GEOGRAPHIC VARIATION IN THE SIZE OF AN ANTARCTIC MITE *TYDEUS EREBUS* STRANDTMANN (ACARINA : PROSTIGMATA)

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ABSTRACT

A collection of *Tydeus erebus* Strandtmann from widespread localities in East Antarctica is reported. The mean body lengths of adult specimens from some of these localities differ significantly from those at other localities and vary with the type of habitat. Geographic variation in size of the magnitude reported here has not been found in other species of Antarctic mites, and possible causes are discussed. Other morphological variation between the specimens is described and brief notes on the behaviour and reproduction of *T. erebus* at the Vestfold Hills are presented.

Three paratypes of *Tydeus wilkesi* Strandt mannare compared with specimens of *T. erebus* Strandtmann and are considered to belong to the latter species.

RESUMÉ

Cette étude porte sur une collection de *Tydeus arebus* Strandtmann provenant de diverses localités de l'Est de l'Antarctique. Les longueurs moyennes du corps des adultes de quelques localités présentent des différences significatives par rapport à celles d'autres localités et varient avec le type d'habitat.

Des variations géographiques de cette ampleur n'ont jamais été signalées dans d'autres espèces d'Acariens antarctiques et ses causes possibles sont discutées. Une autre variation morphologique affectant ces populations est décrite et de brêves notes sur le comportement et la reproduction de *T. erebus* à Vestfold Hill sont présentées.

Trois paratypes de *Tydeis wilkesi* Strandtmann comparés avec des spécimens de *T. erebus* sont considérés comme appartenant à cette dernière espèce.

INTRODUCTION

Tydeus erebus Strandtmann was originally described (STRANDTMANN, 1967) from 16 specimens collected by D. J. LUGG in 1963 at one site on Mule Island (68°39'S, 77°49'E) at the Vestfold Hills. This paper reports on geographic variation in 74 specimens from 12 widespread

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sites in eastern Antarctica : six island sites and six mainland sites up to 1 000 km apart. PITTARD *et al.* (1971) reported a small amount of geographic variation between three populations of *Stereotydeus mollis* around McMurdo Sound, Antarctica. There are no other detailed reports of geographic variation between different populations of Antarctic mites although morphological differences between individuals in different populations have been observed by some (for example by STRANDTMANN (1967) in *Nanorchestes antarcticus*).

A similar but smaller species, *Tydeus wilkesi* Strandtmann, was originally described from 21 specimens collected by O. WILKES in 1965 at nine different sites in the Pensacola Ranges (83°45'S, 55°00'W) Antarctica. STRANDTMANN (1967) named these specimens separately because they came from the opposite side of the Antarctic continent. Since then no further collections or specimens of *T. wilkesi* have been reported. This paper reports the existence of small individuals of *T. erebus* that are similar to specimens of *T. wilkesi* described by STRANDTMANN (1967). Specimens of each species are compared in order to determine whether they are conspecific.

I made the bulk of the collection of *T. erebus* as a member of two Australian National Antarctic Research Expeditions (ANARE), the first in 1973 to Davis station for a year, when some aspects of reproduction and behaviour in this species were observed. The second expedition was to Enderby Land during the 1974-1975 summer for three months. The two specimens from the Mawson Escarpment were obtained from botanical samples collected by J. MANNING of the Division & National Mapping, Department of National Resources, during the 1972-1973 ANARE summer expedition to the Prince Charles Mountains region.

METHODS AND MATERIALS

Mites were collected in the field by hand and placed directly into 70 % ethyl alcohol or 5 % formalin for storage. At each site mites were sampled at one or more places. Except where very few specimens were obtained the samples are considered to be representative of their populations as the range of each was limited to a small area by the availability of moisture. PITTARD *et al.* (1971) found similar conditions when sampling populations of *Stereotydeus mollis* near McMurdo station. At sites where many specimens were collected those examined were obtained by sub-sampling from the whole collection from each site. The two specimens from site 12 (Mawson Escarpment, Prince Charles Mountains) were extracted by flotation from soil adhering to moss.

