B. Identification and expression profiling of six chemosensory protein genes in the beet armyworm, *Spodoptera exigua*. *J. Asia Pac. Entomol.* 2015, 18: 61-66.
- Jiang ZL, Akhtar Y, Zhang X, Bradbury R, Isman MB. Insecticidal and feeding deterrent activities of essential oils in the cabbage looper, *Trichoplusia ni* (Lepidoptera: Noctuidae). *J. Appl. Entomol.* 2012, 136: 191-202.

- Jiménez-Medina J, Aldebis HK, Santiago-Álvarez C. Valoración insecticida de diversos aislados de hongos hifomicetos para el control de la langosta mediterránea, *Dociostaurus maroccanus* (Thunberg). Resúmenes VI Jornadas Científicas de la Sociedad Española de Entomología Aplicada. Lleida, 1997: 17.
- Jin X, Ha TS, Smith DP. SNMP is a signaling component required for pheromone sensitivity in *Drosophila*. Proc. Natl. Acad. Sci. USA. 2008, 105: 10996–11001.
- Jin X, Zhang SG, Zhang L. Expression of odorant-binding and chemosensory proteins and spatial map of chemosensilla on labial palps of *Locusta migratoria* (Orthoptera: Acrididae). Arthropod Struc. Dev. 2006, 35: 47-56.
- Jurenka RA, Roelofs WL. Characterization of the acetyltransferase used in pheromone biosynthesis in moths: specificity for the Z isomer in Tortricidae. Insect Biochem. 1989, 19: 639-644.
- Kanat M, Alma MH. Insecticidal effects of essential oils from various plants against larvae of pine processionary moth (*Thaumetopoea pityocampa* Schiff) (Lepidoptera: Thaumetopoeidae). Pest Manag. Sci. 2003, 60: 173-177.
- Kanga LHB, Pree DJ, van Lier JL. Monitoring for resistance to organophosphorus, carbamate, and pyrethroid insecticides in the Oriental fruit moth (Lepidoptera: Tortricidae). Can. Entomol. 1999, 131: 441-450.
- Kanga LHB, Pree DJ, Van Lier JL, Whitty KJ. Mechanisms of resistance to organophosphorus and carbamate insecticides in Oriental fruit moth populations (*Grapholita molesta* Busck). Pestic. Biochem. Physiol. 1997, 59: 11-23.
- Kasang, G. Bombykol reception and metabolism on the antennae of the silkworm *Bombyx mori*. En: Gustation and Olfaction. Ohloff O, Thomas AF (eds.). Academic Press, London. 1971: 245-250.
- Khater HF, Ramadan MY, El-Madawy, RS. Lousicidal, ovicidal and repellent efficacy of some essential oils against lice and flies infesting water buffaloes in Egypt. Vet. Parasitol. 2009, 164: 257-266.
- Koc S, Oz E, Cetin H. Repellent activities of some Labiatae plant essential oils against the saltmarsh mosquito *Ochlerotatus caspius* (Pallas, 1771) (Diptera: Culicidae). Parasitol. Res. 2012, 110: 2205-2209.
- Konstantopoulou MA, Pratsinis H, Kletsas D, Mazomenos BE. Pheromone-binding protein and general odorant binding protein of *Sesamia nonagrioides*: sex- and diel- dependent expression. Entomol. Exp. Appl. 2006, 119: 129-136.
- Kostyukovsky M, Rafaeli A, Gileadi C, Demchenko N, Shaaya E. Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: Possible mode of action against insect pests. Pest Manag. Sci. 2002, 58: 1101–1106.

- Kromann SH, Saveer AM, Binyameen M, Bengtsoon M, Birgersson G, Hansson BS, Schlyter F, Witzgall P, Ignell R, Becher PG. Concurrent modulation of neuronal and behavioural olfactory responses to sex and host plant cues in a male moth. *Proc. R. Soc. B.* 2015, 282: 20141884.
- Kubli E. Sex-peptides: Seminal peptides of the *Drosophila male*. *Cell. Mol. Life Sci.* 2003, 60: 1689–1704.
- Kuppusamy E, Dhamodharan KI, Jayakumar S. Role of plants and plant based products towards the control of insect pests and vectors: A novel review. *J. Coast. Life Med.* 2016, 4: 902-917.
- Landolt PJ. Effects of host plant leaf damage on cabbage-looper moth attraction and oviposition. *Entomol. Exp. Appl.* 1993, 67: 79–85.
- Landolt PJ, Hofstetter RW, Biddick LL. Plant Essential oils as arrestants and repellents for neonate larvae of the codling moth (Lepidoptera: Tortricidae). *Environ. Entomol.* 1999, 28: 954-960.
- Landolt PJ, Phillips TW. Host plant influences on sex pheromone behavior of phytophagous insects. *Annu. Rev. Entomol.* 1997, 42: 371-391.
- Langenheim JH. Higher plant terpenoids: a phyto-centric overview of their ecological roles. *J. Chem. Ecol.* 1994, 20: 1223-1280.
- Lánský P, Getz WM. Receptor heterogeneity and its effect on sensitivity and coding range in olfactory sensory neurons. *Bull. Math. Biol.* 2001, 63: 885-908.
- Laroque N, Vincent A, Bélanger A, Bourassa JP. Effects of tansy essential oil from *Tanacetum vulgare* on biology of oblique banded leafroller, *Choristoneura rosaceana*. *J. Chem. Ecol.* 1999, 25: 1319-1330.
- Larsson MC, Domingos AI, Jones WD, Chiappe ME, Amrein H, Vosshall LB. Or83b encodes a broadly expressed odorant receptor essential for *Drosophila* olfaction. *Neuron* 2004, 43: 703-714.
- Latchininsky AV. Moroccan locust *Docostaurus maroccanus* (Thunberg, 1815): A faunistic rarity or an important economic pest? *J. Insect Conserv.* 1998, 2: 167-178.
- Laughlin JD, Ha TS, Jones DN, Smith DP. Activation of pheromone-sensitive neurons is mediated by conformational activation of pheromone-binding protein. *Cell* 2008, 133: 1255–1265.
- Leal WS. Pheromone reception. En: *Chemistry of pheromones and other semiochemicals II*, Schulz S (eds.). Springer Berlin Heidelberg, 2005, 240: 1-36.
- Leal WS. Odorant reception in insects: Role of receptors, binding proteins and degrading enzymes. *Annu. Rev. Entomol.* 2013, 58: 373–391.

