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Full Length Research Paper

Quantitative survey of stored products mites infesting wheat flour in Jeddah Governorate

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In this study, a faunistic survey of mites was conducted in different product stores such as bakeries, warehouses, mills, department stores and houses during a nine month study period (October 2009 to June 2010), in Jeddah governorate. The survey was carried out on wheat flour as different samples 150 gm each were collected monthly from three regions; North, Middle and South. The results of the current study identified five species of mites belonging to four families: *Dermatophagoides farinae* (Pyroglyphidae), *Acarophenax tribolii* (Acarophenacidae), *Cheyletus malaccensis* (Cheyletidae), *Blattisocius tarsalis* and *Blattisocius keegani* (Ascidae). The mites' counts ranged from 0.15 to 20.44 mites/150 gm wheat flour. The highest counts for the majority of mites species collected from the three regions were recorded during the months of November, December, January and February, according to the decreasing degrees of temperature and relative humidity during these months. *D. farinae* was the most dominant species in all samples collected from the three regions, followed by *A. tribolii* in samples from North and Middle. The predatory species *C. malaccensis was* detected in three regions but in few numbers, whereas, *B. tarsalis* and *B. keegani* were detected only in samples from the South. These results indicate the effect of temperature and relative humidity on the distribution density of stored products mites.

Key words: Stored products mites, quantitative survey, wheat flour, temperature, relative humidity.

INTRODUCTION

Stored products mites are found in different product stores and sometimes, in high concentration. Mites flourish in warm and damp environments where they feed on protein rich substances such as grain, fungi and other micro-organisms. Both house dust mites and storage mites occur in damp dwelling (Harju et al., 2006). Mites cause significant grain weight losses and decrease of germinability (Zdarkova and Reska, 1976). Their activities cause heating of grain mass and moisture translocation which permits the development of molds and germination of the grain, contamination by alive and dead mites, different stages as well as exuviae and feaces resulting in being harmful for human consumption (Hughes, 1976). Mites are vectors of toxicogenic fungi (Hubert et al, 2003). which contribute to contamination of food and feed with mycotoxins (Franzolin et al., 1999) and Hubert et al, 2004). It is possible for the workers and even the customers to be exposed to mites and their allergens (Harju et al., 2006), either by handling, inhaling or/and ingestion of mites- contaminated food.

Respiratory allergy, bronchial provocation, wheezing, rhinitis, contact dermatitis, urticaria and asthma have been associated with storage mites (Cuthbert and Jeffrey, 1993) and Olsson, Van Hage- Hamsten, 2000), Korunic, 2001), Borghetti et al., 2002), Musken et al., 2003), Wang et al., 2003), Matsumoto and Satoh, 2004), Walusiak et al., 2004), Stejskal and Hubert, 2008), also, there is increasing evidence that ingestion of mites contaminated food can affect human health, causing several intestinal allergic reactions such as vomiting, gastrointestinal disorders, abdominal cramps, wheezing, cough, difficult breathing, throat discomfort, dyspnea, urticaria and angioedema (Castillo et al., 1995), Scala, 1995), Blanco et al, 1997), Sanchez-Borge et al., 1997), Antunes et al., 1999), Sanchez-Borges et al., 2001), Guerra Bernd et al., 2001), Dutau, 2002), Wen et al, 2005), Sánchez-Borges et al., 2008), Sánchez-Borges et al., 2009), Yan et al., 2008). Prolonged ingestion of mite contaminated foods causes various alterations in the small intestinal tissues of rats (Saleh and Al-Nasser, 2007).

The present study aims to estimate the distribution of stored products mites in wheat flour in different regions of Jeddah Governorate.

MATERIALS AND METHODS

Collection of mites

Wheat flour samples of 150 gm each were collected monthly from different product stores such as bakeries, warehouses, mills, department stores and houses. Samples were collected from three different regions in Jeddah (North-Middle and South); three replicates were taken from each region during a nine month period from October 2009 June 2010.

Extraction and identification of mites

Samples were collected in paper bags and transported to the laboratory with labels including the region and date of collection. Mites were extracted using modified Tulgren funnel apparatus (Aspaly et al., 2007) and left for a period of 48 h. Extracted mites were received in Petri dishes containing 70% ethyl alcohol, and then mounted in Hoyer's medium on glass slides. Mites counts were assessed as the number of individuals in each replicate for the three regions monthly with the aid of a dissecting binocular microscope, specimens were identified microscopically and classified into their taxonomical rank by using different specific keys Hughes,1976), Krantz, 1978).

