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Acaroid Mites (Astigmata) Breeding in the Stored Dry Fruits in China

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To investigate the species and breeding density of the acaroid mites in the stored dry fruits, and understand their diversity and community distribution. The stored dry fruits were collected from 30 stores and warehouses in China, and the mites were isolated from the previous samples. Twenty species of acaroid mites, belonging to 16 genera under 6 families, were identified from the total 49 stored dry fruit samples, in which the *Tyrophagus putrescentiae Acarus siro, Charpoglyphus lactis* and *Caloglyphus berlesei* are predominant. High breeding density of acaroid mites was found in the stored dry fruits. This indicates that the dried fruits in storages are seriously contaminated by the acaroid mites, and such infestation should be positively controlled to reduce the potential harm public health.

Key words: Acaroid mites; Stored dry fruit; Habitat; Allergic diseases; Acariasis.

Hypersensitivity disease is recognized by the World Health Organization (WHO) as one of the four major noninfectious diseases for targeted prevention in the 21st century. This disease annually affects 10% to 30% of global population and is growing an important public health concern(Kennedy *et al*. 2012). Allergen is one of the causative factors for development of allergic disorders. Particularly, allergens of mite sources are widely recognized as a primary initiator to induce hypersensitive reaction (Zheng *et al*. 2011, Vichyanond *et al*. 2012). Since the acaroid mites are extensively detected in the human settlements, their discharges, secretions and dead lysate are liable to be spread and transmitted in the air, and are important air-borne allergens responsible for allergic disorders (Arlian *et al*. 2002, Pulsawat *et al*. 2010, Tovey and Marks 2011). Therefore, a thorough investigation and understanding of the diverse habitat for acaroid mites and its species breeding in different products as well as breeding density is of great significance to prevent the allergic asthma attack. Between January and December of 2013, we conducted an investigation on the mite breeding status in the stored dry fruits in the stores/storages in some areas of Anhui province. The present study was undertaken to report our findings on the mite breeding in the total 49 samples detected.

MATERIALS AND METHODS

Specimen collection

In compliance with the inhabiting nature of acaroid mites, the dried fruit samples(primarily including walnut, Juglans sigillata, Chinese walnut, pecan and hazelnut, etc) were collected from the stores or warehouses, where the environment was also examined with the portable environmental

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monitoring instrument(TNHY-11, TOP Shanghai, China)for environmental data, and the dust was taken for testing samples. All of the dried fruits were stored over 6 months on average. And 10 aliquots of the samples were obtained from each of the fruit, separately sealed in sampling bag and transported to the laboratory, where each sample was measured with the balance by 10 g for each. Sieve shaker was used to separate the dusts from physical samples before final isolation of the acaroid mites.

Isolation of the acaroid mite specimens

Mites in the physical samples were isolated using Tullgren funnel and directicopy, while those in the dusts were extracted with waternacopy and redricopy(Chaopin and Qianwen 1996). The mite slides were prepared from the specimens isolated as previous description (Chao-pin *et al*. 2006)for light microscopic observation of the morphology and species identification as well as count. Classification of the acaroid mites was in compliance with the taxonomic system described by Hughes (Hughes 1976).

Determination of the density and diversity of acaroid mites breeding in the dried fruits

The dried fruit samples were collected in the first week of each season (i.e., Jan., Apr., Jul., and Oct.) in 2013. After isolation, the acaroid mites were counted and determined with their species, breeding density, richness index, index of species diversity and evenness index. Calculation of the previous indexes was performed as: '$ D=NÿT×100% for the breeding density(N stands for the number detected in each sample, T for the weight of the sample and D for the breeding density); a$ R-Margalef =(*S*-1)/lnN, where *S* is the number of taxa, and *N* is the number of individuals; b$ Shannon-Wiener index denoted by H'= -ÓPilnP*i*, where P*i*=Ni/N, the proportion of total sample represented by species *i*; and c$Pielou evenness index by J=H'/Hmax, where Hmax =lnS.

The mite species changes under the artificial environment cultivation

In order to observe the effects of artificial environment on the species changes of the acaroid mites, we selected five kinds of dried fruits with the highest breeding density as previously detected. The samples were evenly mixed and cultivated in a artificial cabinet for consecutive 12 weeks to observe the growth and decline status of the acaroid mites. The cabinet was set by temperature at 28±2! and humidity at 75±5%. The cultivation was implemented as: 1) the selected samples were sealed in a clean dish and stored in a multi culture chamber (Sanyo, MLR-350, Japan); 2)the mite growth was daily observed; and 3) parts of the samples(approximate 10 g) were taken every two weeks for isolation, counting and slide preparation of the mites.

