Pakistan J. Zool., vol. 48(6), pp. 1989-1992, 2016.

Short Communication

First Report on Mosquito Parasitic Mites in Saudi Arabia

Essam Abdel-Salam Shaalan,[1,2]* Gamal Bekhet,[1,3] Zeinab Abdelmoaty[1,3] and Nazni Wasi Ahmad[4]

[1]*Biological Science Department, Faculty of Science, King Faisal University, Al-Ahsaa 31982, Saudi Arabia.*
[2]*Zoology Department, Faculty of Science, Aswan University, Aswan 81528, Egypt.*
[3]*Zoology Department, Faculty of Science, Alexandria University, Alexandria, Egypt.*
[4]*Medical Entomology Unit, Institute for Medical Research, Jalan Pahang, 50588 Kuala Lumpur, Malaysia.*

Article Information
Received 18 April 2015
Revised 28 April 2016
Accepted 22 May 2016
Available online 20 October 2016

Authors' Contribution
EAS and GB conceived and designed the project, collected samples and performed the field work. EAS performed laboratory work, identified samples, analyzed data and wrote the article. ZA and NWA only reviewed the manuscript.

Key words
Parasitism, Aquatic Mites, Mosquitoes, *Culex pipiens*

ABSTRACT

Mites are known to be parasitic on both invertebrate and vertebrate animals and mites that parasitize mosquitoes are recorded in a few places worldwide. Immature stages of mosquitoes were collected from different breeding habitats in Al-Ahsaa Oasis, eastern region of Saudi Arabia then identified into species and preserved for further EM studies. Micrographs revealed the parasitism of an aquatic mite species on the *Culex pipiens* mosquito pupa. Such result revealed for the first time the record of mosquito parasitic mite in Saudi Arabia. Both parasitism of mites and its influences on mosquitoes as well as possibility to use as biological control agent for mosquito immatures are discussed.

Mites are considered as the most numerous, diverse, and ecologically important group of freshwater arachnids. More than 5000 species of aquatic mites are currently recognized worldwide (Smith *et al.*, 2001). They are found in a wide range of aquatic bodies such as stagnant and temporary pools, streams, springs, lakes, marshes, swamps, and brackish habitats. The life cycle of aquatic mites includes a parasitic larval stage and predatory nymphal and adult stage (Proctor, 2009). Such parasitic larva of almost all aquatic mites parasitizes hosts from a number of different aquatic insects including Diptera (Smith *et al.*, 2001; Proctor, 2009; Mumcuoglu and Braverman, 2010; Shatrov, 2012), Trichoptera (Smith *et al.*, 2001), Plecoptera (Smith *et al.*, 2001), Coleoptera (Smith *et al.*, 2001), Hemiptera (Smith *et al.*, 2001; Proctor, 2009) and Odonata (Leung *et al.*, 1999; Forbes *et al.*, 1999; Smith *et al.*, 2001; Mayoral and Barranco, 2012; Zawal and Buczynski, 2013). Mites larvae can detect their hosts over a short distance by responding to water currents, to shadows or to chemical cues whilst others depend on accidental contacts (Smith, 1988). This parasitism relationship produces adversely effects on developmental rate, lifespan, and egg production in a wide range of hosts in the orders Odonata, Hemiptera, and Diptera (Proctor, 2009).

Larval aquatic mites, mostly many species of *Arrenurus*, parasitizing 10 mosquito genera inhabiting different aquatic habitats are shown in Table I. Additionally, parasitic mites have an influence on mosquitos biological parameters and emergence. Both *Arrenurus* sp. and *Nilotonia* sp. larvae were found to influence the quantity of blood ingested, survivorship and the time lag between feeding and egg-laying in female mosquito species of *Mansonia uniformis*s (Rejendran and Prasad, 1992). Smith and Mclver (1984) found that both *Ar. Kenki* Marshall and *Ar. angustilimbatus* Mullen mite larvae had significant influence on the emergence of *Aedes* mosquitoes.

The present work reports and describes for the first time both parasitism of mosquito pupa by *Arrenurus* mite and the record of such parasitic mite in Saudi Arabia.

Materials and methods

The present study was carried out in Al-Ahsaa district situated in the eastern region of the Kingdom of Saudi Arabia. Seasonal collections were made from mosquitoes breeding places in four localities (Al-Bataliyah, Al-Jafr, Al-Jishshah, Ar-Rumaylah and Ash-Shu'bah) representing rural areas during March 2012 to March 2013 by means of long dipper. Collected larvae were left inside water from such breeding sites inside labeled plastic containers then taken to the laboratory.