- Leal WS, Ishida Y, Pelletier J, Xu Wei, Rayo J, Xu X, Ames JB. Olfactory proteins mediating chemical communication in the navel orangeworm moth, *Amyelois transitella*. PLoS ONE 2009, 4: e7235.
- Lee MS, Albajes R, Eizaguirre M. Mating behaviour of female *Tuta absoluta* (Lepidoptera: Gelechiidae): Polyandry increases reproductive output. J. Pest. Sci. 2014, 87: 429-439.
- Li GW, Chen X, Li B, Zhang G, Li Y, Wu J. Binding properties of general odorant binding proteins from the Oriental fruit moth, *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae). PLoS ONE 2016a, 11: e0155096.
- Li GW, Du J, Li YP, Wu JX. Identification of putative olfactory genes from the Oriental fruit moth *Grapholita molesta* via an antennal transcriptome analysis. PLoS One, 2015, 10: e0142193.
- Li GW, Zhang Y, Li YP, Wu JX, Xu XL. Cloning, expression and functional analysis of three odorant-binding proteins of the Oriental fruit moth, *Grapholita molesta* (Busck) (Lepidoptera: Tortricidae). Insect Biochem. Physiol. 2016b, 91: 67-87.
- Lietti MM, Botto E, Alzogaray RA. Insecticide resistance in Argentine populations of *Tuta absoluta* (Lepidoptera: Gelechiidae). Neotrop. Entomol. 2005, 34: 113-119.
- Light DM, Knight AL, Henrick CA, Rajapaska D, Lingren B, Dickens JC, Reynolds KM, Buttery RG, Merrill G, Roitman J, Campbell BC. A pear-derived kairomone with pheromonal potency that attracts male and female codling moth, *Cydia pomonella* (L.). Naturwissenschaften 2001, 88: 333-338.
- Liu C, Zhang J. Expression of SNMP1 and SNMP2 genes in antennal sensilla of *Spodoptera exigua* (Hübner). Arch. Insect Biochem. Physiol. 2014, 85: 114-126.
- Ljungberg H, Anderson P, Hansson BS. Physiology and morphology of pheromone-specific sensilla on the antennae of male and female *Spodoptera littoralis* (Lepidoptera: Noctuidae). J. Insect Physiol. 1993, 39: 253-260.
- López S, Guerrero A, Bleda MJ, Quero C. Short-term peripheral sensitization by brief exposure to pheromone components in *Spodoptera littoralis*. J. Comp. Physiol. A 2017: 1-10.
- Luis CPP, Guerrero A, Malo EA. Inhibition of electrophysiological response to the pheromone of the fall armyworm, *Spodoptera frugiperda*. J. Pest. Sci. 2010, 35: 23-26.
- Ma YF, Xiao C. Push-pull effects of three plant secondary metabolites on oviposition of the potato tuber moth, *Phthorimaea operculella*. J. Insect Sci. 2013, 13: 1-7.
- Machial CM, Shikano I, Smirle M, Bradbury R, Isman MB. Evaluation of the toxicity of 17 essential oils against *Choristoneura rosaceana* (Lepidoptera: Tortricidae) and *Trichoplusia ni* (Lepidoptera: Noctuidae). Pest. Manag. Sci. 2010, 66: 1116-1121.
- Malo EA, Rojas JC, Gago R, Guerrero A. Inhibition of the responses to sex pheromone of the fall armyworm, *Spodoptera frugiperda*. J. Insect Sci. 2013, 13: 1-14.



- Mansour SA, El-Sharkawy AZ, Abdel-Hamid NA. Toxicity of essential plant oils, in comparison with conventional insecticides, against the desert locust, *Schistocerca gregaria* (Forskål). *Ind. Crops Prod.* 2015, 63: 92-99.
- Mansour SA, Messeha SS, el-Gengaihi SE. Botanical biocides. 4. Mosquitocidal activity of certain *Thymus capitatus* constituents. *J. Nat. Toxins* 2000, 9: 49–62.
- Manza LL, Stamer SL, Ham AJL, Codreanu SG, Liebler DC. Sample preparation and digestion for proteomic analyses using spin filters. *Proteomics* 2005, 5: 1742-1745.
- Martel V, Anderson P, Hansson BS, Schlyter F. Peripheral modulation of olfaction by physiological state in the Egyptian leaf worm *Spodoptera littoralis* (Lepidoptera: Noctuidae). *J. Insect Physiol.* 2009, 55: 793-797.
- Martín Bernal E, Cobos Suárez JM, Arias Giralda A, Morales Agacino E, Sopeña Mañas JM. La langosta mediterránea, *Dociostaurus maroccanus* (Thunberg). *Bol. San. Veg. Plagas* 1993, 9: 1001-1011.
- Martín Bernal E, Ibarra Ibáñez N. Plagas y enfermedades de las masas forestales españolas, nº 28 *Dociostaurus maroccanus* Thunberg: Plaga de los eriales. REDFORESTA. 14/09/2011. (<http://www.redforesta.com/blog/2011/09/14/dociostaurus-maroccanus-thunberg-plaga-de-los-eriales/>).
- Masante-Roca I, Anton S, Delbac L, Dufour M-C, Gadenne C. Attraction of the grapevine moth to host and non-host plant parts in the wind tunnel: Effects of plant phenology, sex, and mating status. *Entomol. Exp. Appl.* 2007, 122: 239–245.
- McDonough LM, Chapman PS, Weissling TJ, Smithhisler CL. Efficacy of nonpheromone communication disruptants of codling moth (*Cydia pomonella*): Effect of pheromone isomers and of distance between calling females and dispensers. *J. Chem. Ecol.* 1996, 22: 415–423.
- McNeil JN, Delisle J. Host plant pollen influences calling behavior and ovarian development of the sunflower moth, *Homeosoma electellum*. *Oecologia* 1989, 80: 201–205.
- Medeiros MA, Sujii ER, Correa-Rasi G, Setti-Liz R, Castanheira-de-Morais H. Padrão de oviposição e tabela de vida da traça-do-tomateiro *Tuta absoluta* (Meyrick) (Lepidoptera, Gelechiidae). *Rev. Bras. Entomol.* 2009, 53: 452–456.
- Menzel R. Associative learning in honey bees. *Apidologie* 1993, 24: 157–168.
- Miller JR, Roelofs WL. Sustained-flight tunnel for measuring insect responses to wind-borne sex pheromones. *J. Chem. Ecol.* 1978, 4: 187-198.
- Mitchell ER, Sugie H, Tumlinson JH. *Spodoptera exigua*: Capture of feral males in traps baited with blends of pheromone components. *J. Chem. Ecol.* 1983, 9: 95-104.
- Mitchell ER, Webb JR, Hines RW. Capture of male and female cabbage loopers in field traps baited with synthetic sex pheromone. *Environ. Entomol.* 1972, 1: 525-526.

