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References

- Buckman, K. A., Campbell, J. F. and B. Subramanyam, 2013: Tribolium castaneum (Coleoptera: Tenebrionidae) associated with rice mills: fumigation efficacy and population rebound. Journal of Economic Entomology 106, 499-512.
- CARVALHO, M. O., FARO, A. and B. SUBRAMANYAM, 2013: Insect population distribution and density estimates in a large rice mill in Portugal. Journal of Stored Products Research 52, 48-56.
- CAMPBELL, J. F. and R. T. ARBOGAST, 2004: Stored-product insects in a flour mill: population dynamics and response to fumigation treatments. Entomologia Experimentalis et Applicata 112, 217-225.
- CAMPBELL, J. F. and M. A. MULLEN, 2004: Distribution and dispersal behavior of *Trogoderma variabile* and *Plodia interpunctella* outside a food processing plant. Journal of Economic Entomology 97, 1455-1464.
- TOEWS, M. D., CAMPBELL, J. F., ARTHUR, F. H. and S. B. RAMASWAMY: 2006. Outdoor flight activity and immigration of *Rhyzopertha dominica* into seed wheat warehouses. Entomologia Experimentalis et Applicata 121, 73-85.

From stored-product psocids to the other pests: the developments, problems and prospects on research and application of molecular identification

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Abstract

Psocids, beetles, moths and mites are regarded as the common kinds of stored-product pests in the world. The rapid and correct identification of stored-product pests is significant for quarantine, monitoring and control purposes. Molecular methods and techniques have been studied and applied for stored-product pest identification. Based on collection and analysis of literature in the last decade, this paper reviews the developments, questions and prospects for molecular identification of stored-product pests. As a representative model, the molecular methods and techniques for species identification of stored-product pests. As a representative model, the molecular methods and techniques for species identification involving China, Czech Republic, the United States and other countries. More than 10 studies on stored-product psocids related to RFLP, DNA barcoding, PCR, real-time PCR and gene chip have been published during this decade. Subsequently, DNA barcoding, PCR and real-time PCR techniques for the identification of common species of *Tribolium* and *Cryptolestes* pests DNA Barcode Identification System (GPDBIS) has been established in China using SOL SERVER and C#. Like a marathon that requires persistence, we should do our best to continue to promote research and application of molecular identification of stored-product pasts must be application.

Keywords: stored-product pests, molecular identification, review, research, application

Globally, stored-product arthropod pests include a large number of species. The rapid and correct identification of stored-product pests is significant for quarantine, monitoring and control purposes. In recent decades, molecular methods and techniques have been studied and applied for stored-product pest identification. There is quite a substantial amount of literature related to stored-product pests and their molecular identification. In this work, literature from 1900 to 2017 was collected and analyzed using Web of Science (http://apps.webofknowledge.com/). The total count of articles on stored-product pests was found to be 32,123 whereas the total count of articles on molecular identification of stored-product pests was 179. The years with the highest counts for these two categories were 2015 and 2012, respectively. In decreasing order, countries with the most contributions to literature on stored-product insect pests were USA, China, UK and India (Figure 1).



Fig. 1 The top 10 contributors to literature on stored-product pests and molecular identification. A: top 10 years of stored-product pest literature, B: top 10 countries contributing to stored-product pest literature, C: top 10 years of literature on molecular identification of stored-product pests, D: top 10 countries contributing to literature on molecular identification of stored-product pests.

Psocids, beetles, moths and mites are the common kinds of stored-product pests. From the number of articles on molecular identification of stored-product pests, most of the research and application have obviously been in the last 10 years (Table 1). As a representative model, the molecular methods and techniques for species identification of stored-product psocid pests were developed and applied systematically based on international collaboration involving China, Czech Republic, the United States and other countries. More than 10 articles, theses and dissertations on molecular identification of stored-product psocids have been published between 2008 and 2017; methods used including RFLP (Qin et al. 2008; Qin 2009), DNA barcoding (Li et al. 2011; Yang et al. 2012; Cui 2013; Yang et al. 2013b; Yang 2014), PCR (Arif et al. 2012; Yang et al. 2013a; Zhao et al. 2016), realtime PCR (Pang 2017), and gene chip (Liu et al. 2017). Recently, this team discovered the highly divergent mitochondrial genomes and indicated that Liposcelis bostrychophila was a cryptic species, which provided a taxonomic basis for species identification of stored-product psocids (Feng et al., 2018). Subsequently, the techniques such as DNA barcoding, PCR and real-time PCR have been reported for the identification of common species of Tribolium (Wang 2015; Zhang et al. 2016; Zhang 2017), Cryptolestes (Wang et al. 2014; Varadínová et al. 2015; Chen, 2018) and predatory mites (Wu et al. 2016) by the same international team. For more application of DNA barcoding, a web system which was entitled as Grain Pests DNA Barcode Identification System (GPDBIS) has been established in China using SOL SERVER and C# (Figure 2) (Li 2016; Wu et al. 2017).

