Pakistan J. Zool., vol. 45(2), pp. 317-321, 2013.

Humidity Dependent Population Growth of the Psocid, *Liposcelis yunnaniensis* (Psocoptera: Liposcelididae)

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Abstract.- We investigated the effect of four different humidities on population growth of the psocid *Liposcelis yunnaniensis* (Psocoptera: Liposcelididae). The four different relative humidities used were 43, 55, 63, and 75%, respectively. In a 30-d period the initial four female psocids increased to the mean populations of 24±5.72 on 75% humidity and 21±3.45 on 63% humidity. The psocids developing on the humidity of 43 and 55% showed no increase in their population and all the adult female psocids died. The results showed that population growth was highest on higher humidities and the lower humidities of 43 and 55% lead to the death of the insects. According to the analysis of variance there was no significant difference in the population growth between the higher humidities of 75% and 63% RH. An analysis was also done with respect to the psocids placement in 4 different compartments of the incubator from top to bottom. It was found that there was no statistical difference in population growth of the psocids in different chambers of the desiccators which could be due to any variation in temperature inside the incubator. Psocid population growth is explained graphically with respect to different humidities and its placement on different heights of incubator.

Key words: Relative humidity, population growth, stored product Psocids, *Liposcelis* management.

INTRODUCTION

Unlike in the previous decades, stored product psocids have become prominent and have received much attention around the world in recent years. Psocids of family Liposcelididae have been reported worldwide: United Kingdom (Turner, 1994), Spain (Pascual-Villalobos *et al*., 2005), Australia (Rees, 2002), Mexico (Garcia Aldrete and Gutierrez Diaz, 1995), the United States (Mockford, 1991), Zimbabwe (Mashaya, 2001), and some Asian countries (Indonesia, Malaysia, Singapore, Philippines, Thailand, China, and India (Rajendran, 1994; Rees, 1994; Leong and Ho, 1995; Wang *et al*., 1999). Their rise into prominence could be due to the fact that these have shown resistance to residual insecticides and fumigant phosphine (Nayak *et al*., 1998, Nayak and Collins, 2008) and markets regard them increasingly as contaminants (Nayak, 2006). Stored-product protectants such as pyrethroids, carbamates as well as organophosphate insecticides have been shown to be ineffective against stored-product psocids (Nayak *et al*., 2003, Wang *et al*., 2004) and novel insecticides such as spinosad are only effective when mixed with other compounds, for example, to increase its efficacy to the desired levels (Nayak *et al*., 2005; Nayak and Daglish, 2007).

Stored cereal grains remain heavily infested with psocids which are favored by the hot and humid conditions such as those existing in tropical areas of the world (Wang *et al*., 1998). Psocids have a relationship with the humid conditions and are typically seen in moist areas. The bodies of *Liposcelis* species contain water which is directly proportional to the humidity in the ambient environment. An environment containing less than 58% RH is regarded as dry atmosphere for psocids residing indoors and above this critical RH, psocids have to utilize food energy to transport water vapour into their bodies, enabling them to replace transpired water vapour and maintain body mass even in the absence of food that contains water (Knülle and Spadafora, 1969). In high humidity, their life spans range from six months to a year (Broadhead and Hobby, 1944). Their egg laying can be stopped by lowering the surrounding humidity (Knülle and

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0030-9923/2013/0002-0317 $ 8.00/0

Spadafora, 1969). The most reliable way to eliminate psocids and moulds is to dehumidify the building and affected objects. Further the lower humidity can be used in connection with other management practices to get a better overall result (Nayak and Collins, 2008; Ahmedani, 2009). *Liposcelis yunnaniensis* (Psocoptera: Liposcelididae) species have been found infesting a wheat warehouse in Inner Mangolian Autonomous Region of China. Recently we have studied its biology and life history parameters with respect to constant regime of temperature. Hinton (1981) stated that in most insects at normal temperature, there is fairly restricted range of humidity when most eggs will be laid, humidity above or below this optimum range tend to have an adverse effect on oviposition behaviour of the insects. For *L. yunnaniensis* data regarding population growth of the species when reared on a range of humidity at a common temperature is lacking. Therefore this study was initiated to assess the population growth of this species on four different humidities ranging from 43, 55, 63, and 75% kept at a constant temperature of 30°C. The results would declare the comparative population growth of this psocid species at the given range of relative humidites.