- Moawad SS, Ebadah IMA. Impact of some natural plant oils on some biological aspects of the potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera; Gelechiidae). Res. J. Agric. Biotech. Sci. 2007, 3: 119-123.
- Moawad SS, Ebadah IMA, Mahmoud YA. Biological and histological studies on the efficacy of some botanical and commercial oils on *Tuta absoluta* Meyrick (Lepidoptera: Gelechiidae). Egypt. J. Biol. Pest Control 2013, 23: 301-308.
- Momen FM, Amer SAA, Refaat AM. Influence of mint and peppermint on *Tetranychus urticae* and some predacious mites of the family *Phytoseiidae* (Acari: Tetranychidae: Phytoseiidae). Acta Phytopathol. Entomol. Hung. 2001, 36: 143-153.
- Moorhouse JE, Yeadon R, Beevor PS, Nesbitt BF. Method for use in studies of insect chemical communication. Nature 1969, 223: 1174-1175.
- Moreno SC, Carvalho GA, Picanço MC, Morais EGF, Pereira M. Bioactivity of compounds from *Acmella oleracea* against *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) and selectivity to two non-target species. Pest Manag. Sci. 2012, 68: 386-393.
- Morton TC, Venci FV. Larval beetles form a defense from recycled host-plant chemicals discharged as fecal wastes. J. Chem. Ecol. 1998, 24: 765-785.
- Muñoz L, Bosch P, Batllori L, Rosell G, Bosch D, Guerrero A, Avilla J. Synthesis of allylic trifluoromethyl ketones and activity as inhibitors of the sex pheromone of the leopard moth, *Zeuzera pyrina* L. (Lepidoptera: Cossidae). Pest Manage. Sci. 2011, 67: 956-964.
- Nagnan-Le Melliour P, Cain AH, Jacquin-Joly E, François MC, Ramachandran S, Maida R, Steinbrecht, RA. Chemosensory proteins from the proboscis of *Mamestra brassicae*. Chem. Senses 2000, 25: 541-553.
- Nakagawa T, Sakurai T, Nishioka T, Touhara K. Insect sex-pheromone signals mediated by specific combinations of olfactory receptors. Science 2005, 309: 1638-1642.
- Nathanson JA, Hunnicutt E, Kantham L, Scavone C. Cocaine as a naturally occurring pesticide. Proc. Natl. Acad. Sci. USA. 1993, 90: 9645-9648.
- Nerio LS, Olivero-Verbel J, Stashenko E. Repellent activity of essential oils: A review. Bioresour. Technol. 2010, 101: 372-378.
- Nesbitt BF, Beevor PS, Cole RA, Lester R, Poppi RG. Sex pheromones of two Noctuid moths. Nature 1973, 244: 208-209.
- Newcomb RD, Sirey TM, Rassam M, Greenwood DR. Pheromone binding proteins of *Epiphyas postvittana* (Lepidoptera: Tortricidae) are encoded at a single locus. Insect Biochem. Mol. Biol. 2002, 32: 1543-1554.

- Núñez S, Scatoni I. Tecnología disponible para el manejo de plagas en frutales de hoja caduca. Unidad de Comunicación y Transferencia de Tecnología de INIA (eds.). Montevideo, Uruguay. 2013, 150.
- Obeng-Ofori D, Torto B, Hassanali A. Evidence for mediation of two releaser pheromones in the aggregation behavior of the gregarious desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera: Acrididae). J. Chem. Ecol. 1993, 19: 1665-1676.
- Obeng-Ofori D, Torto B, Njagi PG, Hassanali A, Amiani H. Fecal volatiles as part of the aggregation pheromone complex of the desert locust, *Schistocerca gregaria* (Forsk.) (Orthoptera: Acrididae). J. Chem. Ecol. 1994, 20: 2077-2087.
- Ochieng SA, Hallberg E, Hansson BS. Fine structure and distribution of antennal sensilla of the desert locust, *Schistocerca gregaria* (Orthoptera: Acrididae). Cell Tissue Res. 1998, 291: 525-536.
- Odalo JO, Omolo MO, Malebo H, Angira J, Njeru PM, Ndiege IO, Hassanali A. Repellency of essential oils of some plants from the Kenyan coast against *Anopheles gambiae*. Acta Trop. 2005, 95: 210-218.
- Odeyemi OO, Masika P, Afolayan AJ. Insecticidal activities of essential oil from the leaves of *Mentha longifolia* L. subsp. *capensis* against *Sitophilus zeamais* (Motschulsky) (Coleoptera: Curculionidae). Afric. Entomol. 2008, 16: 220-225.
- Palanaswamy P, Seabrook WD. Behavioral responses of the female eastern spruce budworm *Choristoneura fumiferana* (Lepidoptera, Tortricidae) to the sex pheromone of their own species. J. Chem. Ecol. 1978, 4: 649-655.
- Panagiotakopulu E, Buckland PC, Day PM, Dumas C. Natural insecticides and insect repellents in antiquity: A review of the evidence. J. Archaeol. Sci. 1995, 22: 705-710.
- Park JH, Jeon YJ, Lee CH, Chung N, Lee HS. Insecticidal toxicities of carvacrol and thymol derived from *Thymus vulgaris* Lin. against *Pochazia shantungensis* Chou & Lu., newly recorded pest. Sci. Rep. 2017, 7: 40902.
- Parrilla A, Guerrero A. Trifluoromethyl ketones as inhibitors of the processionary moth sex pheromone. Chem. Senses 1994, 19: 1-10.
- Patton WF. A thousand points of light: The application of fluorescence detection technologies to two-dimensional gel electrophoresis and proteomics. Electrophoresis 2000, 21: 1123-1144.
- Pavela R. Acute and synergistic effects of monoterpenoid essential oil compounds on the larvae of *Spodoptera littoralis*. J. Biopest. 2010, 3: 573-578.
- Pavela R. Acute, synergistic and antagonistic effects of some aromatic compounds on the *Spodoptera littoralis* Boisid (Lep., Noctuidae) larvae. Ind. Crops Prod. 2014, 60: 247-258.