RESULTS

Mite species and their breeding density identified in the 49 dried fruit samples

The species of the acaroid mites and their breeding density identified in the total 49 dried fruits are listed in table 1. The results showed that the stored dry fruits are favorable to acaroid mite breeding, and two species or above of the mites occurred in most dried fruits. Different species of acaroid mites varied to a certain degree in their habitat, feeding and ecological habits as well as in diverse fruits by breeding densities. A total of 20 species were identified in the 49 samples, and these species belong to 16 genera under 6 families (Table 2), indicating a diversity of the acaroid mites breeding in the dried fruits.

Apart from that, some larvae and eggs of the acaroid mites were also detected from the dried fruits. We failed to include them in current investigation because these larvae and eggs are hard to identify.

The community diversity for acaroid mites identified in the five dried fruits with highest breeding density

The top five dried fruits in the 49 samples with highest breeding density of acaroid mites were involved sequentially in longan, red dates, flat hazelnut, Juglans sigillata and dried litchi. Also, the eggs, larvae, mymphs, hypopus and adult mites in its development phase were occasionally seen in the same dried fruit. The breeding density, species count, richness index, index of species diversity and evenness index were significantly higher in the previous five dried fruits(Tab. 3). This indicates that there evidently exists a preference of the acaorid mites to their feeding habits and habitat. The highest breeding density was found in the dried litchi, whereas the maximal indexes of richness, diversity and evenness were seen in

Table 1. Species of the acaroid mites and their breeding density identified in the 49 dried fruit samples

Dried fruits	Mite count/g	Mite species identified
Fructus lycii	24.10	*Tyrophagus putrescentiae, G.ornatus*
Longan	79.78	*T.putrescentiae,Caloglyphus berlesei*
Walnut meat	12.67	*Tyrophagus casei, Caloglyphus berlesei*
Diospyros lotus	4.90	*Carpoglyphus lactis, G.domesticus, Acarus siro*
Red dates	6.72	*G.domesticus, Carpoglyphus lactis*
Golden silk Jujube	9.76	*G.domesticus, Carpoglyphus lactis, G.ornatus*
Walnut	18.06	*Lardoglyphus knoni, Rhizoglyphus callae*
Juglans sigillata	21.97	*G.domesticus,G.ornatus*
Flat hazelnut	48.91	*Tyrophagus casei, Suidasia nesbitti, Caloglyphus berlesei*
Chinese walnut	2.85	*G.domesticus, G.ornatus*
Castanea crenata	8.48	*Tyrophagus casei, Acarus siro, Caloglyphus berlesei*
Castanea henryi	9.54	*Tyrophagus longior, Tyrophagus casei, Acarus siro*
Castanea seguinii	4.97	*Tyrophagus tropicus, Acarus siro, Caloglyphus berlesei*
Candied date	11.08	*G.domesticus, G.ornatus*
Amygdale	12.30	*G.ornatus,Tyrophagus caseiÿG.ornatus*
Honey peach	14.93	*G.ornatus,Glycyphagus ornatus*
Anacardium occidentale	8.97	*Acarus siro, Caloglyphus berlesei, Lardoglyphus knoni*
Carya illinoensis Koch	5.92	*G.domesticus,Tyrophagus tropicus*
Red pine nuts	4.46	*Lardoglyphus knoni, Tyrophagus casei,Euroglyphus maynei*
Raisins	9.72	*G.domesticus, G.ornatus,Caloglyphus berlesei*
Chestnut	4.84	*G.ornatus,G.domesticus, Tyrophagus putrescentiae*
Persimmon cake	7.08	*Tyrophagus putrescentiae*
Pine seeds	3.09	*Lardoglyphus knoni, Tyrophagus putrescentiae ,Acarus siro*
Chinese torreya	11.37	*G.domesticus, Tyrophagus putrescentiae*
Wild jujube	3.22	*G.ornatus, Acarus siro*
Dried apricot	9.51	*G.ornatus,Caloglyphus berlesei, Acarus siroÿSuidasia nesbitti*
Ansu apricot seed	10.08	*G.domesticus, Acarus siroÿG.ornatus*
Lohanguo siraitia fruit	8.32	*Tyrophagus putrescentiae, Chortoglyphus arcuatus*
Almond	4.71	*Caloglyphus berlesei, Euroglyphus maynei*
Wild apricot	8.56	*Tyrophagus casei, Carpoglyphus lactis,Euroglyphus maynei*
Baoren apricot	4.33	*Rhizoglyphus callae,Carpoglyphus lactis, Caloglyphus berlesei*
Ginkgo nuts	2.89	*Acarus siro, Dermatophagoides farinae*
Carya illinoinensis	23.18	*Blomia tropicalis, Acarus siro, Caloglyphus berlesei*
Ficus carica	4.43	*Tyrophagus putrescentiae,Tyrophagus longior*
Pistachio nut	8.31	*Caloglyphus berlesei, Acarus siro*
Preserved prune	35.73	*Caloglyphus berlesei, Tyrophagus putrescentiae*
Olive	5.68	*Dermatophagoides farinae*
Dried crabapple	4.58	*G.ornatus,G.domesticus, Acarus siro*
Dried lichee	14.22	*G.ornatus, Caloglyphus berlesei*
Copra	16.54	*Tyrophagus putrescentiae, Chortoglyphus arcuatus*
Dried hawthorn	11.25	*G.ornatus, Acarus siro,G.ornatus*