Tab. 1 Number of articles on molecular identification of common stored-product pests during the period 2008–2017

Arthropods	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008	Total
Beetles	9	7	10	8	7	8	3	4	2	8	66
Moths	3	2	1	1	2	2	0	2	0	0	13
Psocids	1	1	1	1	2	3	4	3	0	2	18
Mites	2	3	0	1	0	0	1	1	0	0	8
Total	15	13	12	11	11	13	8	10	2	10	105



Fig. 2 The main pages of molecular identification in GPDBIS. A: page of sequence input, B: page of sequence similarity, C: page of phylogenetic tree

Globalization accelerates the spread of stored-product pests among different countries and regions. What are the related questions and prospects for research and application on molecular identification of stored-product pests? Apparently, there is more need for molecular identification and common action for the prevention and control of stored-product pests. There is still a gap between the research and application. Like a marathon that requires persistence, we should do our best to continue to promote research and application of molecular identification of stored-product pests with more international collaborations that involve the sharing of more representative samples, development of more practical techniques, and establishment of a more common platform through further research, training and application.

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References

- ARIF, M., OCHOA-CORONA, F., OPIT, G., LI, Z., KUČEROVÁ, Z., STEJSKAL, V. and Q. YANG, 2012: PCR and isothermal-based molecular identification of the stored-product psocid pest *Lepinotus reticulatus* (Psocoptera: Trogiidae). Journal of Stored Products Research 49, 184-188.
- CHEN, D., 2018: Molecular identification for stored *Cryptolestes* based on mitochondrial PCGs, Thesis of China Agricultural University.
- CUI, B., 2013: Molecular identification of common species of stored booklice based on ITS2 rDNA, Thesis of China Agricultural University.
- FENG, S., YANG, Q., LI, H., SONG, F., STEJSKAL, V., OPIT, G., CAI, W., LI, Z. and R. SHAO, 2018: The highly divergent mitochondrial genomes indicate that the booklouse, *Liposcelis bostrychophila* (Psocoptera: Liposcelididae) is a cryptic species. G3- Genes Genomes Genetics 8, 1-9.
- LI, W., 2016: The development and primary application of the Grain Pests DNA Barcode Identification System, Thesis of China Agricultural University.
- LI, Z., KUČEROVÁ, Z., ZHAO, S., STEJSKAL, V., OPIT, G. and M. QIN, 2011: Morphological and molecular identification of three geographical populations of the storage pest *Liposcelis bostrychophila* (Psocoptera). Journal of Stored Products Research **47**, 168-172.
- LIU, L., PANG, A., FENG, S., CUI, B., ZHAO, Z., KUĆEROVÁ, Z., STEJSKAL, V., OPIT, G., AULICKY, R., CAO, Y., LI, F., WU, Y., ZHANG, T. and Z. LI, 2017: Molecular identification of ten species of stored-product psocids through microarray method based on ITS2 rDNA. Scientific Reports 7, 16694, DOI:10.1038/s41598-017-16888-z.