- Pavela R, Vrchotová N, Tříška J. Mosquitocidal activities of thyme oils (*Thymus vulgaris* L.) against *Culex quinquefasciatus* (Diptera: Culicidae). Parasitol. Res. 2009, 105: 1365-1370.
- Pearson GA, Schal C. Electroantennogram responses of both sexes of grape root borer (Lepidoptera: Sesiidae) to synthetic female sex pheromone. Environ. Entomol. 1999, 28: 943–946.
- Pelosi P, Iovinella I, Zhu J, Wang G, Dani FR. Beyond chemoreception: diverse tasks of soluble olfactory proteins in insects. Biol. Rev. 2017, doi: 10.1111/brv.123.
- Pérez E. Plaguicidas botánicos: Una alternativa a tener en cuenta. Fitosanidad 2012, 16: 51-59.
- Peter WK, Wendell MA, Roelofs L. Calcium involvement in the stimulation of sex pheromone production by PBAN in the European corn borer, *Ostrinia nubilalis* (Lepidoptera: Pyralidae). Insect Biochem. Molec. Biol. 1995, 25: 467-473.
- Phelan PL, Silk PJ, Northcott CJ, Tan SH, Baker TC. Chemical identification and behavioral characterization of male wing pheromone of *Ephestia elutella* (Pyralidae). J. Chem. Ecol. 1986, 12: 135-146.
- Picimbon JF, Dietrich K, Breer H, Krieger J. Chemosensory proteins of *Locusta migratoria* (Orthoptera: Acrididae). Insect Biochem. Mol. Biol. 2000, 30: 233-241.
- Piñero JC, Dorn S. Response of female Oriental fruit moth to volatiles from apple and peach trees at three phenological stages. Entomol. Exp. Appl. 2009, 131: 67-74.
- Plettner, E. Insect pheromone olfaction: new targets for the design of species-selective pest control agents. Curr. Med. Chem. 2002, 9: 1075–1085.
- Pollini A, Bariselli M. *Cydia molesta*: pest on the increase and defence of pome fruits. Inf. Agr. 1993, 49: 19-21.
- Pophof B. Inhibitors of sensillar esterase reversibly block the responses of moth pheromone receptor cells. J. Comp. Physiol. A 1998, 183: 153–164.
- Prestwich GD, Streinz L. Haloacetate analogs of pheromones: Effects on catabolism and electrophysiology in *Plutella xylostella*. J. Chem. Ecol. 1988, 14: 1003–1021.
- Priestley CM, Williamson EM, Wafford KA, Sattelle DB. Thymol, a constituent of thyme essential oil, is a positive allosteric modulator of human GABA receptors and a homo-oligomeric GABA receptor from *Drosophila melanogaster*. Br. J. Pharmacol. 2003, 140: 1363–1372.
- Prior C, Greathead DJ. Biological control of locusts: the potential for the exploitation of pathogens. FAO Plant Prot. Bull. 1989, 37: 37-48.
- Proffit M, Birgersson G, Bengtsson M, Reis R, Witzgall P, Lima E. Attraction and oviposition of *Tuta absoluta* females in response to tomato leaf volatiles. J. Chem. Ecol. 2011, 37: 565-574.

- Puigmartí M. Desenvolupament d'antagonistes de feromones sexuals per a un control biorracional de plagues d'insectes: Síntesi i activitat. Tesis Doctoral, Universitat de Barcelona. 2015.
- Pushpanathan T, Jebanesan A, Govindarajan M. The essential oil of *Zingiber officinalis* Linn (Zingiberaceae) as a mosquito larvicidal and repellent agent against the filarial vector *Culex quinquefasciatus* Say (Diptera: Culicidae). Parasitol. Res. 2008, 102: 1289-1291.
- Qiao HL, Deng P, Li DD, Chem M, Jiao ZJ, Liu ZC, Zhang YZ, Kan YC. Expression analysis and binding experiments of chemosensory proteins indicate multiple roles in *Bombyx mori*. J. Insect Physiol. 2013, 59: 667-675.
- Quero C, Bau J, Guerrero A, Renou M. Responses of the olfactory receptor neurons of the corn stalk borer *Sesamia nonagrioides* to components of the pheromone blend and their inhibition by a trifluoromethyl ketone analogue of the main component. Pest Manag. Sci. 2004, 60: 719-726.
- Quero C, Rosell G, Jiménez O, Rodríguez S, Bosch MP, Guerrero A. New fluorinated derivatives as esterase inhibitors. Synthesis, hydration and crossed specificity studies. Bioorg. Med. Chem. 2003, 11: 1047-1055.
- Quero C, Vidal B, Guerrero A. EAG responses increase of *Spodoptera littoralis* antennae after a single pheromone pulse. Nat. Prod. Commun. 2014, 9: 1099-1101.
- Quesada-Moraga E, Sánchez A, Santiago-Álvarez C. Diflubenzuron reduced the biotic potential of the Mediterranean locust *Dociostaurus maroccanus* (Thunberg, 1815). Bol. San. Veg. Plagas, 2000, 26: 113-118.
- Quesada-Moraga E, Santiago-Álvarez C. Rearing and breeding of the Moroccan locust *Dociostaurus maroccanus* (Thunberg) (Orthop., Acrididae) under laboratory conditions. J. Appl. Entomol. 2001, 125: 121-124.
- Rafaeli A. Revelations on the regulatory mechanisms in moth sex-pheromone signals. En: Management of Insect Pests to Agriculture, Czosnek H, Ghanim M (eds). Springer International, 2016: 115-129.
- Rafaeli A, Soroker V, Hirsch J, Kamensky B, Raina AK. The influence of photoperiod and age on the competence of pheromone glands and on the distribution of immunoreactive PBAN in *Helicoverpa spp.* Insect Biochem. Physiol. 1993, 22: 169-180.
- Rafiee-Dastjerdi H, Khorrami F, Hassanpour M. The toxicity of some medicinal plant extracts to the potato tuber moth, *Phthorimaea operculella* (Lepidoptera: Gelechiidae), Arch. Phytopathol. Plant Protect. 2014, 47: 1827-1831.
- Rafiee-Dastjerdi H, Khorrami F, Razmjou J, Esmaeilpour B, Golizadeh A, Hassanpour M. The efficacy of some medicinal plant extracts and essential oils against potato tuber moth, *Phthorimaea operculella* (Zeller) (Lepidoptera: Gelechiidae). J. Crop. Prot. 2013, 2: 93-99.