Dried salted arbutus	16.43	*G.ornatus,Caloglyphus berlesei*
Cashew nut	18.22	*Acarus siro, Suidasia nesbitti*
Dried mango	6.75	*Dermatophagoides farinae,Tyrophagus longior*
Japanese Plum	7.83	*Caloglyphus berlesei, Acarus siro, Lardoglyphus knoni*
Dried lemon	6.89	*Carpoglyphus lactis, Tyrophagus putrescentiae, Glycyphagus ornatus*
Dry cherry tomato	9.11	*Tyrophagus putrescentiae, Chortoglyphus arcuatus*
Kiwi slices	6.35	*G.ornatus,G.domesticus,*
Dried fruit angustifolia	8.16	*Tyrophagus casei, G. ornatus, Euroglyphus maynei*

Table 2. Classification of the acaroid mite species identified in the 49 dried fruits

Families	Genera	Species
Acaridae	*Acarus*	*A.siro*
		A. farris
	Tyrophagus	T. putrescentiae
		T. longior
		T.tropicus
	Mycetoglyphus	M. fungivorus
	Aleuroglyphus	A. ovatus
	Suidasia	S. nesbitti
	Cologlyplus	C. berieses
	Tyrolichus	T.casei
	Rhizoglyphus	R.callae
Lardoglyphidae	*Lardoglyphus*	*L. konoi*
Glycyphagidae	*Glycyphagus*	*G. privates*
		G. domesticus
	Blomia	B. tropicali
	Lepidoglyphus	L. destructor
Chortoglyphidae	*Chortoglyphus*	*C. arcuatus*
Carpoglyphidae	*Carpoglyphus*	*C. lactis*
Pyroglyphidae	*Dermatophagus*	*D. farinae*
	Euroglyphus	E. maynei

Table 3. The ecological parameters of acaroid mites breeding the five dried fruits

Ecological	Dried fruits				
parameters	Red dates	Juglans sigillata	Dried crabapple	Fructus lycii	Walnut
Breeding density	8.425	11.488	18.962	9.025	9.328
Richness index	1.543	1.439	1.526	0.843	1.987
Diversity index	2.012	1.765	1.383	1.614	2.059
Evenness index	0.947	0.936	0.934	0.954	0.978

Junglans sigillata. These findings suggest that dried fruits are favorable to the living and multiplying of the acaroid mites, though they remain rich in species diversity and ecologically stable in the stored dry fruits.

Seasonal distribution for the acaroid mites in the stored dry fruits

Investigation on the breeding diversity of acaroid mites in the dried fruit samples collected in the four seasons(i.e., Jan. to Mar.; Apr. to Jun.;

Jul. to Sept.; Oct. to Dec.) revealed average breeding density of (6.73±3.25)heads/g, (5.69±3.00)heads/g, (10.35±2.53) heads/g, and (11.68±2.21)heads/g; richness index of 2.145±0.037, 1.513±0.115, 6.131±0.021, and 5.059±0.011; diversity index of 1.351±0.210, 1.073±0.110, 3.259±0.082, and 2.039±0.075; evenness index of 0.927±0.041, 0.955±0.034, 0.811±0.053, and 0.841±0.022, respectively, from the first to the fourth season.