Specimens were mounted directly from 5 % formalin into Hoyers' medium and after drying were examined with a Reichert Diapan microscope under phase contrast. Body length (including the gnathosome) was measured in adult specimens (27 males and 47 females) from 12 sites. The lengths of all propodosomal setae were also measured. In each specimen the number and type of setae were examined, particularly on the rostrum, pedipals, coxae and genital region, and noticeable variation between them was recorded.

Means, their standard errors and coefficients of variation were calculated for the body lengths of all the adult specimens examined from each site. Males and females were not treated separately because the numbers examined from most sites were very small. A correlation of body length with sensilla length was calculated by pooling all adult specimens regardless of site of collection. Mean adult body lengths for the three sites from which the greatest numbers of specimens were examined have been compared using Students t-test. Geographic differences are inferred statistically on the basis of a 95 per cent confidence level.

Three paratypes of *T. wilkesi* Strandtmann were loaned by the Bernice P. Bishop Museum, Honolulu, for comparison with specimens of *T. erebus*. Mounted specimens of *T. erebus* examined during the preparation of this paper have been lodged with the South Australian Museum, Adelaide, and the Bernice P. Bishop Museum.

Results

Description of sites

Tydeus erebus was found at sites along 1 000 km of Antarctic coastline extending from the Vestfold Hills to Enderby Land and up to 400 km inland from the coast in the southern Prince Charles Mountains (Figure 1). It is common in the region, along with two other free-living prostigmatic mites, *Nanorchestes antarcticus* Strandtmann and *Stereotydeus mollis* Strandtmann (to be reported in a later paper). It was found in favourable sites at all the localities visited, most of which were islands or rocky outcrops along the mainland coast. A few inland nunataks were also visited although less time was spent studying these than most coastal localities.

Specimens examined from the six island sites and six mainland sites shown in Figure 1 are listed below :

Site 1 Waterhouse Island, below Snow Petrel nests, 68°23'S, 77°58'E : 2 males, 8 females, 7 nymphs ; 26 November 1973.

Site 2 Lugg Island, edge of Adelie Penguin colony, 68°33'S, 77°58'E ; 2 males, 3 females, 3 nymphs ; 26 November 1973.

Site 3 Hop Island, near Adelie Penguin colony, 68°48'S, 77°44'E : 2 females, 1 nymph ; 9 January 1973.

Site 4 Lichen Island, near Adelie Penguin colony, 69°20'S, 75°32'E : 1 male, 7 females ; 7 January 1973.

Site 5 Kidson Island, edge of Adelie Penguin colony, 67°11'S, 61°10'E : 1 male, 1 female, 1 nymph ; 12 February 1975.

Site 6 Martin Island, near McCormick's Skua roost, 66°44'S, 57°00'E : 3 males, 11 females, 2 nymphs ; 27 December 1974.

Site 7 Cape Bruce, near meltstream, 67°25'S, 60°47'E : 6 males, 3 females, 1 nymph ; 12 February 1974.

Site 8 Taylor Rookery, edge of Emperor Penguin colony, 67°27'S, 60°52'E : 4 males, 3 females ; 12 February 1975.

Site 9 Masson station, amongst moss, 67°36'S, 62°53'E : 2 males, 2 females ; 30 January 1975.

Site 10 Davis station, around mummified Elephant Seal carcass, 68°35'S, 77°58'E : 4 males, 2 females, 5 nymphs ; 8 October 1973.

Site 11 North Masson Range, Rumdoodle hut, below nests of Snow Petrels, 67°46'S, 62°49'E : 1 male, 4 females, 6 nymphs ; 14 February 1975.

Site 12 Mawson Escarpment, north east end, amongst moss, 72°40'S, 68°15'E : 1 male, 1 female ; January 1973.

These sites provided a range of habitats that can be grouped into three types :

a) Sites 1-5, 8 and 11 are located near large breeding colonies of birds and most are on islands that are surrounded by unfrozen sea in summer. These sites supported abundant populations of mites.

b) Sites 6, 9 and 10 are not located near large colonies of breeding birds but have an adequate supply of nutrients and water restricted to small areas. These sites sometimes supported sparse populations of mites.

