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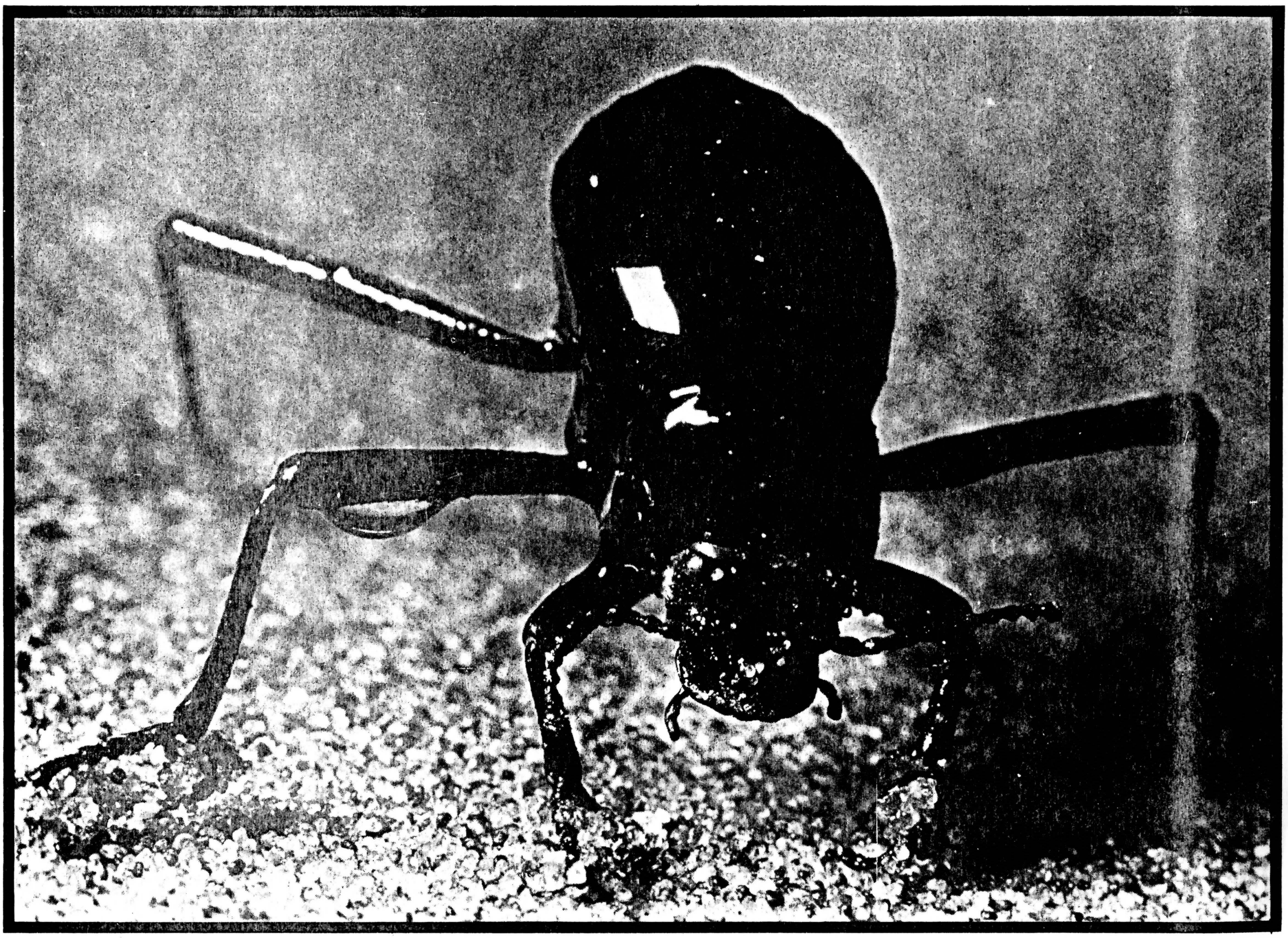

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Cover picture

The Namib Desert beetle, in its head-down stance, collecting drinking water from fog.
See page 284.

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−5 °C. Thus, the decreased frost sensitivity of our untreated control plants may be caused by supercooling to temperatures below those that are possible in the presence of active bacterial ice nuclei (for example, *P. syringae*).

The part played by epiphytic bacteria in promoting frost sensitivity has not been recognised previously. Large epiphytic bacterial populations exist on the leaves of most plants[14–19]. *P. syringae* has been reported as a component of these epiphytic populations on host and non-host plants[16,17,19]. Thus, it may be that 'natural' frost sensitivity of many plants is influenced, or even determined, by the presence of *P. syringae* and possibly certain other epiphytic bacteria.

We thank Dr Arthur Kelman for use of his extensive *P. syringae* culture collection, for assistance in identifying our *P. syringae* isolate, and for many helpful ideas during this investigation. We also thank Dr B. M. Lund for providing the *P. coronafaciens* isolates used here and for her helpful suggestions.