Density changes of the acaroid mites breeding the five dried fruit samples

The mite density changes occurred under artificial environment intervention. Briefly, the *T. putrescentiae*, *C. berieses* and other species accounted for 53%, 36% and 11%, respectively, at the initial cultivation. By subsequent observation at intervals of every two weeks, the number of *T. putrescentiae* were increased from 12.47 heads/g at week 2 to 15.71 heads/g at week 4, and gradually peaked by 23.63 heads/g at week 8. The decline occurred at week 12 by 19.54 heads/g. contrarily, the *C. berieses* count was decreased from 8.54 heads/g at the 2nd week to 5.71 heads/g at the 8th week, and to zero at the 12th week. Still, we found that the number of Cheyletidae mites, such as *Cheyletus malaccensis* were increased in some of the samples, which may be attributable to the decline of *T. putrescentiae* and *C. berieses.*

DISCUSSIONS

A number of studies have been done on the acaroid mites breeding in stored products, such as the mites breeding in traditional Chinese medicinal herbs by CP Li, *et al*(Chao-pin *et al*. 2005), community structure and diversity of acaroid mites breeding in passenger cars in Wuhu by XD Zhan, *et al*(Xiao-dong *et al*. 2013) and mite prevalence in houses if Fujian area by ZY Wu, *et al*(Zi-yi *et al*. 2008), yet little attention has been given to the acaroid mite prevalence in the stored dry fruits. In current work, we attempted to investigate the acaroid mites breeding status in the dried fruits in storage. The findings showed that acaroid mites are prevalent in the 49 dried fruit samples obtained from the stores or storages. Interestingly, the breeding species and the count of mites vary a lot in different fruits. This observation may be associated with the feeding habit of mites, temperature and humidity of the storage as well as duration of the stored dry fruits. Higher breeding density of *C. lactis* was seen in the candied fruit than that in other dried fruits. The breeding density was also found significantly higher in sealed package of the dried fruits stored in a warehouse with artificially controlled temperature and humidity than that observed in common storages or stores. This indicates that mites are able to penetrate the packing material, including polypropylene and aluminum foils(Hubert *et al*. 2011). In addition, determination of the acaroid mites breeding density in dissimilar dried fruit demonstrated that *C. lactis* and *T. putrescentiae* are most prevalent, followed by *C. berieses*.

In order to understand the seasonal distribution pattern of acaroid mites breeding in a full year, we determined and compared the average breeding density, diversity, richness index and evenness index as well as other ecological parameters of mites among the dried fruits samples obtained in the same storage on chronological January, April, July and October basis. The results showed that the indexes of richness and diversity were in top wave in July, whereas the average breeding density was highest in October and evenness index was maximal in April. The potential causes may be involved in the higher temperature (31°C) and humidity(RH 75.6%) in a tightly closed storage with less effective artificial management of the environment, where appears favorable to the mite breeding. By October, the temperature was approximately 25!, and RH 66% in the warehouse, where there is reduced human interference, for the temperature and humidity vary a lot during that season. Excessive high temperature and humidity tend to inhibit the growth of mites (Mourier and Poulsen 2000, Feng *et al*. 2009), and result in decreased richness and diversity of the acaroid mites breeding in the dried fruits. However, the breeding density remained relatively high in October, and this indicates that seasonal distribution of acaroid mites is immediately affected by temperature, humidity, light intensity, category of the products for mite breeding and human interference or other factors (Zannou *et al*. 2013, Zhao-peng 2009). Even if the low temperature in spring season does not favor the development of acaroid mites, yet the mites (e.g., *T. putrescentiae*) with little limitation to the temperature and humidity may still multiply, which possibly explains the highest evenness index measured in April in our work. In summary, if the artificial and food factors are not taken into consideration, the average breeding density, diversity, community richness index and evenness index are strongly associated with the ambient temperature and humidity. As is shown in our work, we observed higher average breeding density and maximal community richness index as well as species diversity in the dried fruits collected in summer and autumn seasons with higher temperature and humidity, and that the acaroid mites are living in hypopus fashion when the environment is disadvantageous (Sanchez-Ramos and Castanera 2000).