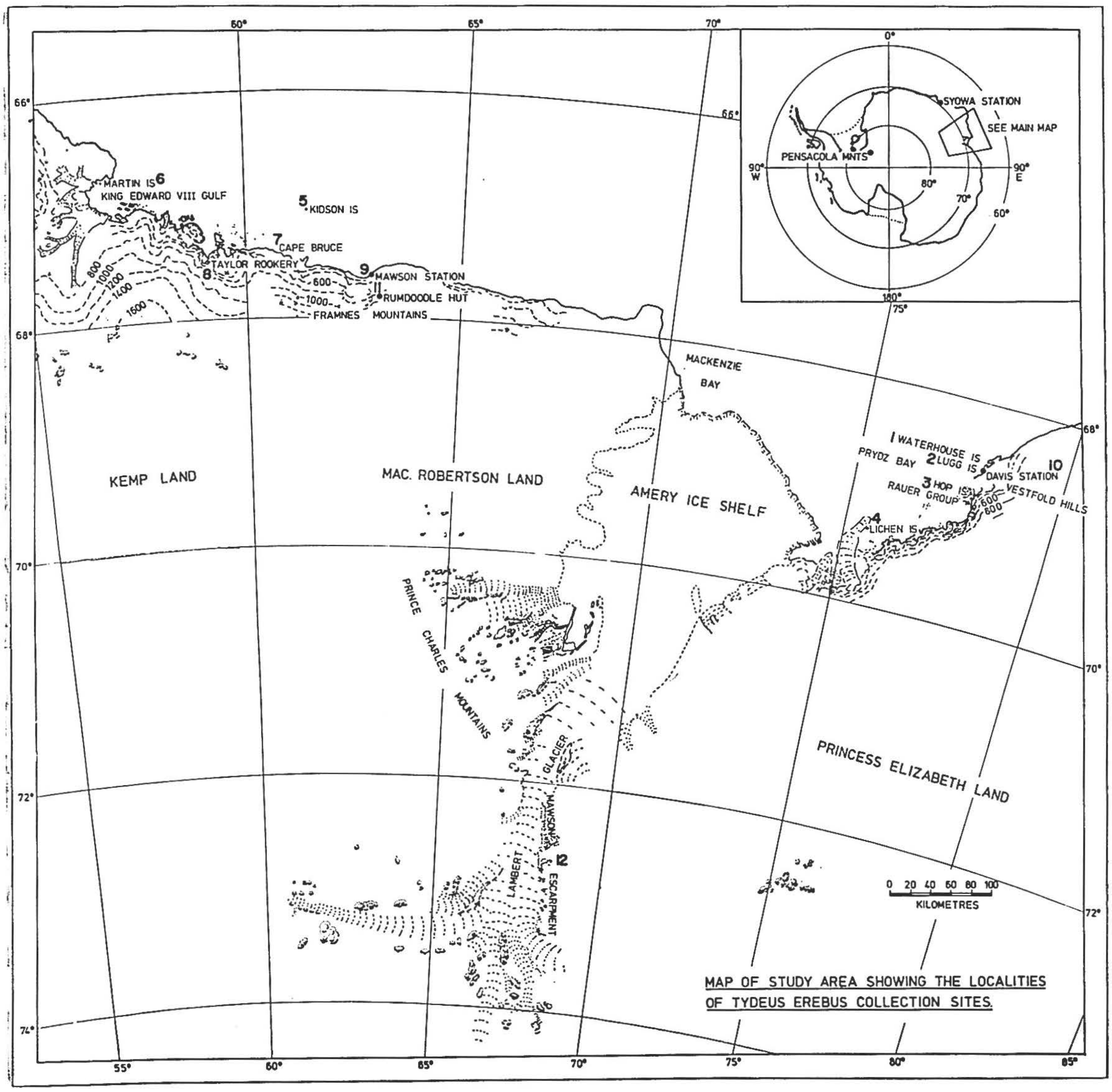

FIG. 1. — Map of study area,
showing the localities of *Tydeus erebus* collection sites.

c) Sites 7 and 12 are not located near large colonies of breeding birds and appeared to have neither an abundant nutrient or water supply. These sites appeared able to support only sparse populations of mites.