MATERIALS AND METHODS

Psocid source

Stock colonies of *L. yunnaniensis* were obtained from nymphs collected from wheat, *Triticum aestivum* L., warehouse in the Inner Mongolian Autonomous Region, China, in 2008. The colonies were maintained on a diet consisting of whole wheat flour, skim milk, and yeast powder (10:1:1) in a temperature controlled room at 28±1°C and with a scotoperiod of 24 h. Cultures were maintained in glass bottles (250 mL) with a nylon screen cover and kept in desiccators (5,000 mL) in which the humidity was controlled with saturated NaCl solution at 75-80%. The identity of *L. yunnaniensis* was confirmed by Wang (Southwest University, Chongqing, China). Voucher specimens were deposited at the insect collection of Southwest University, Chongqing, China, under lot numbers 50 (males) and 60 (females).

Obtaining homogeneous age adult females

Liposcelis yunnaniensis species is known from both sexes but we needed only 1-2 week old females to set up this experiment. To obtain 1-2 week old females, ten adults (both males and females) were aspirated each of 80 plastic boxes (2cm diameter and 1cm high) provided with a small amount of our laboratory diet. The boxes were placed in Petri dishes which were put in the desiccators in which humidity was maintained with saturated NaCl solution (70-80%) and desiccators were placed into incubators at 27±0.5°C and a scotophase of 24 h.

After 48 h, the eggs laid by females were transferred gently with a camel hair brush into 0.5 litre glass jar containing small amount of our laboratory diet. The jar was covered with a silken cloth because it prevents psocids from escaping while air and moisture can move through the jar. Thus jar was placed again into the incubator. After 38 days, psocids were about 2 weeks old because based on our previous experiments it takes ≈ 24 d at 27±0.5°C to complete their development form egg to adult (Hassan *et al*., 2010).

Experimental set up

There were 4 different humidities which were maintained using four different salts solutions (Greenspan, 1977) inside the desiccators namely; NaCl (Chongqing Chem. Co. Ltd, China); $NaNO_2$ (Tianjing Beichen Chem. Ltd, China); NaBr (Hunan Changsha Chem. Ltd, China) and K_2CO_3 (Shanghai Chem. Ltd, China); All the reagents were of analytical grade. The saturated salt solutions were obtained by using distilled water as a solvent. When no more solute could be dissolved in the solvent the solution was regarded as saturated solution of the given salt. The experiment was laid in a randomized complete block design (RCBD). There were 4 replications for each salt solution and sixteen desiccators in total. The incubator was divided into 4 chambers from top to bottom to minimize the risk of any variation in temperature. The desiccators were placed inside of the incubator in such a way that each chamber received all four salt solutions. The temperature of incubator was set at 30±1°C and humidity source of the incubator was turned off.

Inside the incubator was placed a thermometer as well to check the inside temperature.

Four plastic vials (3 cm diameter and 5 cm high) containing 4 adult females (aged 2 weeks) with 2 g of our laboratory diet, were placed in side each desiccators and the psocids were left to grow for a period of up to one generation ≈ 24 d.

RESULTS AND DISCUSSION

After 24 d, the psocids growing on NaCl and $NaNO_2$ salt solutions increased to the mean populations of 24±5.72 and 21±3.45, respectively. But the psocids growing on K_2CO_3 and NaBr did not show any increase in their population and all the females were dead in this period. Therefore data from these salts was excluded from analysis. The statistical analysis of the psocid populations growing on higher humidities showed that these were not statistically different (Table I, P>0.05). Our results are similar to those found for some other psocid species; *Liposcelis brunnea, L. rufa, L. pearmani, and Lepinotus reticulatus* (Opit and Throne, 2009; Gautam *et al*., 2010; Aminatou *et al*., 2011; Opit and Throne, 2008), which were unable to survive at 43% RH at given temperatures for their growth or development. Similarly, *Lepinotus reticulates, L. rufa and L. pearmani* did not survive at 55% relative humidity at different temperatures. The literature shows that the relative humidity of 55% remained unfavorable for the above mentioned stored grain psocid species which is similar to our current findings for *L. yunnaniensis*. Saha *et al.* (2012) reported that the predators associated with stored grain insect pests in stored grain ecosystems are affected in the same fashion due to temperature and humidity variations as do their preys. They studied the mortality, fecundity and developmental rate of *Xylocoris flavipes* (Hemiptera: Anthocoridae) on 30 to 90% relative humidity range. They found that for all the studied parameters relative humidity played a significant role and a humidity of 70% remained optimum for most cases and extremely low or high relative humidites of 30 and 90% had negative effects.