Statistical analysis

Data were analyzed using the 2 ways ANOVA test to compare the mite species numbers monthly in the three regions of Jeddah.

RESULTS

Results of the present study identified five species of store products mites belonging to four families: *Dermatophagoides farinae* (Pyroglyphidae), *Acarophenax tribolii* (Acarophenacidae), *Cheyletus malaccensis* (Cheyletidae), *Blattisocius tarsalis* and *Blattisocius keegani* (Ascidae). Wheat flour samples collected from three regions of Jeddah (North-Middle and South) varied in the mites numbers during the sampling period from October 2009 to June 2010.

Results in Table 1 represent the mean numbers of mites for each species per 150 gm of wheat flour collec-ted monthly from the three regions. According to the mean numbers of mites from the nine months, *D. farinae* was the most dominant species in the three regions, recording a highest rate in the North and the Middle (13.73 and 13.53), respectively. These increasing rates were significant in comparison with the other species. The highest number of *D. farinae* was in the month of January, with 20.89, 20.89 and 19.56 in the North, Mid-dle and South, respectively. We observed a significant difference in May in all the three regions (9.33, 7.11 and 4.89).

The mean number of *A. tribolii* during the nine months was 10.96 and 11.01 in the North and the Middle with significant differences in comparison with the other species. *A. tribolii* was not detected in the South, and it reached the highest number in February (89.20 and 22.22) and the lowest number in June (2.67 and 0.00) in the North and the Middle, respectively (Table1).

C. mallaccensis was detected in all samples collected during the sampling period but in few numbers. Table1 shows that *C. mallaccensis* recorded significant increase in the Middle region (4.25), in comparison to the North and South regions (3.11 and 3.06). The distribution of *C. mallaccensis* varied all through the nine months in the three regions recording the highest number during No-vember in the Middle (7.11), a non significant decrease was observed during the month of June (0.00, 0.44 and 0.44) in the North, South and Middle regions, respectively.

On the other hand, *B. tarsalis* and *B. keegani* were not detected in the North and the Middle during the nine months of study; these two species were recorded just in the South region with a mean number of 6.87 and 5.43 for *B. tarsalis* and *B. keegani* respectively (Table 1).

Distribution of the five species of mites throughout the nine months of study is represented in Table 2. It is obvious that *D. farinae* (12.84) was the most dominant species in Jeddah followed by *A.tribolii* (7.32), C. *mallaccensis* (3.47), *B. tarsalis* (2.29) and *B. keegani* (1.81) with significant differences.

According to the numbers of mites in each region, regardless of the species, it was observed that the distri-bution of mites slightly varied in the three regions (Table 3). The differences between the mean numbers of studied species were not significant except for the month of October where a significant difference appeared bet-ween the Middle region (3.02) and South region (1.78).

Increasing rate of temperature and relative humidity was observed during the season of sampling except for the months of December, January and February which recorded a slight decrease in the temperature degrees (Table 4).

DISCUSSION

The results of the current study showed that wheat flour samples collected during nine months, from three regions in Jeddah contained small numbers of stored product mites. We noticed that *D. farinae* was the most prevalent species in all the collected samples. *D. farinae* is a free living mite belonging to the family Pyroglyphidae which is meanly found in house dust, feeding on organic debris, fungi, saprophages and detretivores, but it could be found in stored products too. Several studies referred to the presence of *D. farinae* in different stored food stuff such as wheat flour (Zaher, 1986), Matsumoto et al., 2001), Al-Nasser, 2007; Yi et al., 2009), bran and maize (Saleh et al., 1985), Bran (Baker, 2000), wheat and grain residue (Mahgoob et al., 2006), broad bean and rough rice (El-Sayed and Ghallab, 2007).

Table 1. Distribution of five mites' species in three locations (North, Middle and South) in Jeddah during the nine months from October 2009 to June 2010.