At the Vestfold Hills *T. erebus* occurred on the mainland and on many of the numerous offshore islands along the coast. On these islands it was found under rocks in large numbers near nesting colonies of the Adelie Penguin *Pygoscelis adeliae,* mainly in areas of summer meltwater drainage where the green alga *Prasiola* is abundant (for example, Site 2). It was also found on islands near nesting colonies of the Southern Giant petrel *Macronectes giganteus,* the Cape Petrel *Daption capense,* and the Snow Petrel *Pagodroma nivea* (for example, Site 1). On the mainland it lived under rocks amongst the rich growth of lichens and moss below nesting colonies of the Snow Petrel and near meltwater streams that were permanent in summer. Other mainland populations at the Vestfold Hills occupied areas around small rock outcrops where penguins moult and around the mummified carcass of a Southern Elephant Seal *Mirounga leonina* in a shallow depression (Site 10) on the coastal foreshore. These populations contained few individuals and were very sparse. Their areas were prescribed by the limited seepage of meltwater from small snowdrifts that thawed completely in early summer.

At the Rauer Group *T. erebus* occurred on Hop Island (Site 3) and on a small island nearby where it was found beneath rocks around a nesting colony of the Antarctic Fulmar *Fulmarus glacialoides.*

Site 6 on Martin Island is located near the roost of a pair of McCormick's Skuas *Stercorarius maccormicki.* It contained a dense population of mites in a small area. Martin Island had no breeding colonies of other birds, probably because it is normally surrounded by fast sea ice and far from open sea during most of the summer.

Sites 7-10 are all located within 100 m of the sea on outcrops of rock and moraine along ice-free parts of the mainland coast. At Site 8 a population covered an area of morainic debris adjacent to the site of a nesting colony of the Emperor Penguin *Aptenodytes forsteri,* and Site 9 is near a permanent meltwater pool in summer. Sites 7 and 10 appeared to be marginal because their sparse mite populations depended upon meltwater from small snowdrifts nearby.

Sites 11 and 12 are on inland nunataks. Site 11 is near a breeding colony of Snow Petrels. I did not visit Site 12 but it is probably similar to Site 7 where the activities of vertebrates are minimal. Nevertheless, Snow Petrels nest at Mawson Escarpment (J. MANNING, personal communication) and the nutrients they introduce would have enriched the substrate locally.

T. erebus probably occurred further west than Site 6. I found specimens of *Tydeus* sp. at Mt King (67°01'S, 52°48'E) on 12 January 1975 that are thought to be *T. erebus,* but these were not available during the preparation of this paper.

Size variation

Measurements of adult specimens in samples of *T. erebus* from 12 sites gave the mean body lengths shown in Table 1. The mean lengths of specimens from Sites 1 to 5, 8 and 11 exceed 300 µm ; those from Sites 6, 9 and 10 are between 300 and 260 µm, and those from Sites 7 and 12 are less than 260 µm. The mean lengths of samples from Sites 1, 6 and 7, representing the three size ranges, are significantly different. Means from other samples were not compared statistically because they were based on too few specimens.

All the populations in which the mean length of individuals is greater than 300 µm are located near large breeding colonies of birds (Table 1). Those with means between 300 and 260 µm are not located near large numbers of nesting birds in summer but are adequately supplied with moisture. The populations with means less than 260 µm are located at drier marginal sites where birds rarely visit. A probit transformation (that is, cumulative percentage plot on arithmetic probability graph paper) of the body length distribution for all the specimens produced a linear plot. Thus it can be assumed that the distribution of all body lengths is close to a normal distribution.

