The first report of storage mites, *Caloglyphus hughesi* (Acaridae) on laboratory-reared *Aethina tumida* Murray (Coleoptera: Nitidulidae) in South Africa

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Small hive beetles, *Aethina tumida* Murray, (Coleoptera: Nitidulidae) are native to sub-Saharan Africa where they parasitize honey bee (*Apis mellifera* L) colonies (Lundie 1940). Small hive beetles feed on pollen, brood and honey inside honey bee hives (Lundie 1940). Pupation occurs in the soil and the transitions from larvae to pupae to adult are vulnerable stages in the developmental cycle of small hive beetles (Lundie 1940; Hepburn & Radloff 1998; Neumann & Elzen 2004). Small hive beetles can potentially be transporters of mites and one example of such an association is an undescribed *Caloglyphus* sp. from the U.S.A. that is phoretic on the scarab beetle, *Phyllophaga anxia* (Jarvis 1964). Phoresy is the term used to describe the exploitation by mites of beetles or other insects as a means of transport from an unfavourable habitat to a more favourable one (Delfinado & Baker 1975).

Mites (subclass: Acari) are extremely abundant arachnids and can be found in almost any habitat type, but are rarely noticed due to their small size (0.5 to 1 mm) (Hughes 1976; Fain 1994). They are known to be common soil inhabitants and can thrive in humid and hot environments (Chmielewski 2003). Food sources of mites include microorganisms such as fungi and bacteria which are associated with rotting plant and animal tissues (Christensen & Kaufmann 1969; Erban & Hubert 2008). Mites are furthermore known predators of nematodes and have also been observed feeding on beetle larvae (Coleoptera: Scarabaeidae) as well as on the nematodes responsible for killing the adult scarab beetles (Karagoz *et al.* 2007). Other host associations of mites include Hymenoptera, Orthoptera, Myriapoda, and terrestrial Crustacea (Klimov *et al.* 2004).

A small hive beetle laboratory rearing programme (Neumann *et al.* 2001) was conducted in an incubator (±33 °C, 55–66 % relative humidity) at the University of Pretoria, South Africa in 2009 from March–October. Ten small hive beetles, five males and five females were collected from hives at the Experimental Farm of the University of Pretoria. Additional beetles were collected as required to supply other experiments. Small hive beetles were reared on bananas, honey and pollen (stored at –20 °C for six months before being used as a rearing medium). Larvae in the wandering stage were transferred to fresh soil (commercially available: a single package of soil used for the last four years for small hive beetle rearing) kept moist in a covered container to pupate. Fresh soil and containers were used for each breeding attempt. During the month of September 2009 we unexpectedly found all life stages of the mite, *Caloglyphus* (= *Sancassania*) *hughesi* Samsinak (Figs 1–6) in the culture on small hive beetle larvae, pupae and to a lesser extent on adults.

Caloglyphus hughesi (suborder: Astigmata, family: Acaridae) is classified as a storage pest and was first described on rice bran, imported from Burma (Hughes 1976). *C. hughesi* has been found in tamarind, imported from Thailand into the U.S.A. (Olsen 1983), mushroom cultivating material (China) (Zou & Wang 1989), stored grains (Indonesia) (Haines 1995) and soil samples collected on farms (Germany) (Franz *et al.* 1997). They have also been reported in human urine samples (China) (Li *et al.* 2003), stored food products (Cuba) (Cuervo & Almaguel 2004) and supermarket products (Brazil) (De Sousa. *et al.* 2005).

The length of the idiosoma which consists of the alimentary canal, reproductive organs and nervous system of females is ±500–700 μm and that of males is ±400–500 μm (Hughes 1976). Most dorsal setae of both male and female *C. hughesi* have rounded spatulate ends (Hughes 1976).