Insect	Location	October	November	December	January	February	March	April	May	June	Total	Mean
Dermatophagoides farinae	North	9.78^{a}	18.67^{a}	20.89^{a}	20.89^{a}	18.67^{b}	14.22^{a}	9.78^{a}	7.11^{b}	3.56^{a}	123.56^{a}	13.73^{a}
	Middle	9.33^{a}	18.67^{a}	19.56^{a}	20.89^{a}	18.67^{b}	13.33^{a}	8.44^{a}	9.33^{a}	3.56^{a}	121.78^{a}	13.53^{a}
	South	3.56^{bc}	17.33^{a}	15.56^{b}	19.56^{a}	16.00^{c}	12.00^{a}	9.78^{a}	4.89^{c}	2.67^{a}	101.33^{b}	11.26^{b}
Acarophenax tribolii	North	1.33^{d}	18.22^{a}	20.44^{a}	20.44^{a}	20.89^{ab}	13.33^{a}	4.00^{b}	0.00^{f}	0.00^{a}	98.67^{b}	10.96^{b}
	Middle	1.78^{cd}	19.56^{a}	19.11^{a}	20.00^{a}	22.22^{a}	13.33^{a}	3.11^{bc}	0.00^{f}	0.00^{a}	99.11^{b}	11.01^{b}
	South	0.00^{d}	0.00^{f}	0.00^{e}	0.00^{d}	0.00^{f}	0.00^{d}	0.00^{d}	0.00^{f}	0.00^{a}	0.00^{g}	0.00^{g}
Blattisocius tarsalis	North	0.00^{d}	0.00^{f}	0.00^{e}	0.00^{d}	0.00^{f}	0.00^{d}	0.00^{d}	0.00^{f}	0.00^{a}	0.00^{g}	0.00^{g}
	Middle	0.00^{d}	0.00^{f}	0.00^{e}	0.00^{d}	0.00^{f}	0.00^{d}	0.00^{d}	0.00^{f}	0.00^{a}	0.00^{g}	0.00^{g}
	South	1.78^{cd}	12.00^{b}	12.44^{c}	12.44^{b}	15.11^{c}	5.33^{b}	2.22^{bc}	0.44^{ef}	0.00^{a}	61.78^{c}	6.87^{c}
Blattisocius keegani	North	0.00^{d}	0.00^{f}	0.00^{e}	0.00^{d}	0.00^{f}	0.00^{d}	0.00^{d}	0.00^{f}	0.00^{a}	0.00^{g}	0.00^{g}
	Middle	0.00^{d}	0.00^{f}	0.00^{e}	0.00^{d}	0.00^{f}	0.00^{d}	0.00^{d}	0.00^{f}	0.00^{a}	0.00^{g}	0.00^{g}
	South	1.78^{cd}	9.78^{bc}	10.22^{c}	9.78^{b}	11.56^{d}	4.44^{bc}	1.33^{cd}	0.00^{f}	0.00^{a}	48.89^{d}	5.43^{d}
Cheyletus malaccensis	North	1.33^{d}	6.22^{de}	5.78^{d}	5.33^{c}	3.56^{e}	2.22^{cd}	1.33^{cd}	1.78^{de}	0.00^{a}	27.56f	3.06f
	Middle	4.00^{b}	7.11^{cd}	6.22^{d}	6.67^{c}	5.78^{e}	3.56^{bc}	2.67^{bc}	1.78d^{e}	0.44^{a}	38.22^{e}	4.25^{e}
	South	1.78^{cd}	4.00^{e}	5.78^{d}	4.44^{c}	5.33^{e}	2.22^{cd}	1.78^{cd}	2.22d	0.44^{a}	28.00^{f}	3.11^{f}
F 0.05		*	*	*	*	*	*	*	*	n.s	*	*
LSD 0.05		2.10	3.03	2.59	2.70	2.63	2.74	2.08	1.76	-	9.60	1.07

Values within columns not sharing common superscript letters are differ significantly at $p < 0.05$.

Favorable conditions for high populations of house dust mites are 25 to 32°C at relative humidity and 5 to 87% (Saleh et al., 1985). Dust mites populations flourish best in wheat flour compared to the other varieties of flour and at ambient temperature with high humidity instead of the air conditioned environment (Yi et al., 2009). High relative humidity in combination with temperatures at about 25°C leads to high density of mites in whole wheat (Danielsen et al., 2004).

In the present study, *D. farinae* was present in the wheat flour samples collected all over the nine months despite the increasing rate of temperature and relative humidity in Jeddah which is in agreement with previous study (Edrees and Saleh, 2008), reporting that *D. farinae* was the only species collected during summer season from dust samples in Jeddah, as it can undergo dryness and low humidity in comparison with other species of dust mites.