Table I

Mean Lengths of *T. erebus* from Twelve Different Populations

Site	Number of Adult Specimens	Length of Specimens (μm) Mean	Max	Min	SE	CV
1	9	303.7	338	273	6.8	6.7
2	5	316.0	340	280	11.2	7.9
3	2	339.0	340	338	1.0	0.4
4	8	303.8	340	280	8.4	7.9
5	3	311.7	325	300	7.3	4.0
6	14	283.6	312	266	4.2	5.6
7	9	257.7	265	250	2.0	2.4
8	7	300.6	325	279	6.0	5.3
9	4	289.0	312	279	7.8	5.4
10	6	279.0	300	260	5.9	5.2
11	5	314.0	340	300	7.5	5.3
12	2	240.5	247	234	6.5	3.8

A significant regression of body length on sensilla length is described by the relation shown in Figure 2. The data shown in Figure 2 for *T. wilkesi* Strandtmann are included only for comparison and were not used in calculating the regression coefficient. Body length and sensilla length are positively correlated with a significant correlation coefficient of $r = + 0.33$. The smaller remaining propodosomal setae, internal and external verticals and scapular setae, appear to vary similarly with body length in proportion to their relative sizes. There are no apparent allometric differences in the size of any parts of the body between specimens of different body length. Variation in size was the most noticeable difference between specimens.

The tritonymphs, distinguished by four pairs of both paragenital and external genital setae, also vary in size. The largest of the 14 tritonymphs measured is 300 μm long and was collected at Site 1, while the smallest is 250 μm long and was collected at Site 7. Tritonymphs were examined from all but Sites 4, 8, 9, and 12. The maximum length of tritonymphs at each of the remaining eight sites is similar to but always less than the mean length of adults for those sites shown in Table 1. The mean length of the 14 tritonymphs measured is 273 μm.

Other variation

Sixty-six of the 74 specimens examined carry normal genital setation ; five pairs of paragenital, six pairs of external genital and six (males) or two (females) pairs of internal genital setae. The eight remaining specimens carry additional paragenital or external genital setae. Amongst these, five females carry one or two extra external genital setae added either unilaterally or bilaterally. The remaining two males and one female have up to three extra paragenital setae either unilaterally or bilaterally that are produced by the doubling of normally single setae at the same socket. This type of doubling was also observed in a nymph. Meristic variation in other somatic setae was not detected.

A small amount of variation was found in the form of some setae on the gnathosome. The posterior pair of rostral setae is slightly longer and coarser than the anterior pair. Both pairs are commonly nude but in some specimens the distal half of the posterior pair is very finely plumose. The apical setae of the third pedipalp segment is nude or finely plumose but the basal setae of the second pedipalp segment is always nude.

Comparison of T. EREBUS *(Str.) and* T. WILKESI *(Str.)*

STRANDTMANN'S (1967) original description of *T. erebus* remains valid. I have examined all the specimens listed above and found that the description applies to the typical large form of this species usually occurring at island sites. Individuals of this species vary in size according to the type of locality in which they live. They also carry minor differences in setation.

Both *T. erebus* and *T. wilkesi* were described by STRANDTMANN (1967) as new species similar except in size. He named them separately because the specimens he examined were collected on opposite sides of Antarctica (Figure 1). I have examined three male paratypes of *T. wilkesi* that are similar in size (260, 242 and 230 µm) to the smaller forms of *T. erebus* usually collected at mainland locations during this work (Figure 2). The smallest paratype is smaller than any of the specimens of *T. erebus* examined during this study. A possible reason for this is suggested in the discussion.

The mean length of the 74 specimens of *T. erebus* listed above is 292 µm. STRANDTMANN (1967) gave the average lengths of *T. wilkesi* and *T. erebus* as 230 µm and 320 µm respectively.

The sepcimens of *T. wilkesi* have rostral setae that are finely plumose but the posterior pair are more plumose than the anterior pair. The basal seta of the second pedipalp segment is nude and the apical seta of the third pedipalp segment is plumose. In many specimens of *T. erebus* all except the latter of these setae are nude although in some specimens from the same populations the posterior pair of rostral setae and the apical seta of the third pedipalp are very finely plumose. The latter specimens of *T. erebus* are intermediate in form between the description of *T. erebus* and *T. wilkesi* given by STRANDMANN (1967).