Little is known about the biology of *C. hughesi,* but females of a closely related species, *C. berlesei,* can lay 213 eggs in 24 hours (Hughes 1976). Their life cycle lasts from 2–3 weeks (hypopi absent) to several months (hypopi present) (Chmielewski 2003). A fascinating biological characteristic of the

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Fig. 1. Scanning electron micrograph of hypopus and adult stage of *Caloglyphus* (= *Sancassania) hughesi.*

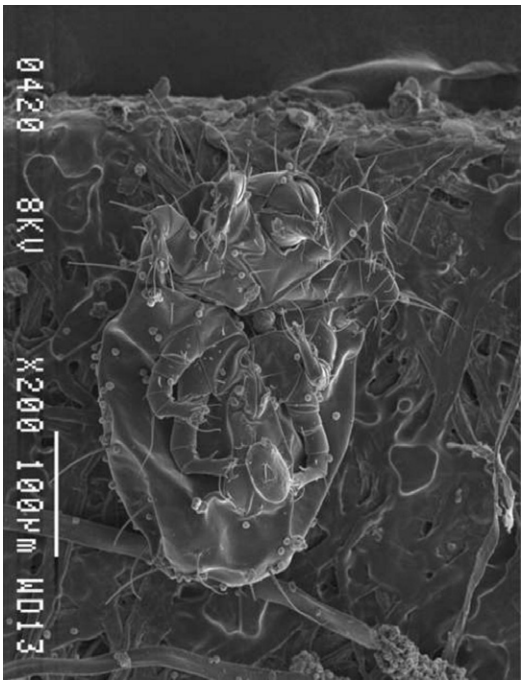
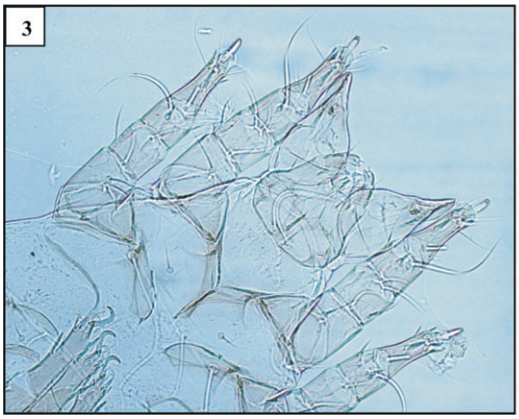


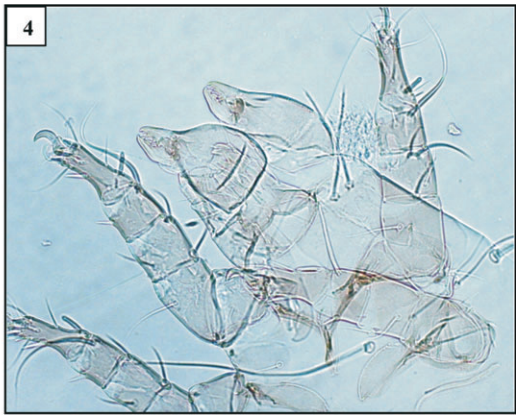
Fig. 2. Scanning electron micrograph of the adult stage of *Caloglyphus hughesi.*

genus *Caloglyphus,* typical of the Acaridae, is the development of hypopi (heteromorphic deutonymphs) (Figs 1, 5) under unfavourable conditions (Griffiths 1966; Chmielewski 2003). Hypopi, active or inert forms, are especially adapted for the dispersal and survival of mites (Hughes 1976; Corente & Knulle 2003). The inert form remains within the environment in which it was formed and can be resistant to dehydration and starvation over extended periods while active hypopi are transmitted or transported by wind or insects (Griffiths 1966; Chmielewski 2003).

Larvae, nymphs and adults of *C. hughesi* were observed feeding on small hive beetle larvae and pupae in the soil. Mites were also found under the wings and on the abdominal segments of newly emerged adult small hive beetle. We observed hypopi on the larvae, in the soil taken from the culture, and on the lids of the containers. In addition we observed eggs (Fig. 6), larvae, nymphs, including hypopi inside the bodies of female mites (in contrast to normal development outside the female body), a phenomenon common to this genus (Chmielewski 2003).