For further knowledge on the dynamic variation of acaroid mites breeding the stored dry fruits, we intentionally selected five dried fruits(longan, flat hazelnut, dried litchi, red date and Juglans sigillata) with highest breeding density of mites by artificially cultivation. The breeding species in those samples are primarily associated with *T. putrescentiae* and *C. berieses*. In an effort to understand their living habit and habitat as well as change tendency in related ecological parameters, we obtained equal sample of the two mites for determination by every other two weeks. The observation demonstrated that the *C. berieses* count were persistently decreased, whereas the population of *T. putrescentiae* went up uninterruptedly till the peak, a full capacity of the species, at the 8^{th} week, then were somewhat declined at the 10^{th} and 12 week as a result of occurrence of some cheyletid mites(e.g, *Cheyletus malaccensis*) that led to insufficient feeding supply. This distribution pattern may be associated with the living habit of mites and species dominance, for only one dominant species can survive the same community by its strong controlling capacity over the community structure and breeding environment(Erdmann *et al*. 2012). This is why the T. putrescentiae can breed in greater quantity in the aforementioned five dried fruits by inhibiting other species, because of its dominance, higher bio-mass and stronger survival power(Gotoh *et al*. 2014). Actually, when the acaroid mites multiply to a certain stage, their predatory counterparts, cheyletid mites, will occur and develop in large quantity, which lead to a dynamic balance of the mites in the same community.

Our investigation also suggested that the breeding density of acaroid mites is significantly greater in warehouses than stores. This is probably attributed to relatively invariable temperature and humidity in warehouse with less day light exposure to favor the breeding of mites. Moreover, the dried fruits may be in transpiration that potentially produce biological temperature accumulation effect and eventually increase the room temperature (Rong-ting and Meng-jun 2005). Apart from that, the dried fruits in storage can be 'sweating' due to the residual water evaporation, which tends to increase the humidity in the room and creates optimal environment for the acaroid mites to breed(Hai-sheng and Xue-dong 2007). The dried fruits also contain a lot of proteins, fats and carbohydrates. These components are not only the feedings to the acaroid mites but also the nourishment to some organisms like fungi (e.g., *Aspergillus flavus, Penicillium citreo-virde* and *Penicillium citrinum*) that are additional foods for mite breeding (Zhao-peng 1985). Acaroid mites have the ability to automatically find a desirable place to multiply with the season change and increased population density of insects in a certain community. Besides, the murines and arthropods that act as mechanical carrier in the warehouse, together with human transmission, may create optimal conditions for the acaroid mites dispersing and breeding in the stored dry fruits (Cevizci *et al*. 2010).

Acaroid mites breeding in the dried fruits will lead to degraded quality of such products (Mei-song 1996). In addition, acaroid mites can be the vectors of fungi, such as *Aspergillus flavus*, *Penicillium citreo-virde* and *Penicillium citrinum*(Lian-gao 1884, Palyvos *et al*. 2008), and the dead lysates and discharges of mites are important allergen producers of allergic disorders(Aycan *et al*. 2007, Sih and Mion 2010, Tovey and Marks 2011). Previous reports described that once the food contaminated by mites is mistakenly digested by a person, the acariasis of digestive system will likely occur (Chao-pin 2000), which suggests that dried fruit contamination with the mites can be of great harm to human health.

In conclusion, we conducted a preliminary investigation on the species, density and diversity of acaroid mites breeding in the stored dry fruits. These findings may be additional data for systematic research on the mites in stored products, and supply theoretical evidences for prevention and control of the acaroid mite contamination in the dried fruits.