- Rafiei-Karahroodi Z, Moharramipour S, Farazmand H, Karimzadeh-Esfahani J. Insecticidal effect of six native medicinal plants essential oil on Indian meal moth, *Plodia interpunctella* Hübner (Lep.: Pyralidae). *Munis Entomol. Zool.* 2011, 6: 339-345.
- Raina AK. Selected factors influencing neurohormonal regulation of sex pheromone production in *Heliothis* species. *J. Chem. Ecol.* 1988, 14: 2063–2069.
- Raina AK. Neuroendocrine control of sex pheromone biosynthesis in Lepidoptera. *Annu. Rev. Entomol.* 1993, 38: 329-349.
- Raina AK, Kingan TG, Mattoo AK. Chemical signals from host plant and sexual behavior in a Moth. *Science* 1992, 255: 592-594.
- Ramachandran R, Khan ZR, Caballero P, Juliano BO. Olfactory sensitivity of two sympatric species of rice leaf folders (Lepidoptera: Pyralidae) to plant volatiles. *J. Chem. Ecol.* 1990, 16: 2647-2665.
- Ramírez JE, Gómez MI, Cotes JM, Núñez CE. Insecticidal effect of labiate essential oils on *Tecia solanivora* Povolny in laboratory. *Agron. Colomb.* 2010, 28: 255-263.
- Rao PV, Lu X, Standley M, Pattee P, Neelima G, Girish G, Dakshinamurthy KV, Roberts CT Jr., Nagalla SR. Proteomic identification of urinary biomarkers of diabetic nephropathy. *Diabetes Care* 2007, 30: 629-637.
- Reddy GV, Guerrero A. Behavioral responses of the diamondback moth, *Plutella xylostella*, to green leaf volatiles of *Brassica oleracea* subsp. *capitata*. *J. Agric. Food Chem.* 2000, 48: 6025–6029.
- Reddy GV, Guerrero A. Interactions of insect pheromones and plant semiochemicals. *Trends Plant Sci.* 2004, 9: 253-261.
- Reddy GV, Guerrero A. New Pheromones and Insect Control Strategies. En: *Vitamins & Hormones, Pheromones*, Litwack G (eds). Elsevier Inc., Oxford, U.K. 2010, 83: 493-519.
- Regnault-Roger C, Hamraoui A. Fumigant toxic activity and reproductive inhibition induced by monoterpenes on *Acanthoscelides obtectus* (Say) (Coleoptera), a bruchid of kidney bean (*Phaseolus vulgaris* L.). *J. Stored Prod. Res.* 1995, 31: 291-299.
- Regnault-Roger C, Hamraoui A, Holeman M, Theron E, Pinel R. Insecticidal effect of essential oils from Mediterranean plants upon *Acanthoscelides obtectus* Say (Coleoptera, Bruchidae), a pest of kidney bean (*Phaseolus vulgaris* L.). *J. Chem. Ecol.* 1993, 19: 1233-1244.
- Regnault-Roger C, Vincent C, Arnanson JT. Essential oils in insect control: low-risk products in a high-stakes world. *Annu. Rev. Entomol.* 2012, 57:405-424.
- Renou M, Berthier A, Guerrero A. Disruption of responses to pheromone by (Z)-11-hexadecenyl trifluoromethyl ketone, an analogue of the pheromone, in the cabbage armyworm *Mamestra brassicae*. *Pest Manag. Sci.* 2002, 58: 839-844.

- Renou M, Guerrero A. Insect parapheromones in olfaction research and semiochemical-based pest control strategies. *Annu. Rev. Entomol.* 2000, 45: 605-630.
- Renou M, Lucas P, Malo E, Quero C, Guerrero A. Effects of trifluoromethyl ketones and related compounds on the EAG and behavioural responses to pheromones in male moths. *Chem. Senses*, 1997, 22: 407-416.
- Renwick JAA, Chew FS. Oviposition behavior in Lepidoptera. *Annu. Rev. Entomol.* 1994, 34: 377-400.
- Reyes H, Arzuffi R, Robledo N. Effects of male age and mating status on response to the female sex pheromone of *Copitarsia decolora* (Lepidoptera: Noctuidae). *Fla. Entomol.* 2015, 98: 47-51.
- Riba M, Eizaguirre M, Sans A, Quero C, Guerrero, A. Inhibition of pheromone action in *Sesamia nonagrioides* by haloacetate analogues. *Pestic. Sci.* 1994, 41: 97-103.
- Riba M, Sans A, Bau P, Grolleau G, Renou M, Guerrero A. Pheromone response inhibitors of the corn stalk borer *Sesamia nonagrioides*. Biological evaluation and toxicology. *J. Chem. Ecol.* 2001, 27: 1879-1897.
- Riba M, Sans A, Solé J, Muñoz L, Bosch MP, Rosell G, Guerrero A. Antagonism of pheromone response of *Ostrinia nubilalis* males and implications on behavior in the laboratory and in the field. *J. Agric. Food Chem.* 2005, 53: 1158-1165.
- Ribeiro RC, Zanuncio TV, Ramalho FS, da Silva CAD, Serrao JE, Zanuncio JC. Feeding and oviposition of *Anticarsia gemmatalis* (Lepidoptera: Noctuidae) with sublethal concentrations of ten condiments essential oils. *Ind. Crops Prod.* 2015, 74: 139-143.
- Riddiford LM, Williams CM. Chemical signalling between *Polyphemus* moths and between moths and host plant. *Science* 1967, 156:541.
- Riddiford LM, Williams CM. Volatile principle from oak leaves: Role in sex life of the *Polyphemus* moths. *Science* 1967, 155: 589-590.
- Rizwan-ul-Haq M, Aljabr AM. *Rhynchophorus ferrugineus* midgut cell line to evaluate insecticidal potency of different plant essential oils. *In Vitro Cell. Dev. Biol. Anim.* 2015, 51: 281-286.
- Roelofs WL, Comeau A. Sex pheromone perception: Synergists and inhibitors for the red-banded leaf roller attractant. *J. Insect. Physiol.* 1971, 17: 435-448.
- Roessingha P, Bouaïchib A, Simpson SJ. Effects of sensory stimuli on the behavioural phase state of the desert locust, *Schistocerca gregaria*. *J. Insect Physiol.* 1998, 44: 883-893.
- Rogers ME, Krieger J, Vogt RG. Antennal SNMPs (sensory neuron membrane proteins) of Lepidoptera define a unique family of invertebrate CD36-like proteins. *J. Neurobiol.* 2001a, 49: 47-61.

