JOURNAL OF NATURAL HISTORY, 1988, **22**, 1111–1119

Species associations of oribatid mites in lichens on the island of Ailsa Craig, Firth of Clyde (Acarei: Cryptostigmata)

M. J. COLLOFF

Department of Zoology, University of Glasgow, Glasgow G12 8QQ, Scotland, U.K.

(*Accepted 14 September 1987*)

Species associations of oribatid mites in maritime lichens on the island of Ailsa Craig, Firth of Clyde, were investigated. The thirteen lichen species examined yielded a total of seventeen oribatid species assignable to two discrete associations. One was characteristic of foliose lichens on exposed rocks and the other was found in terricolous fruticose lichen on acid heathland. Morphology of the lichen thallus and altitude of the collection site were found to influence the abundance, occurrence and species diversity of the mites.

KEYWORDS: Oribatid mites, species associations, maritime lichens, Ailsa Craig.

Introduction

Since the pioneering studies of Travé (1963), the importance of lichens as habitats for oribatid mites has become increasingly recognised. Previous studies on oribatids in maritime lichens have been carried out by Schulte (1976), Gjelstrup & Søchting (1979; 1984), Colloff (1983) and Søchting & Gjelstrup (1985).

In a recent review (Seyd & Seaward, 1984), eighty-three oribatids found in lichens were detailed and a provisional classification system based on affinity was proposed as follows. Group 'A' was composed of mites which were confined to lichens though present as 'accidentals' elsewhere; group 'B' species preferred lichens but also lived in other habitats, whilst group 'C' species were frequently found in lichens but were equally common in other habitats. This framework was intended to provide a working guide for lichenologists and acarologists who wished to examine the relationship in more detail. It also served to point out the inadequacies in current knowledge of oribatid species associations found in lichens. The term 'species association' has been used here in preference to 'community' because the latter implies sets of coexisting interdependent populations. Interdependence of oribatid populations in lichens has not yet been studied.

A study at a maritime site on Great Cumbrae, Clyde Islands, (Colloff, 1983) revealed two oribatid species associations; a terrestrial one associated with terricolous lichens, especially *Cladonia* spp., and a maritime one associated with the orange and grey lichens of the supralittoral zone.

The aims of this study were to see if the same species associations were present on Ailsa Craig and to assess two factors which may affect the abundance, occurrence and species diversity of the mites. These were thallus morphology and altitude of the collecting site. The number of lichen species in which each oribatid species was found was assessed against its degree of affinity with lichens assigned by Seyd & Seaward (1984).

Materials and methods

Ailsa Craig (55°15′N, 5°7′W) is the most southerly of the Clyde Islands (Fig. 1). It is just over 1 km long and rises to a height of 338 m. Physiographic, climatic and vegetational features were detailed by Vevers (1936).