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REFERENCES

1. Arlian, L. G., M. S. Morgan, and J. S. Neal. Dust mite allergens: ecology and distribution. *Curr Allergy Asthma Rep* 2002; **2**: 401-411.
2. Aycan, O. M., M. Atambay, and U. N. Daldal. [Investigation of house dust mite incidence related to social factors]. *Turkiye Parazitol Derg* 2007; **31**: 219-224.
3. Cevizci, S., S. Gokce, K. Bostan, and A. Kaypmaz. [A view of mites infestation on cheese and stored foods in terms of public health]. *Turkiye Parazitol Derg* 2010; **34**: 191-199.
4. Chao-pin, L., Study on the therapy of intestinal acariasis. *World Journal of Gastroenterology* 2000; **8**: 919-920.
5. Chao-pin, L., Z. Hong-fu, and Y. Qing-gui. Medical Acarology, People's Military Medical Press, 2006.
6. Chao-pin, L., J. Jia-jia, H. Ji, and W. Hui-yong. Constitution and Diversity of Acaridida Community in Storaged Chinses Traditional Medicines in Huainan Region. *Acta Arachnological Sinica* 2005; **14**: 100-103.
7. Chaopin, L., and W. Qianwen. Acaroid Mites in House Dusts and Store Products, Press of University of Science and Technology of China 1996.
8. Erdmann, G., S. Scheu, and M. Maraun., Regional factors rather than forest type drive the community structure of soil living oribatid mites (Acari, Oribatida). *Exp Appl Acarol* 2012; **57**: 157-169.
9. Feng, M., W. Sun, and X. Cheng., Seasonal dynamics and distribution of house dust mites in China. *Biosci Trends* 2009; **3**: 210-215.
10. Gotoh, T., M. Hanawa, S. Shimazaki, N. Yokoyama, C. Q. Fu, R. Sugawara, and S. Yano. Factors determining species displacement of related predatory mite species (Acari: Phytoseiidae). *Exp Appl Acarol* 2014; **63**: 205-215.
11. Hai-sheng, G., and C. Xue-dong., Dried Fruits Storage and Processing Technology, Chemical Industry Press, 2007.
12. Hubert, J., T. Erban, M. Nesvorna, and V. Stejskal., Emerging risk of infestation and contamination of dried fruits by mites in the Czech Republic. Food Addit Contam Part A Chem Anal Control Expo Risk Assess 2011; **28**: 1129-1135.
13. Hughes, A. The mites of Stored Food and Houses, Her Majesty's stationary Office London, 1976.
14. Kennedy, J. L., P. W. Heymann, and T. A. Platts-Mills. The role of allergy in severe asthma. Clin Exp Allergy 2012; **42**: 659-669.
15. Lian-gao, L. The Mite Species in Chinese Storages, Sichuan Science & Technology Press, 1884.
16. Mei-song, W., Review of the research on prevention and control of mites infestation in stored products. *Grain Storage* 1996; **25**: 17-22.
17. Mourier, H., and K. P. Poulsen., Control of insects and mites in grain using a high temperature/short time (HTST) technique. *J Stored Prod Res* 2000; **36**: 309-318.
18. Palyvos, N. E., N. G. Emmanouel, and C. J. Saitanis. Mites associated with stored products in Greece. *Exp Appl Acarol* 2008; **44**: 213-226.
19. Pulsawat, P., S. Piboonpocanun, S. Sirivichayakul, S. Buranapraditkun, A. Jacquet, M. Shimada, K. Okuda, and K. Ruxrungtham. Production and immunogenicity of hypoallergenic codon-optimized DNA vaccine encoding mature Der p 1 allergen. *J Investig Allergol Clin Immunol* 2010; **20**: 582-590.
20. Rong-ting, X., and L. Meng-jun., Chinese Dried Fruits, China Forestry Publishing House, 2005.
21. Sanchez-Ramos, I. I., and P. Castanera., Acaricidal activity of natural monoterpenes on Tyrophagus putrescentiae (Schrank), a mite of stored food. *J Stored Prod Res* 2000; **37**: 93-101.
22. Sih, T., and O. Mion., Allergic rhinitis in the child and associated comorbidities. *Pediatr Allergy Immunol* 2010; **21**: e107-113.
23. Tovey, E. R., and G. B. Marks., It's time to rethink mite allergen avoidance. *J Allergy Clin*

Immunol 2011; **128**: 723-727 e726.

24. Vichyanond, P., R. Pensrichon, and S. Kurasirikul., Progress in the management of childhood asthma. *Asia Pac Allergy* 2012; **2**: 15-25.
25. Xiao-dong, Z., G. Wei, C. Qi, and L. Chao-pin., Investigation on community structure and diversity of acaroid mites breeding in passenger cars in Wuhu, Anhui. *Journal of Environment and Health* 2013; **30**: 332-334.
26. Zannou, I. D., H. O. Adebo, E. Zannou, and K. Hell., Mites associated with stored grain commodities in Benin, West Africa. *Exp Appl Acarol* 2013; **61**: 449-470.
27. Zhao-peng, S., Environmental pollution from the mites of stored products. *Environmental Science* 1985; **10**: 80-83.
28. Zhao-peng, S., Mites of stored food and house are risk factors of modern living environment. Heilongjiang Grain: 2009; 3-6.
29. Zheng, Y. W., J. Li, X. X. Lai, D. Y. Zhao, X. F. Liu, X. P. Lin, B. Gjesing, P. Palazzo, A. Mari, N. S. Zhong, and M. D. Spangfort., Allergen micro-array detection of specific IgE-reactivity in Chinese allergy patients. *Chin Med J (Engl)* 2011; **124**: 4350-4354.
30. Zi-yi, W., L. Jia, X. Xia, and F. Qing-hai., Investigation on mites in houses from Fujian area. *Chin J Vector Bio& Control* 2008; **19**: 446-449.