The only consistent difference between specimens of *T. erebus* and *T. wilkesi* is in the anterior pair of rostral setae which are always nude in *T. erebus* but finely plumose in the three *T. wilkesi* examined. This apparent difference in setation is minor and, because it is no longer possible to maintain *T. erebus* and *T. wilkesi* as separate species based on size alone, *T. wilkesi* should be considered as a subjective synonym of *T. erebus*. Since the name *T. erebus* was allotted to the first specimens of this species collected I have designated the name *T. wilkesi* as the new synonym. STRANDTMANN'S (1967) description of *T. erebus*, although based on fewer specimens than his description of *T. wilkesi*, represents the larger phenotype of this species.

Notes on T. EREBUS *at the Vestfold Hills*

The only published information on *T. erebus* and *T. wilkesi* gives taxonomic descriptions (STRANDTMANN, 1967). Descriptions of habitats, or other information, are not available. In order to discuss the possible causes of geographic variation in the size of *T. erebus* it is necessary to have some ecological information about the species. The following brief account is a summary of the results of work done while I over-wintered at Davis station in 1973. Some informaton on the ecology of the three other known Antarctic species of *Tydeus* is contained in GRESSITT (1967), GRESSITT and SHOUP (1967), STRONG (1967), and TILBROOK (1967).

Mature specimens of *T. erebus* have bright red legs and a black body with a white stripe