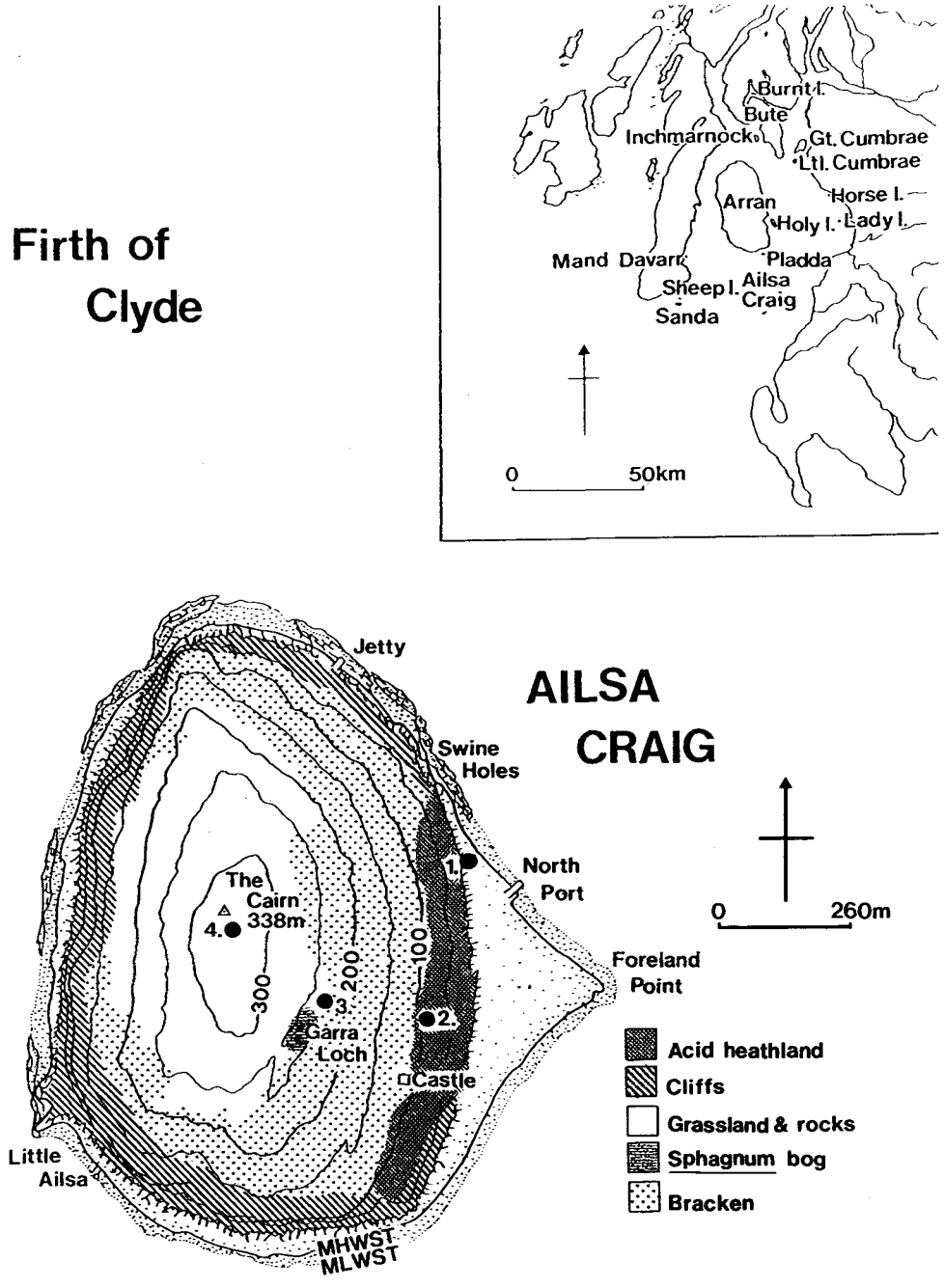

FIG. 1. Map of Ailsa Craig showing sampling sites and major patterns of vegetation (redrawn partly from Vevers, 1936). Inset: location of Ailsa Craig in relation to the other Clyde Islands.

Sampling sites were all on the more accessible eastern part of the island. The northern, western and southern parts consist mainly of steep cliffs. Sites were as follows (Fig. 1).

(1) Rocks on shore, supralittoral zone, near North Port pier (*ca* 1 m above MSL; 'shore').
(2) Rocks and soil on acid heath near ruined castle (98 m; 'castle').
(3) Rocks near *Sphagnum* bog, Garra Loch (230 m; 'plateau').
(4) Rocks at the Cairn (338 m; 'Summit').