Mite-infested small hive beetle larvae and pupae were removed from the soil and the number of mites present was counted using a binocular dissecting microscope. We found three dead pupae infested





Figs 3–4. Close-up views of two different *Caloglyphus hughesi* females showing their upper body regions with their mouthparts, claws, setae and legs (magnification ×20).

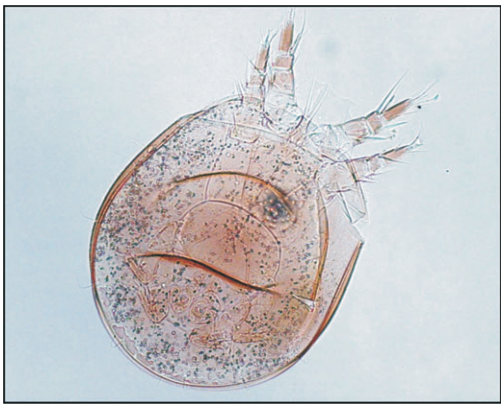


Fig. 5. Dorsal view of the hypopus (heteromorphic deutonymph) of *Caloglyphus hughesi* (magnification ×20).

with mites and they had on average 165 ± 177.5 mites per pupa. Over a period of 14 days, 42 dead larvae were examined, and they had on average 51 ± 97.5 mites per larva. The number of mites counted on either pupae or larvae ranged from a single mite up to a maximum of 535 mites. Mites were nearly exclusively found on dead larvae and were rarely observed on live larvae. The reason for the death of the larvae is unknown.

Rearing conditions provided to small hive beetles were also ideal for rearing *C. hughesi.*

The infestation affected small hive beetle emergence and survival (U. Strauss & H. Human, pers. obs.) since a smaller number of adult small hive beetle emerged from the soil during this period. It may very well be that the mites were just opportunistic feeders, feeding on a readily available food source. This is possible given the fact that most of the astigmatid mites are scavengers (Eickwort 1988). They are also quite common in honey bee hives where they feed on pollen, dead honey bees and hive debris without causing any obvious damage to strong colonies (Eickwort 1988). However, information on this particular species is scanty and the literature mostly refers only to the genus *Caloglyphus* and not the species *C. hughesi.* Since the soil and food used in the present culture seems an unlikely source of the mites, it appears that the original source of the mite infestation was the adult small hive beetle collected in the field for the rearing programme, suggesting that small hive beetles can be carriers of these mites.

Fig. 6. Ventral view of a female *Caloglyphus hughesi* with developing egg (magnification ×10).

The association, if any, between small hive beetle and *C. hughesi,* as well as *C. hughesi* and honey bees in the natural environment, still needs to be investigated and confirmed. To the best of our knowledge this is the first report of *C. hughesi* in South Africa, the first description of a potential association with honey bees, and finally the first information on these mites being associated with and feeding on small hive beetle larvae and pupae reared in the laboratory.

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REFERENCES

CHMIELEWSKI, W. 2003. Effect of buckwheat sprout intake on population increase of *Caloglyphus berlesei* (Michael) (Acari: Acaridae). *Fagopyrum* **20**: 85–88.

CHRISTENSEN, C.M. & KAUFMANN, H.H. 1969. *Grain Storage: The Role of Fungi in Quality Loss.* University of Minnesota Press, Minneapolis.

CORENTE, C.H. & KNULLE, W. 2003. Trophic determinants of hypopus induction in the stored-product mite *Lepidoglyphus destructor* (Acari: Astigmata). *Experimental and Applied Acarology* **29**: 89–107.

CUERVO, N. & ALMAGUEL, L. 2004. Composicion taxonomica de los acaros domesticos de Cuba. *Fitosanidad* **8**: 33–36.

DELFINADO, M.D. & BAKER, E.W. 1975. Mites (Acarina) associated with *Popilius disjunctus* (Illiger) (Coleoptera: Passalidae) in Eastern United States. *New York State Museum and Science Service Journal Series* **83**: 49–59.