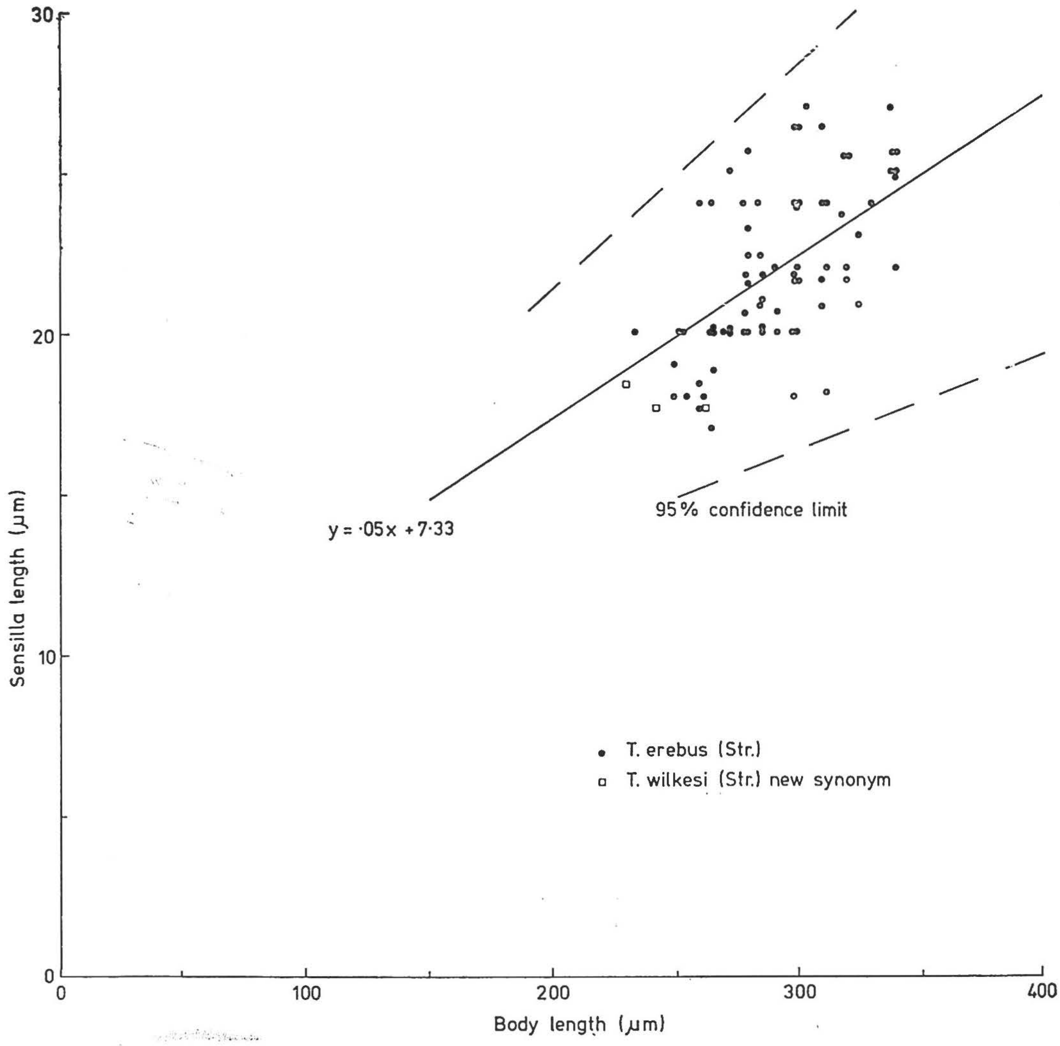

FIG. 2. — The relation between sensilla length and body length in adult *Tydeus erebus*.

dorsally along the hysterosoma. Some unpigmented specimens were found in populations at several sites in March and October. Presumably these specimens had just moulted.

In the field *T. erebus* is active but not fast-moving. Active individuals continuously beat the first pair of walking legs alternately on the substrate as they move. No overwintering eggs were found but all other life-stages were recorded in winter, when inactive beneath rocks lying on the soil. In a small population near Davis station (Site 10) the first salmon-pink eggs were laid during the second week in October when local soil temperatures first began to exceed 0°C diurnally. Females laid their eggs in concavities on the undersurfaces of flat rocks heated by insolation. Laid eggs are oblate-spheroid in shape with major axes measuring approximately 70×105 µm. They were attached to the undersurfaces of rocks by a thin stalk-like extension of the hyaline egg membrane located dorsally at the posterior end of the developing embryo. Eggs were laid from October probably until at least early January. Some gravid females containing single mature eggs were found in collections made elsewhere in late December and early January (at Sites 6 and 4 respectively). All gravid females mounted on slides for examination contained only one egg.

In August, when mites had been at temperatures below 0°C through most of the winter, a few inactive individuals collected in the field were warmed from — 15°C at a rate of 1°C/min. in the laboratory. They first began to move at 8.5°C. By October, when the soil had been warmed to temperatures above 0°C, at least diurnally, fresh mites collected in the field were subjected to the same temperature change in the laboratory as above. These mites began to move at — 4°C, but normal movement (that is, beating of the first pair of walking legs) began at about 1°C. This suggests that the mites are active only at temperatures above 0°C in summer and that dormant mites in winter differ from summer mites in their reactions to changes in temperature.

Discussion

Tydeus erebus is the first species of Antarctic mite reported to have considerable geographic variation in size. Its size appears to be positively correlated with increasingly favourable conditions in the habitat available to populations at different localities. Differences in either the energy available, the period of growth (Mayr, 1966), or a combination of both (Thomas, 1974) for mite progeny at different sites could explain the observed differences between populations in the size of tritonymphs and adults. Proximal conditions such as the abundance and type of food present, the relative humidity and temperature regimen of the soil appear to have a greater influence on size rather than the regional climate. These conditions are largely dependent upon the presence or absence of vertebrates and local relief for the provision of nutrients, meltwater and insolation at the sites. Dense populations of large individuals are usually found at sites near breeding colonies of birds where there is an abundant supply of these requirements. Small individuals are usually found in populations at less favoured sites.

For growth and activity of juvenile *T. erebus*, soil temperatures need to exceed 0°C. The length of time over which these conditions prevail during the austral summer season decreases with increasing latitude. At high latitudes one or (in some populations) possibly two seasons may be required for the juveniles to become adult. Females lay one large egg at a time and thus maximize the chance for juveniles to attain maximum growth when the season is short and food (algae) is scarce. This is important in the absence of over-wintering eggs.

