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SPECIAL ISSUE – IMPROVING PEST CONTROL:
MASS REARING AND FIELD PERFORMANCE

Improving pest control: mass rearing and field performance – an introduction

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Insects are the new livestock. They are increasingly being used for food, feed, and pest control. Humans have been breeding cattle and poultry to increase their size or egg and milk production for centuries. Methods to improve the performance of livestock can be roughly divided as genetics-based or environment-induced. For example, artificial selection is a genetic method that has been extensively used by livestock breeders to increase yields, such as meat production. It refers to selecting only those individuals to breed the next generation that show a certain desired trait. Nutrient fortification of diet is an example of an environmental factor that can improve livestock performance. In contrast to the enormous efforts and successes in improving methodology for breeding traditional livestock, such approaches have hardly been successful to increase the efficiency of insects in pest control. But articles in this special issue on pest control reveal that times are finally changing.

More types of organisms are being used for pest control, such as mites, fungi, and bacteria, but insects have a long tradition of being exploited for biological control, going back to 304 AD (Huang & Yang, 1987). Most articles in this issue deal with parasitoid wasps, the main insect group used to control pests. However, this issue also contains articles about herbivorous thrips that are being applied to fight invasive weeds. Also featured in this issue is a field closely related to biological control, the sterile insect technique (SIT). SIT controls pest infestations through mass release of sterilised males that outcompete natural males of a pest species. Like biocontrol, it requires knowledge of the genetics, physiology and behaviour of the insect. The two practices also both involve mass rearing and field performance monitoring.

All insects carry a diversity of microorganisms in their body, collectively referred to as their microbiome. There is an increasing realisation that the microbiome affects many important life-history characteristics of their insect carriers. This means that there is enormous potential in exploiting and manipulating the insect microbiome for improving biological control agents. With reference to the opening sentence of this introduction, insects can therefore be considered as the new *mini* livestock and their microbiome as the new *micro* livestock. The 14 papers in this issue present a variety of novel approaches for exploiting genetic and environmental factors to improve insect control agents.

Lommen et al. (2017) begin this issue with a mini-review on how genetic variation within species may be exploited by selecting for genotypes that potentially improve traits of interest for pest control. It requires knowledge of the genetic basis and heritability of insect life-history traits that affect their rearing and performance. Recent advances in genome science and genome-editing techniques make it possible to link genes to traits, and thus identify what we might call 'biological control genes'. These are genes that code for traits significant to biological control, such as host specificity and desiccation resistance. Cui et al. (2017) review the application of the CRISPR gene-editing technique in insect functional genomics studies. Although still in its infancy and not without ethical issues, this technique is currently revolutionising medical science and will undoubtedly also find its application in the biological control industry.

Sánchez-Rosario et al. (2017) apply artificial selection to increase mating competitiveness of *Anastrepha ludens* (Loew) (Diptera: Tephritidae) for SIT application. They find that selection for improved mating success may trade off with fecundity and survival, calling for careful management and balancing of traits when practising such strategies. Clarke et al. (2017) highlight the importance of paying closer attention to the variability within host species. They find strong differences in the parasitism success of the parasitoid *Aphidius ervi* Haliday (Hymenoptera: Braconidae) on genetically distinct clonal lines of the potato aphid *Macrosiphum euphorbiae* Thomas (Hemiptera: Aphididae). Additionally, in contrast to previous studies that found endosymbiont-induced resistance, the *Hamiltonella* and *Regiella* of their *Macrosiphum* lines appear to provide little protection against parasitism.

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Optimisation of mass rearing procedures is an important goal in insect control industry. Rearing conditions need to be as economical as possible and yield large numbers of individuals that are physically robust and, in case of SIT, competitive for mates upon release. In the context of improving pest control by SIT, Mudavanhu et al. (2017) test effects of mass rearing conditions and gamma irradiation on the mating behaviour of the sugarcane stalk borer, *Eldana saccharina* Walker (Lepidoptera: Pyralidae). Bloomfield et al. (2017) conduct a similar study on Queensland fruitfly, *Bactrocera tryoni* (Froggatt) (Diptera: Tephritidae). These studies reveal that proper irradiation dose is a delicate balance between effective sterilisation and negative effects on performance.

Rearing and performance of biocontrol agents are affected by diet. Diet effects may occur directly via food fed to the agent. However, they can also occur through indirect means, such as when a host species used as a food source is changed in some way that alters its nutritional value to the agent. Lahiri et al. (2017) offer different carbohydrate diets to the egg parasitoid *Telenomus podisi* Ashmead (Hymenoptera: Platigastridae) in an attempt to determine its nutritional requirements. Masoumzadeh et al. (2017) show that enzyme inhibitors exert adverse effects on the development of the pest species *Plodia interpunctella* (Hübner) (Lepidoptera: Pyralidae), but these effects do not extend to its control agent *Habrobracon hebetor* Say (Hymenoptera: Braconidae). Yao et al. (2017) report that the mating competitiveness of *Bactrocera cucurbitae* (Coquillett) (Diptera: Tephritidae) genetic sexing strain (being used for SIT) can be improved by adding probiotics (*Enterobacter* sp.) to the larval diet.