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Fog basking by the Namib Desert beetle, *Onymacris unguicularis*

THE Namib Desert along the south-western coast of Africa supports a sand dune fauna without counterpart elsewhere in the world[1]. The trophic base of the arthropod fauna is wind-blown detritus[2]. Aperiodic advective fog collection from vegetation[3] or detritus[4] is a possible source of water for diverse Namib animals. For the specialised fauna living in vegetation-less dunes, fog collection from detritus[4], disturbed sand projections[5], directly from humid air[6], or from water precipitated on the body[4,7], seem to be the only possible water uptake methods. Water uptake from saturated or subsaturated air, demonstrated for a few arthropod species[6], is not a physiological capability of Namib tenebrionids already investigated[4,6,7].

Here we report field observations of direct water uptake from fog precipitated on the body of the tenebrionid beetle, *Onymacris unguicularis*. In early October 1975 we established a study area on sand dunes south of the Kuiseb River at Gobabeb (23°34′S, 15°03′E, elevation 408 m), South West Africa, and continued observations through January 1976. On a series of small linear dunes all *O. unguicularis* were collected and marked with small (diameter 2.5 mm) numbered disks glued to the thorax. The study area, including 5 km of dune ridges, was traversed every afternoon, during the peak activity period of these beetles. We took all beetles collected to the laboratory, weighed them, and returned them to their dunes within 2 h of capture. The beetles either burrowed into dune slipfaces when returned or remained active, feeding on detritus for an hour or more before retiring to subsurface sands. Collections were repeated daily and numbering continued until over 90% of all beetles collected were numbered individuals. Recollection of marked individuals was facilitated in this environment because, in spite of the large spatial dimension of the study area there is no vegetation and these large (13–22 mm) black beetles stand out against the reddish sand substrate.

Ordinarily *O. unguicularis* are diurnal, preferring the warm part of day, and remaining buried in the sand of dune slipfaces overnight. But during nocturnal fogs they emerge and climb the slipface to the crest. There they take a characteristic head-down stance (Fig. 1), facing into the fog-laden wind. Dune slipfaces oriented into the wind also intercept fog. Beetles emerging there adopt the typical head-standing posture where they emerge.

As water collects on these beetles it trickles down the body to the mouth. Actual uptake of water was established by collecting beetles at the end of the head-standing performance, when they burrowed into subsurface sands. They were then taken to the laboratory and allowed to dry for 2 h. All adhering sand grains were removed with a brush and the beetles were weighed. Fog water uptake ranged from an

Fig. 1 *a*, Windward view of *Onymacris unguicularis* in a typical fog-collecting stance. *b*, Another individual at the usual fog-collecting site, the crest of a sand dune. Note the water collected under the head, which is being drunk.

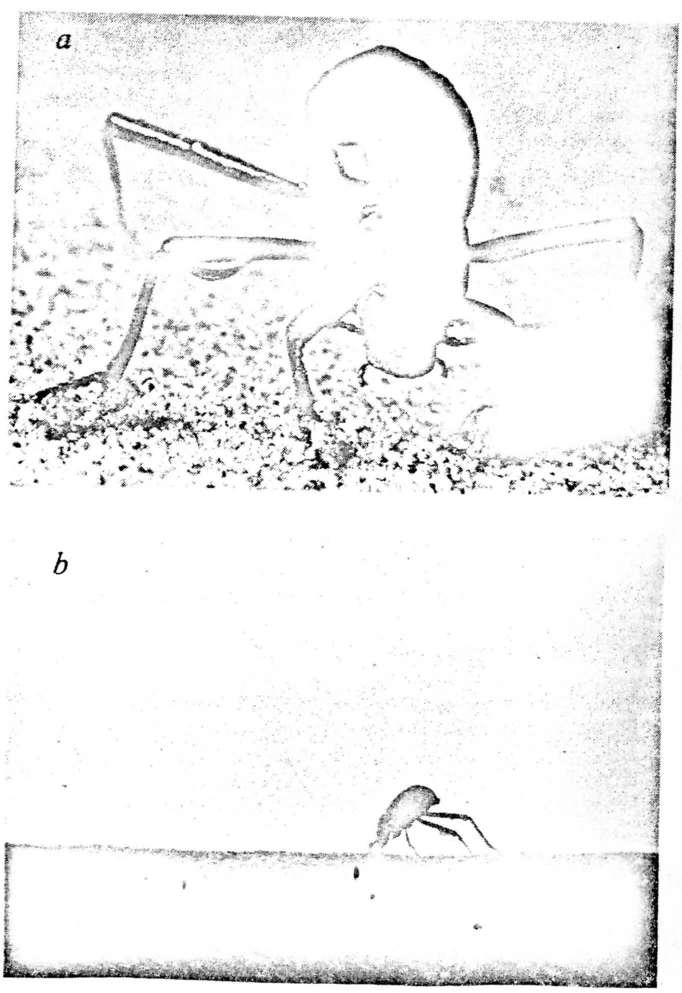

Table 1 Fog water gain expressed as percentage weight change of total body weight following fogs of various strengths on the Namib Desert