Larvae were examined and identified according to keys of Abdel-Maleck (1956), Mattingly and Knight (1956), Gad (1963) and Harbach (1985, 1988) then they left for pupation. Some pupae were preserved in fixative (glutaraldehyde) for Scanning Electron Microscopy

* Corresponding author: eshaalan@kfu.edu.sa
0030-9923/2016/0006-1989 $ 8.00/0

(SEM) studies whilst the others were left to adult emergence then preserved for SEM as well.

Specimens were prepared for electron microscope studies according to method of Adham *et al*. (2013) but with slight modifications. Mosquito pupae were placed in a prefixative solution (2.5% glutaraldehyde in 0.1 M. acodylate buffer pH 7.4) and fixed for at least 2 hours at 4°C and subsequently were washed three times with calcium carbonate buffer for 5 min each. The specimens were dehydrated two times in a graded ethanol ascending series (50%, 70%, 80%, 90%, 95% and 100%) for 5 min each. After dehydration, ethanol was substituted by t-butyl alcohol 5 min each for three times. Specimens were dried in critical point dryer (freeze drying device, JFD-320 JOEL) then attached to double coated carbon conductive tape and coated with sputter coater (auto fine coater JFC-1600 JOEL). Scanning of specimens was carried out using a scanning electron microscope (JSM 6390 LA, JOEL) at 80 kv.

The mite specimen was identified by using of keys produced by Hopkins (1961), Proctor (2006), Zawal (2008) and Harvey and Proctor (2013).

Results

Mites encountered in the present work parasitizing *Culex pipiens* pupa (Fig. 1) were collected from Al-Bataliyah village on March 17, 2013. It was found attached to the *Cx. pipiens* pupa cephalothorax. Although identification of mite larva to species is extremely difficult, utilizing different keys for mites identification (Hopkins, 1961; Proctor, 2006; Zawal, 2008; Harvey and Proctor, 2013) revealed that this mite species belonging to the genus *Arrenurus*. Encountered mite's larva anchored, embedded and cemented itself to the pupal cephalothorax through their chelicerae (Fig. 1B) in a behavior common to *Arrenurus* spp. (Smith, 1988).

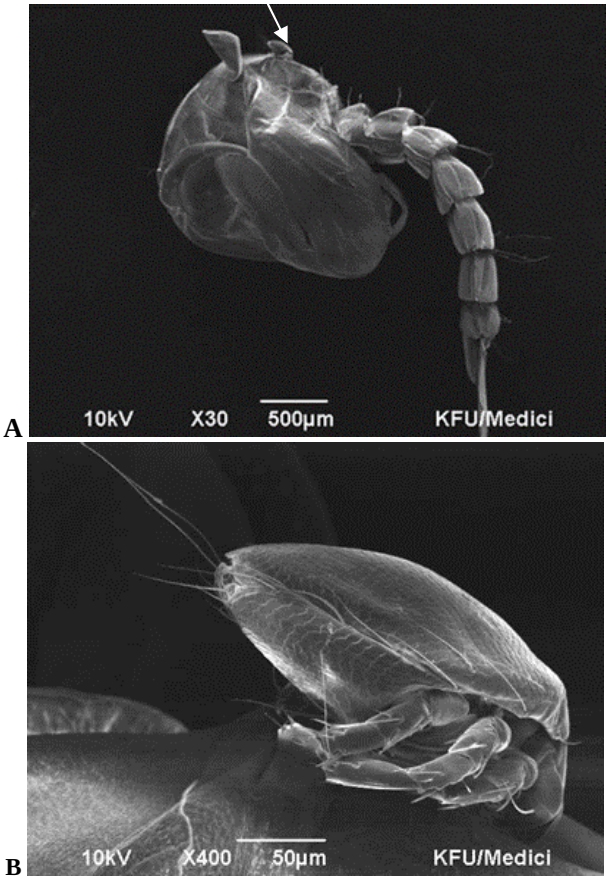

Fig. 1. Scanning electron micrograph of larva of parasitic mite (A) attached to the *Culex pipiens* pupa cephalothorax (B).

Discussion

The mite–host association presented here are novel, and it is the first time to record mites parasitizing mosquito pupa. Furthermore, it is also the first time to record such mosquito parasitic mite in Saudi Arabia.