- PANG, A., 2017: Research and primary application on molecular identification technique of real-time PCR of common stored booklice, Thesis of China Agricultural University.
- QIN, M., 2009: Molecular identification of four common species of stored booklice, Thesis of China Agricultural University.
- QIN, M., LI, Z., KUCEROVA, Z., CAO, Y. and V. STEJSKAL, 2008: Rapid discrimination of the common species of the stored product pest Liposcelis (Psocoptera: Liposcelididae) from China and the Czech Republic, based on PCR-RFLP analysis. European Journal of Entomology 105, 713-717.
- VARADÍNOVÁ, Z., WANG, Y., KUČEROVÁ, Z., STEJSKAL, V., OPIT, G., CAO, Y., LI, F. and Z. LI, 2015: COI barcode based species-specific primers for identification of five species of stored-product pests from genus *Cryptolestes* (Coleoptera: Laemophloeidae). Bulletin of Entomological Research **105**, 1-8.
- WANG, Y., 2015: Molecular techniques for identification of stored Tribolium, Thesis of China Agricultural University.
- WANG, Y., LI, Z., ZHANG, S., VARADÍNOVÁ, Z., JIANG, F., KUČEROVÁ, Z., STEJSKAL, V., OPIT, G., CAO, Y. and F. LI, 2014: DNA barcoding of five common stored-product pest species of genus *Cryptolestes* (Coleoptera: Laemophloeidae). Bulletin of Entomological Research **104**, 671-678.
- WU, Y., LI, F., LI, Z., STEJSKAL, V., AULICKY, R., KUČEROVÁ, Z., ZHANG, T., HE, P. and Y. CAO, 2016: Rapid diagnosis of two common storedproduct predatory mite species based on species-specific PCR. Journal of Stored Products Research **69**, 213-216.
- WU, Z., LI, W., ZHAO, Z., WU, Y., ZHANG, T., CAO, Y., LI, F. and Z. LI, 2017: Development and primary application of the DNA barcode identification system of grain pest. Journal of China Agricultural University 22, 82-89.
- YANG, Q., 2014: Molecular identification, reproduction evolution and comparative mitochondrial genome of booklice *Liposcelis* (Psocodea: Liposcelididae), Dissertation of China Agricultural University.
- YANG, Q., KUČEROVÁ, Z., LI, Z., KALINOVIĆ, I., STEJSKAL, V., OPIT, G. and Y. CAO, 2012: Diagnosis of *Liposcelis entomophila* (Insecta: Psocodea: Liposcelididae) based on morphological characteristics and DNA barcodes. Journal of Stored Products Research 48, 120-125.
- YANG, Q., ZHAO, S., KUČEROVÁ, Z., OPIT, G., CAO, Y., STEJSKAL, V. and Z. LI, 2013a: Rapid molecular diagnosis of the stored-product psocial Liposcelis corrodens (Psocodea: Liposcelididae): Species-specific PCR primers of 16S rDNA and COI. Journal of Stored Products Research 54, 1-7.
- YANG, Q., ZHAO, S., KUČEROVÁ, Z., STEJSKAL, V., OPIT, G., QIN, M., CAO, Y., LI, F. and Z. LI, 2013b: Validation of the 16S rDNA and COI DNA barcoding technique for rapid molecular identification of stored product Psocids (Insecta: Psocodea: Liposcelididae). Journal of Economic Entomology **106**, 419-425.
- ZHANG, T., 2017: Geographical distribution, spread pathway and biological control techniques of predatory mites of *Tribolium castaneum* (Herbst) (Coleoptera: Tenebrionidae) in China, Dissertation of China Agricultural University.
- ZHANG, T., WANG, Y., GUO, W., LUO, D., WU, Y., KUČEROVÁ, Z., STEJSKAL, V., OPIT, G., CAO, Y., LI, F. and Z. LI, 2016: DNA barcoding, speciesspecific PCR and real-time PCR techniques for the identification of six *Tribolium* pests of stored products. Scientific Reports 6, 28494, DOI: 10.1038/srep28494.
- ZHAO, Z., CUI, B., LI, Z., JIANG, F., YANG, Q., KUČEROVÁ, Z., STEJSKAL, V., OPIT, G., CAO, Y. and F. LI, 2016: The establishment of species-specific primers for the molecular identification of ten stored-product psocids based on ITS2 rDNA. Scientific Reports 6, 21022, DOI: 10.1038/srep21022.

Enhancing surveillance for exotic stored pests in the Australian grains industry using a partnership approach with industry and government.

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Abstract

Verifying freedom from exotic pests such as Khapra beetle (*Trogoderma granarium*) & Karnal Bunt (*Tilletia indica*) is critical to supporting & maintaining access for Australian grain producers to international markets. Despite Australia's geographical isolation & strong quarantine systems, increasing levels of travel & trade continues to place pressure on our biosecurity systems, emphasising the need for improving our regional efforts in prevention, preparedness & surveillance to mitigate risks. The Australian Grains Farm Biosecurity Program (GFBP) is a national initiative to assist in the development & implementation of improved biosecurity practice, playing a vital role in the education of exotic pests & the role of surveillance by industry. The GFBP has undertaken a targeted surveillance program for stored product pests, with Khapra beetle as the main focus. A range of sites based on potential risk groups & pathways (e.g. farming enterprises, seed distributors & agricultural stores) were targeted, with different approaches used across the three grain growing regions of Australia depending on State