Date	Fog (mm)	Weight change (%) Mean	Corrected mean	Minimum	Maximum	*N*
October 14, 1975	0.50	+13.36	+14.50	+3.57	+34.01	24
November 5, 1975	0.35	+ 0.49	+ 1.63	−1.99	+10.48	32
November 25, 1975	0.10	+ 4.33	+ 5.47	−5.76	+16.31	52
November 29, 1975	0.65	+ 7.25	+ 8.39	−2.19	+20.79	33
December 1, 1975	0.10	+ 0.97	+ 2.11	−2.46	+ 4.91	16

The correction factor of 1.14% determined to be the mean overnight weight loss without fog has been added to the mean to provide a corrected mean weight change during fog more closely approximating the actual uptake of fog water but is not applied to the maximum and minimum weight changes.

average of 12% to no gain for various fogs (Table 1). The maximum weight gain by an individual in a single fog was 34% of total body weight before the fog. These values are for beetles captured and weighed the evening before a fog, and recaptured the morning immediately following the fog.

To determine the weight changes from evening weighing to morning weighing in the absence of an intervening fog, a control sample of beetles was weighed, marked and placed on a dune in the evening, then recaptured the following fogless morning. Of 48 such recaptures all but three individuals lost weight ($\bar{x}$ change −1.14%, range −3.00% to +0.72%). Thus any mean weight increase by a population of beetles overnight during a fog can be assigned to uptake of fog water.

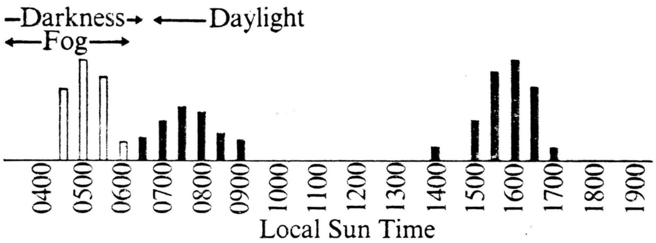

Fig. 2 The timing of activity by *O. unguicularis* on November 12, 1975. The open colums represent individuals holding the fog-collecting posture. The dark colums are individuals actively engaged in other activities. The maximum number of active individuals at any time was 45 on this date.

Fog basking by *O. unguicularis* occurs at times when they are not ordinarily active (Fig. 2). They may emerge any time during the night that wet fogs occur. Their usual foraging periods occur during the morning and late afternoon, coinciding in the afternoon with the strongest winds which transport the detritus on which they feed.

Onymacris unguicularis is active throughout the year and thus encounters variable intervals between fogs. Fogs as light as 0.1 mm on the Gobabeb fog screen elicited fog basking.

Another group of Namib dune tenebrionid beetles, genus *Lepidochora*, living near Gobabeb build ridges in the sand to catch water[5] and we have observed spiders, lepismids and other tenebrionids active on foggy mornings. Direct collection of fog water seems to be important in the water economy of some Namib Desert animals, and to involve in certain cases highly developed methods.

We thank Drs E. B. Edney and M. D. Robinson for valuable comments. This study was supported by the CSIR and Transvaal Museum (M.K.S.) and the National Science Foundation (W.J.H.). The permission to conduct this study from the Nature Conservation Department, South West Africa, is gratefully acknowledged.

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Nucleating agents in the haemolymph of insects tolerant to freezing

MANY insects that survive the winter in cold, exposed habitats in arctic or temperate regions are sensitive to freezing. These insects usually have supercooling points below −15 °C, and their capacity for supercooling has been shown to increase considerably with increasing concentrations of glycerol in their body fluid[1]. On the other hand, adult insects that are tolerant to freezing ('freeze tolerant') seem to freeze invariably at high subzero temperatures (from −6 to −10 °C), without regard to the concentration of glycerol and other polyols in their body fluid[2–4]. We report here that haemolymph from freeze-tolerant adult beetles contains a substance, which induces freezing in the haemolymph at about −6.5 °C. Haemolymph from freeze-sensitive species seems to lack this substance. Such substances probably constitute the physical basis of the remarkably high supercooling points of freeze-tolerant adult insects.

During the winter of 1975 we found that several species of tenebrionid beetle, inhabiting the mountain areas of southern California, were tolerant to freezing. These beetles had supercooling points from −5.5 to − 7.0 °C, whereas freeze-sensitive beetles froze at temperatures from −12 to −20 °C. Preliminary experiments showed that 5-μl samples of isolated haemolymph from freeze-tolerant (*Eleodes blanchardi* Blaisd.) and freeze-sensitive (*Iphthimus laevissimus* Csy.) tenebrionids froze within the same temperature range as did the respective intact beetles. Mixtures of haemolymph from the two species, however, also froze within the range of the intact freeze-tolerant beetles, even when the haemolymph of this species constituted as little as 5% of the volume of the mixture. These observations indicate that haemolymph from freeze-tolerant *E. blanchardi* contains nucleating agents, which induce freezing at a few degrees below zero, and which probably cause the low supercooling capacity of these beetles. Similar nucleating agents might be the cause of the high supercooling points reported for other freeze-tolerant beetles.

If freezing at high subzero temperatures is physiologically important to freeze-tolerant insects, they would be expected to contain nucleating agents, except in cases where freezing, as described by Salt[5], is initiated by inoculation. To investigate the distribution of nucleating agents, we took