Larvae of many aquatic mites exhibit strong selectivity for attaching to particular sites on the body of the host (Smith *et al*., 2001). The location depends primarily on mite species but can vary with the host species or even host's gender (Smith, 1988). Similarly, literatures revealed that site of larval mites' attachment on mosquitoes vary according to both mosquitoes and mites species. In the adult mosquitoes, larval mites were most commonly found attached to the posteroventral region of the thorax near the junction of the abdomen (89%), followed by attachment at the neck region (Spurrier, 1998). Kirkhoff *et al*. (2013) mentioned that most *Parathyas barbigera* individuals were attached on the pre-abdominal region and when not in this position, they were attached anterior on the thorax, and less commonly on the cervix or abdomen. Most *Ar. danbyensis* and *Ar. delawarensis* individuals were attached to the cervix region. *Ar. danbyensis* on *Coquillettidia perturbans* had mean and maximum intensities of 2.8 and 31, and showed a clear trend in attachment site distribution, with sequential progression from head to abdomen. Linam (1962) mentioned that 29 immature hydracarina mites were found on the dorsal and lateral sides of the first 7 abdominal segments. They were all attached on the intersegmental membrane specifically on the dorsal. Mullen (1977) pointed out that larvae of the parasitic mite *Thyasides sphagnorum* typically attaches to adult mosquitoes as they emerge from the pupal stage, in contrast to *Thyas barbigera* which normally attaches to ovipositing females. In contrast to these studies, larval

Table I.- Larval aquatic mites parasitizing mosquitoes.

Mosquito Species	Sex	Mite family or species	Reference
21 mosquito species representing *Aedes*, *Anopheles*, *Coquillettidia*, *Culex*, *Ochlerotatus*, *Orthopodomyia* and *Psorophora*	Male and female	1 *Parathyas* sp. and 7 *Arrenurus* spp.	Kirkhoff *et al*. (2013)
Anopheles annulipes and *Culex quinqufasciatus* (mosquitoes that use ground pools for larval habitat)	Females	Larva of Arrenuridae	Williams and Proctor (2002)
Ochlerotatus notoscriptus and *Tripteroides atripes* (tree-hole and container-breeding species)		Larva of Hydryphantidae	
Culex annulirostris and *Ochlerotatus chomptorhynchus*		Larva of Erythraeidae	
Aedes dorsalis, *Culex tarsalis* and *Culiseta inornata*	Male and female	Larvae of *Thyasides sphagnorum*	Spurrier (1998)
Mansonia uniformis	Female	*Arrenurus* sp. *Nilotonia* sp.	Rajendran and Prasad (1992)
Aedes spp.	Male and female	*Arrenurus kenki* *Arrenurus angustilimbatus*	Smith and Mclver (1984)
Anopheles crucians	Female	*Arrenurus* sp.	Lanciani (1979)
9 *Aedes* species	Female	Larvae of *Thyas barbigera*	Mullen (1977)
4 *Aedes* species and *Culiseta morsitans*	Both sexes	*Thyasides sphagnorum*	
9 mosquito species representing *Aedes* (8) and *Culiseta* (1)	Female	Not identified	Graham (1969)
Culex tarsalis	Female	Hydracarinidae	Linam (1962)

mite collected in the present work was found attached to the cephalothorax region of the *Cx. pipiens* pupa.

Although *Arrenurus* is one of the most common water mite genera occurring in most geographical regions, it lacks the cosmopolitan species and each region supports its own set of species (Zawal, 2008). For instance, Europe is inhibited by 152 *Arrenurus* species. Accordingly, it could be concluded that the aquatic mite fauna of Saudi Arabia could be differentiated and further studies may lead to discovering new species and even new genera. Further studies are recommended for better understanding the mosquitos-mites relationship and it would be interesting because little work has been done on this aspect in Saudi Arabia.

Conclusions

In conclusion, it is expected that the nuisance capability of parasitized female mosquitoes may be greater than that of non-parasitized female mosquitoes. This could be due to compensation for nutritional loss to mites therefore they may be visiting more hosts making them more effective disease vectors. Accordingly, such parasitized mosquitoes will bite more frequently but also will have a lower survivorship than non-parasitized ones. Vice versa, particularly in immature mosquitoes, parasitized individuals may suffer increased mortality due to either a slower response by the mosquito to its host defense mechanism or predation. Unfortunately, the low mite prevalence and abundance demonstrated in this study indicate no potential for successfully utilizing mites as a control agent.

Acknowledgment

This specimen was collected as a part of a scientific project "utilizing electron micrographs of mosquitoes developmental stages as taxonomic features" supported by research grant "130167" from Deanship of Scientific Research, King Faisal University, Saudi Arabia.

Our thanks go to the technician Youssif El-Gasem, Biological Sciences Department, College of Science, King Faisal University, Saudi Arabia for his assistance in collecting mosquitoes. We also appreciated to Dr. Walid Al-Melhim and technician Hani Al-Rosassi, Electron microscope Unit, College of Medicine, King Faisal University, Saudi Arabia for their assistance in preparing samples and conducting micrographs.

Statement of conflict of interest

Authors have declared no conflict of interest.

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