This situation, which is supported by field studies, provides a basis for suggesting mechanisms to explain the observed size variation in *T. erebus*. Associated with the latitudinally shortened growing season, there is a general decrease in the numbers of vertebrates present. The type and abundance of algae available as food for mites probably decreases correspondingly but this aspect needs more investigation. If these latitudinal gradients impose a resource gratient in terms of the time and nutrition available to the mites then the recorded variation of body size can be explained : the smallest forms would be expected at the most southern locations (for example, Pensacola Range) but small forms would also be expected at lower latitudes (for example, Cape Bruce) around the Antarctic coastline in improverished habitats where nutrition may limit size.

The variation in body length observed has so far been assumed to be entirely phenotypic in origin. It can alternatively be explained by genetic differences between populations at different sites, but this is considered to be less likely because populations containing mainly large individuals (for example, Sites, 1, 2 and 8) are located only a few kilometres distant from populations of much smaller individuals (for example, Sites 10 and 7). Throughout the region studied size appears to vary in a mosaic pattern correlated mainly with the habitat. In addition there is considerable overlap in the range of body lengths between populations (Table 1). This suggests that even within populations the changing conditions during summer or spatial heterogeneity in the habitat may produce individuals of quite different sizes at a different time or place in the same site.

The results suggest that geographic variation in the size of this species is mainly phenotypic. It may be caused by limitations on either the time or food available for the growth of juvenile stages in each population. The sizes of juveniles would in turn determine the sizes of adults. Similar results have been reported in species of Arctic Lepidoptera by Downes (1964) who also suggests that depauperate phenotypes of small size seem to represent a response — either directly by the individual or, through genetic assimilation, in an inheritable form — to the need for economy of resources, imposed by the severe climate or nutritional conditions of the environment.

Considering *T. wilkesi* as a synonym of *T. erebus*, the known distribution of the species is disjunct. It reflects more the distribution of collecting of mites rather than the species' probable distribution which may be far wider than is presently known. Matsuda (in press) reports the occurrence of a species of *Tydeus*, tentatively identified from sketches as *T. erebus*, near Syowa station (69°00'S, 39°35'E). Bowra *et al.* (1966) have also reported *T. erebus* from Tottanfjella (72°S, 10°W). Further careful collecting in unstudied areas of East Antarctica is needed to increase knowledge of the distribution of Antarctic mites.

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LITERATURE CITED

Bowra (G. T.), Holdgate (M. W.) and, Tilbrocok (P. J.), 1966. — Biological investigations in Tottanfjella and Central Heimefrontfjella. — British Antarctic Survey, Bull. **9** : 63-70.

Downes (J. A.), 1964. — Arctic Insects and Their Environment. — Canadian Entomologist, **96** : 279-307.

GRESSITT (J. L.), 1967. — Notes on Arthropod Populations in the Antarctic Peninsula — South Shetland Islands — South Orkney Islands Area. — Antarctic Research Series, **10** : 373-391.

GRESSITT (J. L.), and SHOUP (J.), 1967. — Ecological Notes on Free-living Mites in North Victoria Land. Antarctic Research Series, **10** : 307-320.

MAYR (E.), 1966. — Animal species and Evolution. — Harvard University Press, Cambridge, Mass., 795 pp.

PITTARD (D. A.), ROBERTS (L. A.), and STRANDTMANN (R. W.), 1971. — Morphological Variation in Three Populations of the Antarctic Mite, *Stereotydeus mollis*, W. and S. (Arthropoda : Acarina). — Acarologia, **23** : 88-97.

STRANDTMANN (R. W.), 1967. — Terrestrial Prostigmata (Trombidiform Mites). — Antarctic Research Series, **10** : 51-80.

STRONG (J.), 1967. — Ecology of Terrestrial Arthropods at Palmer Station, Antarctic Peninsula. — Antarctic Research Series, **10** : 357-371.

THOMAS (D. G.), 1974. — Some Problems associated with the Avifauna. — In : Biogeography and Ecology in Tasmania, edited by W. D. Williams. — Dr. W. Junk, The Hague, 498 pp.

TILBROOK (P. J.), 1967. — Arthropod Ecology in the Maritime Antarctic. — Antarctic Research Series, **10** : 331-356.

Paru en Mars 1978.