- Rogers ME, Steinbrecht RA, Vogt RG. Expression of SNMP-1 in olfactory neurons and sensilla of male and female antennae of the silkworm *Antheraea polyphemus*. *Cell Tissue Res.* 2001b, 303: 433-446.
- Rontani JF, Acquaviva M. The aerobic bacterial metabolism of phytol in seawater: temperature dependence of an abiotic intermediate step and its consequences. *Chemosphere*, 1993, 26: 1513-1525.
- Rontani JF, Bonin PC, Volkman JK. Biodegradation of free phytol by bacterial communities isolated from marine sediments under aerobic and denitrifying conditions. *Appl. Environ. Microbiol.* 1999, 65: 5484-5492.
- Rosell G, Herrero S, Guerrero A. New trifluoromethyl ketones as potent inhibitors of esterases. <sup>19</sup>F NMR spectroscopy of transition state analog complexes and structure-activity relationships. *Biochem. Biophys. Res. Commun.* 1996, 226: 287-292.
- Rosell G, Quero C, Coll J, Guerrero A. Biorational insecticides in pest management. *J. Pest. Sci.* 2008, 33: 103-121.
- Rota MC, Herrera A, Martínez RM, Sotomayor JA, Jordán MJ. Antimicrobial activity and chemical composition of *Thymus vulgaris*, *Thymus zizis* and *Thymus hyemalis* essential oils. *Food Contr.* 2008, 19: 681-687.
- Rothschild GHL, Vickers RA. Biology, ecology and control of the Oriental fruit moth. En *Tortricid pests: Their biology, natural enemies and control*. Van der Geest, LPS, Evenhuis, HH (eds). Elsevier, 1991, 5: 389-412.
- Ryan MF, Byrne O. Plant-insect coevolution and inhibition of acetylcholineesterase. *J. Chem. Ecol.* 1988, 14: 1965-1975.
- Rybczynski R, Reagan J, Lerner MR. A pheromone-degrading aldehyde oxidase in the antennae of the moth *Manduca sexta*. *J. Neurosci.* 1989, 9: 1341-1353.
- Rybczynski R, Vogt RG, Lerner MR. Antennal-specific pheromone-degrading aldehyde oxidases from the moths *Antheraea polyphemus* and *Bombyx mori*. *J. Bio. Chem.* 1990, 265: 19712-19715.
- Sabatier L, Jouanguy E, Dostert C, Zachary D, Dimarcq JL, Bulet P, Imler JL. Pherokine-2 and -3. *Eur. J. Biochem.* 2003, 270: 3398-3407.
- Sahayaraj K. Antifeedant effect of some plant extracts on the Asian armyworm, *Spodoptera litura* (Fabricius). *Curr. Sci.* 1998, 74: 523-525.
- Salas J. Captura de *Tuta absoluta* (Lepidoptera: Gelechiidae) en trampas cebadas con su feromona sexual. *Rev. Colomb. Entomol.* 2004, 30: 75-78.
- Sánchez-Vioque R, Izquierdo-Melero ME, Polissiou M, Astraka K, Tarantilis PA, Herraiz-Peñalver D, Martín-Bejarano M, Santana-Méridas O. Comparative chemistry and biological properties of



- the solid residues from hydrodistillation of Spanish populations of *Rosmarinus officinalis* L. *Grasas y Aceites* 2015, 66: e079.
- Sans A, Gago R, Mingot A, García W, Bosch D, Coll J, Rosell G, Bosch MP, Riba M, Guerrero, A. Electrophilic derivatives antagonise pheromone attraction in *Cydia pomonella*. *Pest Manag. Sci.* 2013, 69: 1280-1290.
- Saveer AM, Kromann SH, Birgersson G, Bengtsson M, Lindblom T, Balkenius A, Hansson BS, Witzgall P, Becher PG, Ignell R. Floral to green: Mating switches moth olfactory coding and preference. *Proc. R. Soc. Lond. B. Sci.* 2016, 279: 2314–2322.
- Schneider D. Elektrophysiologische Untersuchungen von Chemo-und Mechanorezeptoren der Antenne des Seidenspinners *Bombyx mori* L. *J. Comp. Physiol. A*, 1957, 40: 8-41.
- Schneider D, Schulz S, Priesner E, Ziesmann J, Francke W. Autodetection and chemistry of female and male pheromone in both sexes of the tiger moth *Panaxia quadripunctaria*. *J. Comp. Physiol. A* 1998, 182: 153-161.
- Schulz S, Yildizhan S, Van Loon JJ. The biosynthesis of hexahydrofarnesylacetone in the butterfly *Pieris brassicae*. *J. Chem. Ecol.* 2011, 37: 360-363.
- Sciarretta A, Trematerra P. Geostatistical characterization of the spatial distribution of *Grapholita molesta* and *Anarsia lineatella* males in an agricultural landscape. *J. Appl. Entomol.* 2006, 130: 73-83.
- Sharaby A, El-Nojiban A. Evaluation of some plant essential oils against the black cutworm *Agrotis ipsilon*. *Glob. J. Adv. Res.* 2015, 2: 701-711.
- Sharaby A, Rahman HA, Abdel-Aziz S, Moawad SS. Natural plant oils and terpenes as protector for the potato tubers against *Phthorimaea operculella* infestation by different application methods. *Ecol. Balkan.* 2014, 6: 45-59.
- Shearer PW, Usmani KA. Sex-related response to organophosphorus and carbamate insecticides in adult Oriental fruit moth, *Grapholita molesta*. *Pest Manag. Sci.* 2001, 57: 822-826.
- Shi WP, Sun HL, Edward N, Yan YH. Fecal volatile components elicit aggregation in the Oriental migratory locust, *Locusta migratoria manilensis* (Orthoptera: Acrididae). *Insect Sci.* 2011, 18: 166-174.
- Shi W, Yan Y, Zhang L, Wang X. Attraction of fecal volatile of Oriental migratory locust for the aggregation of its nymphs. *J. China Agric. Univ.* 2000, 5: 54-58.
- Shu S, Grant GG, Langevin D, Lombardo DA, MacDonald L. Oviposition and electroantennogram responses of *Dioryctria abietivorella* (Lepidoptera: Pyralidae) elicited by monoterpenes and enantiomers from eastern white pine. *J. Chem. Ecol.* 1997, 23: 35–50.