DE SOUSA., J.M., GONDIM, M.G.C., BARROS, R. & DE OLIVEIRA, J.V. 2005. Mites in stored foods commercialized in supermarkets and markets in Recife. *Neotropical Entomology* **34**: 303–309.

EICKWORT, G.C. 1988. The origins of mites associated with honey bees. In: Needham, G.R., Page, R.E., Delfinado-Baker, M. & Bowman, C.E. (Eds) *Africanized Honey Bees and Bee Mites.* 327–338. Ellis Horwood, Chichester, England.

ERBAN, T. & HUBERT, J. 2008. Digestive function of lysozyme in synanthropic acaridid mites enables utilization of bacteria as a food source. *Experimental and Applied Acarology* **44**: 199–212.

FAIN, A. 1994. Adaptation, specificity and host-parasite-coevolution in mites (Acari). *International Journal for Parasitology* **24**: 1273–1283.

FRANZ, J.T., MASUCH, G., MUSKEN, H. & BERGMANN, K.C. 1997. Mite fauna of German farms. *Allergy* **52**: 1233–1237.

GRIFFITHS, D.A. 1966. Nutrition as a factor influencing hypopus formation in the *Acarus siro* species complex (Acarina, Acaridae). *Journal of Stored Products Research* **1**: 325–340.

HAINES, C.P. 1995. Grain storage in the tropics. In: Jayas, D.S., White, N.D.G. & Muir, W.E. (Eds) *Stored Grain Ecosystems.* 55–100. Marcel Dekker, New York.

HEPBURN, H.R. & RADLOFF, S.E. 1998. *Honeybees of Africa.* Springer, Berlin.

HUGHES, A.M. 1976. *The Mites of Stored Food and Houses.* Ministry of Agriculture, Fisheries and Food. Technical Bulletin **9**. Her Majesty's Stationary Office, London.

JARVIS, J.L. 1964. An association between a species of *Caloglyphus* (Acarina: Acaridae) and *Phyllophaga anxia* (Coleoptera: Scarabaeidae**)**. *Journal of the Kansas Entomological Society* **37**: 207–210.

KARAGOZ, M., GULCU, B., CAKMAK, I., KAYA, H.K. & HAZIR, S. 2007. Predation of entomopathogenic nematodes by *Sancassania* sp. (Acari: Acaridae). *Experimental and Applied Acarology* **43**: 85–95.

KLIMOV, P.B., LEKVEISHVILI, M., DOWLING, A.P.G. & OCONNOR, B.M. 2004. Multivariate analysis of morphological variation in two cryptic species of *Sancassania* (Acari: Acaridae) from Costa Rica. *Annals of the Entomological Society of America* **97**: 322–345.

LI, C.P., CUI, Y.B., WANG, J., YANG, Q.G. & TIAN, Y. 2003. Acaroid mite, intestinal and urinary acariasis. *World Journal of Gastroenterology* **9**: 874–877.

LUNDIE, A.E. 1940. The small hive beetle: *Aethina tumida.* Science Bulletin 220, Union of South Africa. Department of Agriculture and Forestry, Entomological Series **3**.

NEUMANN, P., PIRK, C.W.W., HEPBURN, H.R., ELZEN, P.J & BAXTER, J.R. 2001. Laboratory rearing of small hive beetles, *Aethina tumida* (Coleoptera, Nitidulidae). *Journal of Apicultural Research* **40**: 111–112.

NEUMANN, P. & ELZEN, P.J. 2004. The biology of the small hive beetle (*Aethina tumida*, Coleoptera: Nitidulidae): gaps in our knowledge of an invasive species. *Apidologie* **35**: 229–248.

OLSEN, A.R. 1983. Food contaminating mites from imported foods entering the United States through southern California. *International Journal of Acarology* **9**: 189–193.

ZOU, P. & WANG, X.Z. 1989. A new species and two new records of Acaridae associated with edible fungi from China (Acarina: Acaroidea). *Acta Agriculturae Shanghai* **5**: 21–24.

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