Our results about psocids' preference of higher humidities are in agreement with many previously reports about psocids (Back, 1920; Rees and Walker, 1990; Mashaya, 2001; Nayak and Collins, 2008; Opit *et al.*, 2009, 2010). Thus this is well established here by this experiment that all stored product psocids species including *L. yunnaniensis* are sensitive to lower humidities particularly below 60 % R. H. and keeping this fact in mind such pests can be well managed if humidity conditions are kept below their tolerance level and this is suggested that such environmental factors as humidity should be incorporated in to integrated pest management program along with other control measures to get better control results for management of stored grain psocid pests.

Table I.- Statistical results of salts and chambers for *L. yunnaniensis*'s population growth

Source	*df*	*SS*	*MS*	*F*	*P*	
Salts	1	55.1	55.13	0.143	0.7076	>0.05
Chamber	3	343.2	114.42	0.2982	0.8264	>0.05
Residual	27	10359.1	383.67			

P > 0.05 means that population growth of psocids did not different statistically with respect to salts as well as chambers
Cumulative Mean population growth on NaCl = 24±5.72 & $NaNo_2$ = 21±3.45

Table II.- Means ± SE of population growth of psocids on respective salts and replications

Replication	NaCl	$NaNo_2$
R_1	20 ± 8.43	24 ± 6.60
R_2	36 ± 14.43	18 ± 8.67
R_3	23 ± 14.40	20 ± 8.05
R_4	14 ± 9.25	20 ± 6.87

The statistical analysis of the data from top to bottom showed that there was no significant difference in population growth of the psocids when placed in any designated chamber (R_1 to R_4) of the incubator from top to bottom. Therefore, it is concluded that there was not any remarkable variation in temperature or humidity among the replications inside the incubator that could affect the population growth of this species (Table I, P > 0.05; Fig. 1). Large size insect growth chambers or incubators may have variation in temperature or humidity and these may lack the uniformity of these conditions throughout the incubator. This is due to the fact that when a large size growth chamber is

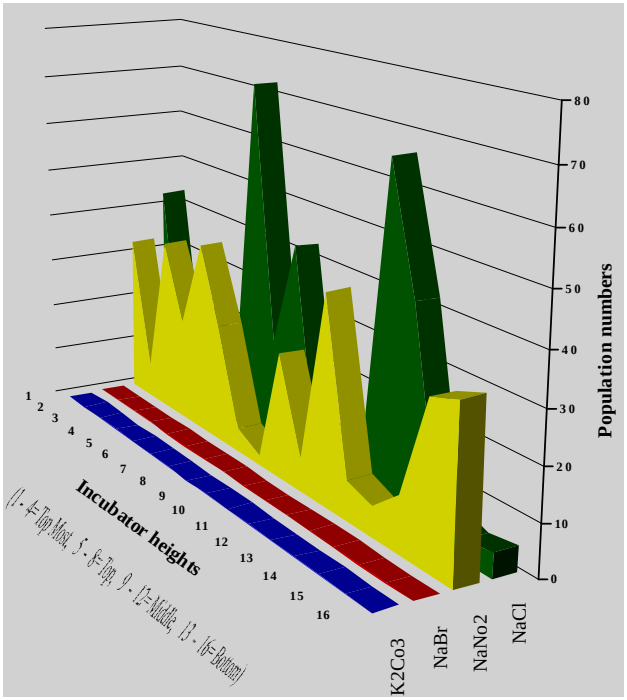

Fig. 1. Increase in number of psocids in 24 d period from an initial 4 adult females. Every height represents a chamber of incubator containing one replication. Numbers in the figure show an original increase in number of psocids from an initial of 4 adult females in each plastic box.

totally filled with glass desiccators from top to the bottom the forced air system may not distribute heat or humidity evenly through out the system which may result in slight changes in these conditions in different shelves of the incubator. Insects have a quite restricted range of environmental conditions which influence their oviposition behavior thus affecting fecundity and population growth (Hinton, 1981). This is an important study regarding comparison of insect population growth with respect to different relative humidities and its comparison in different parts of growth chamber. We recommend that in future studies in order to avoid any likely fluctuation in temperature or humidity inside growth chambers replications of treatments should be done in growth chambers from top to bottom.

ACKNOWLEDGEMENTS

This study was funded in part by the National Natural Sciences Foundation of China (31000860). We are thankful to the anonymous reviewers for their useful comments about the manuscript. We are also thankful to Mr. Sami Ullah, University of Sargodha, Pakistan for giving suggestions about statistics.

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(Received 2 June 2012, revised 16 January 2013)