To prevent adverse effects on the native fauna, field releases of potential biological control agents are becoming more and more stringent. Therefore, host range testing of non-native agents to evaluate their potential to attack native hosts is of utmost importance. Wheeler et al. (2017) conclude that the thrips *Pseudophilothrips ichini* (Hood) (Thysanoptera: Phlaeothripidae) can be safely used to control the Brazilian peppertree, *Schinus terebinthifolia* Raddi (Anacardiaceae) in North America and Hawaii. When designing a new biocontrol programme, possible interference with other agents must also be considered. Dao et al. (2017) test whether varying densities of five parasitoids and one predator of the red scale *Aonidiella aurantii* (Maskell) (Hemiptera: Diaspididae) in Australian citrus orchards affect their control efficiency. Ramanand et al. (2017) measure the thermal tolerance of the thrips *Liothrips tractabilis* Mound & Pereyra (Thysanoptera: Phlaeothripidae), a biological control agent of pompom weed, *Campuloclinium macrocephalum* (Less.) DC. (Asteraceae), that has recently become invasive in South Africa. By combining this information with climatic data, predictions can be made about whether the biocontrol agent can establish in a specific environment.

Field performance is the ultimate stage in pest control strategies and agents need to be monitored post-release. Results obtained in the laboratory may not always translate directly to field conditions. Manoukis et al. (2017) measure survivorship of male and female *Bactrocera dorsalis* Hendel (Diptera: Tephritidae) in the field in the context of the male annihilation technique, the use of baits containing a male lure combined with an insecticide. Martinez-Ferrer & Campos-Rivela (2017) develop sampling methods for ant distribution and abundance to assess their utility in integrated pest management programmes in citrus groves. These studies provide data specific to these agent species, and also inform on methodology for measuring field performance of other agents.

Collectively, the articles in this special issue reflect important progress in insect control research. It is time that insects are seen as modern livestock that can be improved not only with breeding methods that humans have been using for centuries in agriculture but also by exploiting novel genomic and genome-editing techniques. At the same time, there remains a clear need for research on ecological and environmental factors that affect rearing and the performance of control agents under field conditions.

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References

Bloomfield CIA, Fanson BG, Mirrington R, Gillespie PS & Dominiak BC (2017) Optimizing irradiation dose in mass-produced Queensland fruit fly, *Bactrocera tryoni*: the incorporation of residual effects of irradiation dose on F_1 progeny. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12538.

Clarke HV, Cullen D, Hubbard SF & Karley AJ (2017) Susceptibility of *Macrosiphum euphorbiae* to the parasitoid *Aphidius ervi*: larval development depends on host aphid genotype. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12516.

Cui Y, Sun J-L & Yu L (2017) Application of the CRISPR gene-editing technique in insect functional genome studies – a review. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12530.

Dao HT, Meats A, Beattie GAC & Spooner-Hart R (2017) Mortality on fruit in citrus orchards caused by natural enemies of red scale *Aonidiella aurantii*: relation to spatial distribution of patch density and season. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12525.

Huang HT & Yang P (1987) The ancient cultured citrus ant. BioScience 37: 665–671.

Lahiri S, Orr D, Cardoza YJ & Sorenson C (2017) Longevity and fecundity of the egg parasitoid *Telenomus podisi* provided with different carbohydrate diets. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12531.

Lommen STE, de Jong PW & Pannebakker BA (2017) It is time to bridge the gap between exploring and exploiting: prospects for utilizing intraspecific genetic variation to optimise arthropods for augmentative pest control – a review. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12510.

Manoukis NC, Jang EB & Dowell RV (2017) Survivorship of male and female *Bactrocera dorsalis* in the field and the effect of male annihilation technique. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12536.

Martinez-Ferrer MT & Campos-Rivela JM (2017) Diversity, spatial distribution, and sampling for ant management decision-making in integrated pest management programs in citrus groves. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12535.

Masoumzadeh A, Hosseininaveh V & Ghamari M (2017) Impact of carbohydrase inhibition on *Habrobracon hebetor* in a tritrophic diet-host-parasitoid system. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12537.

Mudavanhu P, Addison P & Conlong DE (2017) Effect of mass rearing and gamma irradiation on the mating behaviour of *Eldana saccharina*. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12489.

Ramanand H, McConnachie AJ & Olckers T (2017) Thermal tolerance of *Liothrips tractabilis*, a biological control agent of *Campuloclinium macrocephalum* recently established in South Africa. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12528.

Sánchez-Rosario M, Pérez-Staples D, Toledo J, Valle-Mora J & Liedo P (2017) Artificial selection on mating competitiveness of *Anastrepha ludens* for sterile insect technique application. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12540.

Wheeler GS, Manrique V, Overholt WA, McKay F & Dyer K (2017) Quarantine host range testing of *Pseudophilothrips ichini*, a potential biological control agent of Brazilian peppertree, *Schinus terebinthifolia*, in North America and Hawaii. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12506.

Yao M, Wang D, Gu X, Huang J & Ji Q (2017) Enhanced fitness of a *Bactrocera cucurbitae* genetic sexing strain based on the addition of gut-isolated probiotics (*Enterobacter* sp.) to the larval diet. Entomologia Experimentalis et Applicata 162: doi:10.1111/eea.12529.