- Silva GA, Picanço MC, Bacci L, Crespo ALB, Rosado JF, Guedes RN. Control failure likelihood and spatial dependence of insecticide resistance in the tomato pinworm, *Tuta absoluta*. *Pest Manag. Sci.* 2011, 67: 913-920.
- Siqueira HAA, Guedes RNC, Fragoso DB, Magalhaes LC. Abamectin resistance and synergism in Brazilian populations of *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae). *Int. J. Pest Manag.* 2001, 47: 247-251.
- Slifer EH, Prestag JJ, Beams HW. The chemoreceptors and other sense organs on the antennal flagellum of the grasshopper (Orthoptera; Acrididae). *J. Morphol.* 1959, 105: 145-191.
- Smith DP. Odor and pheromone detection in *Drosophila melanogaster*. *Pflugers Arch.* 2007, 454: 749-758.
- Smith R. Two-dimensional electrophoresis: an overview. En *Two-Dimensional Electrophoresis Protocols. Methods in Molecular Biology (Methods and Protocols)*. Tyther R, Sheehan D (eds.). Humana Press. 2009, 2-17.
- Solé J, Sans A, Riba M, Rosell G, Rosa E, Muñoz L, Bosch MP, Guerrero A. Differential activity of non-fluorinated and fluorinated analogues of the European corn borer pheromone. *Chemoecology* 2008a, 18: 99-108.
- Solé J, Sans A, Riba M, Rosa E, Bosch MP, Barrot M, Palencia J, Castellà J, Guerrero A. Reduction of damage by the Mediterranean corn borer, *Sesamia nonagrioides*, and the European corn borer, *Ostrinia nubilalis*, in maize fields by a trifluoromethyl ketone pheromone analog. *Entomol. Exp. Appl.* 2008b, 126: 28-39.
- Song YQ, Dong JF, Qiao HL, Wu JX. Molecular characterization, expression patterns and binding properties of two pheromone-binding proteins from the Oriental fruit moth, *Grapholita molesta* (Busck). *J. Integr. Agric.* 2014, 13: 2709-2720.
- Soques S, Vazquez GM, Grozinger CM, Gould F. Age and mating status do not affect transcript levels of odorant receptor genes in male antennae of *Heliothis virescens* and *Heliothis subflexa*. *J. Chem. Ecol.* 2010, 36: 1226-1233.
- Sousa RMO, Rosa JS, Oliveira L, Cunha A, Fernandes-Ferreira M. Activities of Apiaceae essential oils against armyworm, *Pseudaletia unipuncta* (Lepidoptera: Noctuidae). *J. Agric. Food Chem.* 2013, 61: 7661-7672.
- Steinbrecht RA, Laue M, Ziegelberger G. Immunolocalization of pheromone-binding protein and general odorant binding protein in olfactory sensilla of the silk moths *Antheraea* and *Bombyx*. *Cell Tissue Res.* 1995, 282: 203-217.
- Stelinski L, Holdcraft R, Rodriguez-Saona C. Female moth calling and flight behavior are altered hours following pheromone autodetection: Possible implications for practical management with mating disruption. *Insects* 2014, 5: 459-473.

- Stelinski LL, IL'ichev AL, Gut LJ. Antennal and behavioral responses of virgin and mated Oriental fruit moth (Lepidoptera: Tortricidae) females to their sex pheromone. *Ann. Ent. Soc. Am.* 2006, 99: 898-904.
- Stjernholm F, Karlsson B. Nuptial gifts and the use of body resources for reproduction in the green-veined white butterfly *Pieris napi*. *Proc. R. Soc Lond. B. Biol. Sci.* 2000, 267: 807–811.
- Su CY, Menuz K, Carlson JR. Olfactory perception: Receptors, cells, and circuits. *Cell*, 2009, 139: 45-59.
- Sun X, Liu Z, Dong H, Zeng F, Pan X, Wang Y, Wang M. Electrophysiological responses of the rice leaffolder, *Cnaphalocrocis medinalis*, to rice plant volatiles. *J. Insect Sci.* 2014, 14: 1-14.
- Sun YL, Wang CZ, Pelosi P, Huang LQ. Expression in antennae and reproductive organs suggests a dual role of an odorant-binding protein in two sibling *Helicoverpa species*. *PLoS ONE* 2012, 7: e30040.
- Tak JH, Jovel E, Isman MB. Contact, fumigant, and cytotoxic activities of thyme and lemongrass essential oils against larvae and an ovarian cell line of the cabbage looper, *Trichoplusia ni*. *J. Pest Sci.* 2016, 89: 183-193.
- Thiéry D, Moreau J. Relative performance of European grapevine moth (*Lobesia botrana*) on grapes and other hosts. *Oecologia* 2005, 143: 548-557.
- Tingle FC, Mitchell ER. Aqueous extracts from indigenous plants as oviposition deterrents for *Heliothis virescens* (F.). *J. Chem. Ecol.* 1984, 10: 101-113.
- Torres JB, Faria CA, Evangelista WS, Pratisoli D. Within-plant distribution of the leaf miner *Tuta absoluta* (Meyrick) immatures in processing tomatoes, with notes on plant phenology. *Int. J. Pest Manag.* 2001, 47: 173-178.
- Torto B, Njagi PG, Hassanali A, Amiani H. Aggregation pheromone system of nymphal gregarious desert locust, *Schistocerca gregaria* (Forskål). *J. Chem. Ecol.* 1996, 22: 2273-2281.
- Torto B, Obeng-Ofori D, Njagi PG, Hassanali A, Amiani H. Aggregation pheromone system of adult gregarious desert locust *Schistocerca gregaria* (Forskål). *J. Chem. Ecol.* 1994, 20: 1749-1762.
- Touhara K, Prestwich G. Juvenile hormone epoxide hydrolase. Photoaffinity labeling, purification and characterization from tobacco hornworm eggs. *J. Biol. Chem.* 1993, 268: 19604-19609.
- Trimble RM, Pree DJ, Carter NJ. Integrated control of Oriental fruit moth (Lepidoptera: Tortricidae) in peach orchards using insecticide and mating disruption. *J. Econ. Entomol.* 2001, 94: 476-485.
- Ukeh DA. Bioactivities of essential oils of *Aframomum melegueta* and *Zingiber officinale* both (Zingiberaceae) against *Rhyzoverpa dominica* (Fabricius). *J. Entomol.* 2008, 5: 193-199.