A. tribolii was detected in the present study in samples collected from the North and Middle regions, belonging to the family Acarophenacidae which is meanly parasitic on *Tribolium* spp. (Lopez, 2005), sucking their haemolymph. *A. tribolii* was recorded previously in flour and rice (Saleh,1980); wheat, corn, lentil and bean (Wafa et al,1996); bran (Baker, 2000); wheat flour and grainresidue (Al-Nasser, 2007), Mahgoob et al., 2006). Results of the present study revealed the presence of *C. malaccensis* in all samples collected during the nine months from the three regions but it was detected in small numbers. *C. malascensis* belongs to the family Cheyletidae, this predator is found in stored products and/or in house dust predating on Pyroglyphids and Acarids mites (Kandil,1974; Hafez, 1977) *C. malaccensis* is a major predatory mite in grain storage sys-tems (Athanassiou et al., 2002; Putatunda, 2005;

Table 2. Distribution of five mites' species in Jeddah during the nine months from October 2009 to June 2010.

Insect	October	November	December	January	February	March	April	May	June	Total	Mean
Dermatophagoides farinae	7.56 ^{a}	18.22 ^{a}	18.67 ^{a}	20.44 ^{a}	17.78 ^{a}	13.19 ^{a}	9.33 ^{a}	7.11 ^{a}	3.26 ^{a}	115.56 ^{a}	12.84 ^{a}
Acarophenax tribolii	1.04 ^{c}	12.59 ^{b}	13.19 ^{b}	13.48 ^{b}	14.37 ^{b}	8.89 ^{b}	2.37 ^{b}	0.00 ^{c}	0.00 ^{b}	65.93 ^{b}	7.32 ^{b}
Blattisocius tarsalis	0.59 ^{c}	4.00 ^{d}	4.15 ^{d}	4.15 ^{cd}	5.04 ^{c}	1.78 ^{c}	0.74 ^{cd}	0.15 ^{c}	0.00 ^{b}	20.59 ^{d}	2.29 ^{d}
Blattisocius keegani	0.59 ^{c}	3.26 ^{d}	3.41 ^{d}	3.26 ^{d}	3.85 ^{c}	1.48 ^{c}	0.44 ^{d}	0.00 ^{c}	0.00 ^{b}	16.30 ^{d}	1.81 ^{d}
Cheyletus malaccensis	2.37 ^{b}	5.78 ^{c}	5.93 ^{c}	5.48 ^{c}	4.89 ^{c}	2.67 ^{c}	1.93 ^{bc}	1.93 ^{b}	0.30 ^{b}	31.26 ^{c}	3.47 ^{c}
F 0.05	*	*	*	*	*	*	*	*	*	*	*
LSD 0.05	1.21	1.75	1.49	1.56	1.52	1.58	1.2	1.02	0.78	5.54	0.62

Values within columns not sharing common superscript letters are differ significantly at $p< 0.05$.

Table 3. Distribution of mites in three locations (North, Middle and South) in Jeddah during the nine months from October 2009 to June 2009.

Location	October	November	December	January	February	March	April	May	June	Total	Mean
North	2.49 ^{ab}	8.62 ^{a}	9.42 ^{a}	9.33 ^{a}	8.62 ^{a}	5.96 ^{a}	3.02 ^{a}	1.78 ^{a}	0.71 ^{a}	49.96 ^{a}	5.55 ^{a}
Middle	3.02 ^{a}	9.07 ^{a}	8.98 ^{a}	9.51 ^{a}	9.33 ^{a}	6.04 ^{a}	2.84 ^{a}	2.22 ^{a}	0.80 ^{a}	51.82 ^{a}	5.76 ^{a}
South	1.78 ^{b}	8.62 ^{a}	8.80 ^{a}	9.24 ^{a}	9.60 ^{a}	4.80 ^{a}	3.02 ^{a}	1.51 ^{a}	0.62 ^{a}	48.00 ^{a}	5.33 ^{a}
F 0.05	*	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.
LSD 0.05	0.94	-	-	-	-	-	-	-	-	-	-

Values within columns not sharing common superscript letters are differ significantly at $p< 0.05$.