- Ukeh DA, Birkett MA, Pickett JA, Bowman AS, Mordue AJ. Repellent activity of alligator pepper, *Aframomum melegueta*, and ginger, *Zingiber officinale*, against the maize weevil, *Sitophilus zeamais*. *Phytochemistry* 2009 70: 751-758.
- Umpiérrez ML, Lagreca ME, Cabrera R, Grille G, Rossini C. Essential oils from Asteraceae as potential biocontrol tools for tomato pests and diseases. *Phytochem. Rev.* 2012, 11: 339-350.
- Urbaneja A, Montón H, Mollá O. Suitability of the tomato borer *Tuta absoluta* as prey for *Macrolophus pygmaeus* and *Nesidiocoris tenuis*. *J. Appl. Entomol.* 2009, 133: 292-296.
- Usmani KA, Shearer PW. Susceptibility of male Oriental fruit moth (Lepidoptera: Tortricidae) populations from New Jersey apple orchards to azinphosmethyl. *J. Econ. Entomol.* 2001, 94: 233-239.
- Vacas S, Alfaro C, Primo J, Navarro-Llopis V. Studies on the development of a mating disruption system to control the tomato leafminer, *Tuta absoluta* Povolny (Lepidoptera: Gelechiidae). *Pest Manag. Sci.* 2011, 67: 1473-1480.
- Van der Pers JNC. *Electroantennography: A Practical Introduction*. Syntech Inc., Hilversum, The Netherlands. 1998.
- Varela N, Avilla J, Anton S, Gemeno C. Synergism of pheromone and host-plant volatile blends in the attraction of *Grapholita molesta* males. *Entomol. Exp. Appl.* 2011, 141: 114-122.
- Vercauteren FGG, Arckens L, Quirion R. Applications and current challenges of proteomic approaches, focusing on two-dimensional electrophoresis. *Amino acids* 2007, 33: 405-414.
- Visser JH. Host odor perception in phytophagous insects. *Annu. Rev. Entomol.* 1986, 31: 121-144.
- Vogel H, Heidel AJ, Heckel DG, Groot AT. Transcriptome analysis of the sex pheromone gland of the noctuid moth *Heliothis virescens*. *BMC Genomics*, 2010, 11:29-50.
- Vogt RG. Biochemical diversity of odor detection: OBPs, ODEs and SNMPs. En: *Insect Pheromone Biochemistry and Molecular Biology*. Blomquist G & Vogt R (eds.). London: Elsevier Academic Press. 2003: 391-445.
- Vogt RG, Prestwich GD, Lerner MR. Odorant-binding-protein subfamilies associate with distinct classes of olfactory receptor neurons in insects. *J. Neurobiol.* 1991, 22: 74-84.
- Vogt RG, Riddiford LM. Pheromone binding and inactivation by moth antennae. *Nature*, 1981, 293: 161-163.
- Vogt RG, Riddiford LM, Prestwich GD. Kinetic properties of a pheromone degrading enzyme: the sensillar esterase of *Antheraea polyphemus*. *Proc. Natl. Acad. Sci. USA* 1985, 82: 8827-8831.
- Vogt RG, Rogers ME, Franco MD, Sun M. A comparative study of odorant-binding protein genes: differential expression of the PBP1-GOBP2 gene cluster in *Manduca sexta* (Lepidoptera)

- and the organization of OBP genes in *Drosophila melanogaster* (Diptera). *J. Exp. Biol.* 2002, 205: 719-744.
- Waliwitiya R, Belton P, Nicholson RA, Lowenberger CA. Effects of the essential oil constituent thymol and other neuroactive chemicals on flight motor activity and wing beat frequency in the blowfly *Phaenicia sericata*. *Pest Manag. Sci.* 2010, 66: 277-289.
- Wee SL, Oh HW, Park KC. Antennal sensillum morphology and electrophysiological responses of olfactory receptor neurons in trichoid sensilla of the diamondback moth (Lepidoptera: Plutellidae). *Florida Entomol.* 2016, 99: 146-158.
- Wiedemann J, Heiner T, Mloston G, Srya Prakash GK, Olah GA. Direct preparation of trifluoromethyl ketones from carboxylic esters: trifluoromethylation with (trifluoromethyl)trimethylsilane. *Angew. Chem. Int. Ed.* 1998, 37: 820-821.
- Wisniewski JR. Quantitative evaluation of filter aided sample preparation (FASP) and multienzyme digestion FASP protocols. *Anal. Chem.* 2016, 88: 5438-5443.
- Wisniewski JR, Zougman A, Nagaraj N, Mann M. Universal sample preparation method for proteome analysis. *Nat. Methods* 2009, 6: 359-362.
- Witzgall P, Kirsch P, Cork A. Sex pheromones and their impact on pest management. *J. Chem. Ecol.* 2010, 36: 80-100.
- Xu P, Hooper AM, Pickett JA, Leal WS. Specificity determinants of the silkworm moth sex pheromone. *PLoS ONE*, 2012, 7: e44190.
- Yamane T, Yasuda T. The effects of mating status and time since mating on female sex pheromone levels in the rice leaf bug, *Trigonotylus caelestialium*. *Naturwissenschaften* 2014, 101: 153-156.
- Yang K, Liu Y, Wei D, Li F, Wang GR, Dong SL. Identification of novel odorant binding protein genes and functional characterization of OBP8 in *Chilo suppressalis* (Walker). *Gene*, 2016, 591: 425-432.
- Yang YQ, Gao XH, Zhang YZ, Zhang LW, Wan XC. Comparative mating strategies of male and female *Ectropis oblique* (Lepidoptera: Geometridae). *Fla. Entomol.* 2011, 94: 9-14.
- Yang Z, Bengtsson M, Witzgall P. Host plant volatiles synergize response to sex pheromone in codling moth, *Cydia pomonella*. *J. Chem. Ecol.* 2004, 30: 619-629.
- Yazdani E, Sendi JJ, Aliakbar A, Senthil-Nathan S. Effect of *Lavandula angustifolia* essential oil against lesser mulberry pyralid *Glyphodes pyloalis* Walker (Lep: Pyralidae) and identification of its major derivatives. *Pest. Biochem. Physiol.* 2013, 107: 250-257.
- Yildizhan S, van Loon J, Sramkova A, Ayasse M, Arsene C, ten Broeke C, Schulz S. Aphrodisiac pheromones from the wings of the small cabbage white and large cabbage white butterflies, *Pieris rapae* and *Pieris brassicae*. *ChemBioChem* 2009, 10: 1666-1677.

- Zhang DD, Wang HL, Schultze A, Frob H, Francke W, Krieger J, Löfstedt C. Receptor for detection of a Type II sex pheromone in the winter moth *Operophtera brumata*. *Sci. Rep.* 2016, 6: e1857.
- Zhang GH, Li YP, Xu XL, Chen H, Wu JX. Identification and characterization of two general odorant binding protein genes from the Oriental fruit moth, *Grapholita molesta* (Busck). *J. Chem. Ecol.* 2012a, 38: 427-436.
- Zhang GH, Liu YF, Wu JX. cDNA cloning, sequence analysis and prokaryotic expression of a chemosensory protein from the oriental fruit moth, *Grapholita molesta* (Lepidoptera: Tortricidae). *Kun Chong Xue Bao* 2012b, 55: 668-675.
- Zhang QR, Xu WH, Chen FS, Li S. Molecular and biochemical characterization of juvenile hormone epoxide hydrolase from the silkworm, *Bombyx mori*. *Insect Biochem. Mol. Biol.* 2005, 35: 153-164.
- Zhang YN, Ye ZF, Yang K, Dong SL. Antenna-predominant and male-biased CSP19 of *Sesamia inferens* is able to bind the female sex pheromones and host plant volatiles. *Gene* 2014, 536: 279–286.
- Zhang ZQ. Animal biodiversity: An introduction to higher-level classification and taxonomic richness. *Zootaxa* 2011, 3148: 7–12.
- Zhang ZQ. Phylum Arthropoda. En: *Animal Biodiversity: an outline of higher-level classification and survey of taxonomic richness*, Zhang ZQ (eds). *Zootaxa* 2013, 3703: 17-26.