Table 4. Temperature degrees and relative humidity in Jeddah during the nine months from October 2009 to June 2010.

Month	Temperature (°C)			Relative humidity (%)		
	Maximum	Minimum	Mean	Maximum	Minimum	Mean
October	37.9	24.4	30.3	98	8	62
November	33.0	22.8	27.6	98	13	66
December	30.7	20.7	25.0	97	16	66
January	32.0	19.6	25.0	96	6	59
February	31.2	19.3	24.7	97	18	66
March	33.9	20.2	26.5	96	11	61
April	35.8	23.8	29.3	100	14	58
May	37.0	24.1	30.0	91	4	57
June	40.2	25.8	32.2	97	3	53

Palyvos et al., 2008).

It has been detected previously in wheat (El-Desouky, 1991; Athanassiou et al., 2005), bran (Al-Nasser 2007, Saleh et al., 1985; Baker, 2000; El-Desouky, 1991) wheat flour (Al-Nasser, 2007; Saleh et al.,1985; El-Sayed and Ghallab, 2007; Putatunda, 2005) rice (Al-Nasser AS, 2007), Saleh et al.,1985), maize, broad bean and rough rice (El-Sayed and Ghallab, 2007), grain residue (Putatunda, 2005; Palyvos et al., 2008; Hubert et al., 2006) and, different grains (Mahgoob et al., 2006; Habibpour et al., 2002), in stores dust (Zheltikova et al., 1997).

A previous study reported that there is a significant positive correlation between the occurrence and population density of the predatory and pest mites, indicating that the occurrence of Cheyletus predators and their prey are either density dependent or regulated by the same physical factors such as temperature, humidity and cleaning, and that decreasing temperatures decrease the development of *Cheyletus* spp. more rapidly than those of pest mites (Lukas et al., 2007).In the present study, it was obvious that increasing temperature and relative humidity were the reason for decreasing the development of the predatory mite because of the hot weather in Jeddah during the sampling period.

B. tarsalis and *B. keegani* were detected in small numbers during the present study and were not detected in the North nor the Middle; belonging to the family Ascidae, *Blattisocius* species were predators which feed on eggs of different grain beetles (*Tribolium confusium, T. castaneum* and *Oryzoephilus surinamensi*) (Barker, 1967), and on the eggs of Acarids mites (Thind and Ford, 2006).

B. keegani was reared on two stored grain mites Fawzy MMH, 1996), *Suidasia nesbetti* (Hughes) and *Grammolichus aegypticus* Shereef and Fawzy. The same species was reared on the larval stages of *Tyrophagus putrescentiae* (Schrank) and *Rhizoglyphus robini* Claparéde (El-Sanady, 2005).

Previous studies recorded the presence of *Blattisocius* species in different stored foodstuff: bean (Saleh, 1980), wheat bran (Saleh et al., 1985), bran (Baker, 2000), Athanassiou et al., 2001), rice and barley (Al-Nasser, 2007), maize, wheat flour, wheat, broad bean and rice (El-Sayed and Ghallab, 2007).

Decrease of mite numbers observed in the current study could be related to the climatic conditions during the seasons of sampling, which were inconvenient to the development and reproduction of the mites. We suggest that the components of wheat flour and its moisture content could be effective in decreasing the mites' numbers. Previous study mentioned that the environmental and storage conditions may influence food contamination and mite development (Brazis et al., 2008).

A study on dust mites in groceries related the presence of mites in high numbers to the moisture, mould damage or lack of cleaning and they reported that having no mites in a sample does not mean that there are no mites in the premises because mite densities can be low or the sampled location may not be ideal for mites to thrive.

Conclusion

The previous discussed results provide limited but important information concerning the presence of mites in stored foodstuff especially wheat flour and their possibility to affect human health if handled, inhaled and/or ingested. Despite the decreasing rates of mites during the sampling period of this study, nevertheless, mites and their allergen could increase and accumulate in the infested wheat flour during the prolonged periods of storage especially if the climatic conditions were convenient for their development and reproduction.

There is a need to undertake similar studies on a wide range of foodstuff and to investigate the levels of mites allergen in food and to establish the threshold for allergic response with consideration to the prolonged period of storage and to the climatic changes (temperature and relative humidity) throughout the year which might be somehow convenient for the development and reproduction of mites and cause an increase in their population and allergen in the foodstuff.

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