Lichens were removed from the substrate into polythene bags and stored at 4°C until extraction in Tullgren funnels. Final extraction temperature reached 45°C after six days. Mites were collected into 70% ethanol, sorted and identified. Further extraction from the dried lichens was carried out by flotation. The samples were immersed in 70% ethanol in crystallizing dishes and the mites were removed from the surface of the liquid with a fine brush. Lichen samples were dried and weighed and numbers of mites/10 g dry weight of lichen thallus were calculated. Only intact specimens were counted: damaged specimens were assessed as dead at the time of sampling and not included in the results

Results

Species list

A total of 17 species of oribatid mite were extracted from 24 samples of lichen representing 13 species (Table 1). The presence of *Ommatocepheus ocellatus* and *Ameronothrus maculatus* has been discussed in a previous paper (Colloff, 1984), in which *O. ocellatus* was recorded as new to Scotland and, on the basis of gut analysis, redesignation from group 'B' to group 'A' was suggested. All other oribatid species (except the undetermined *Scheloribates* sp.) have been recorded from Scotland previously. The species in Table 1 marked with a cross were not recorded on Great Cumbrae.

Table 1. List of oribatid and lichen species from Ailsa Craig. Cr = crustose lichen thallus, Fo = foliose, Fr = fruticose. Oribatid spp. marked with + = those not present on Great Cumbrae (Colloff, 1983).

	Classification (Seyd & Seaward, 1984)	no. lichen spp. inhabited
ORIBATIDA		
CAMISIIDAE		
+ *Camisia biurus* (C. L. Koch)	—	1
C. spinifer (C. L. Koch)	—	1
+ *C. segnis* (Hermann)	B	1
HERMANNIIDAE		
+ *Hermannia scabra* (L. Koch)	C	1
H. reticulata Thorell	C	1
CERATOPPIIDAE		
Ceratappia bipilis (Hermann)	—	1
CARABODIDAE		
+ *Carabodes labyrinthicus* (Michael)	B	3
C. marginatus (Michael)	C	2
C. willmanni Bernini	B	1
+ *Ommatocepheus ocellatus* (Michael)	A	3
AMERONOTHRIDAE		
+ *Ameronothrus lineatus* Thorell	C	3

A. maculatus (Michael)	A	11
ORIBATULIDAE		
Phauloppia lucorum (C. L. Koch)	B	9
Zygoribatula exilis (Nicolet)	—	1
SCHELOROBATIDAE		
+ *Scheloribates* sp.	—	2
CERATOZETIDAE		
+ *Trichoribates trimaculatus* (C. L. Koch)	—	1
MYCOBATIDAE		
Mycobates parmeliae (Michael)	B	3
	Thallus morphology	No. orib. spp. present
LICHENES		
CLADONIACEAE		
C. portentosa (Dufour) Coem.	Fr	9
LECANORACEAE		
L. muralis (Schreber) Rabenh.	Cr	1
ACAROSPORACEAE		
Acarospora fuscata (Nyl.) Arnold	Cr	1
PERTUSARIACEAE		
Ochrolechia parella (L.) Massal.	Cr	1
PARMELIACEAE		
P. conspersa (Ach.) Ach.	Fo	4
P. caperata (L.) Ach.	Fo	4
P. omphalodes (L.) Ach.	Fo	7
Hypnogymnia physodes (L.) Ach.	Fo	2
Cetraria chlorophylla (Willd.) Vanio.	Fo	6
USNACEAE		
Ramalina siliquosa (Huds.) A.L.Sm.	Fr	6
PHYSICACEAE		
Anaptychia runcinata (With.) Laund.	Fo	4
TELOSCHISTACEAE		
Xanthoria parietina (L.) Th.Fr.	Fo	4
X. candelaria (L.) Th.Fr.	Fo	3

Abundance, occurrence and species diversity

The abundance, occurrence and species diversity of the oribatids are shown in Fig. 2. The largest numbers of mites were found in the *Xanthoria candelaria* sample taken at the summit (3920/10 g), nearly all of which were *Ameronothrus lineatus*. The smallest numbers were found in *Ramalina siliquosa* taken at the shore site (3/10 g). The most abundant mites were *Ameronothrus lineatus* (3538/10 g), *A. maculatus* (2994/10 g), *Phauloppia lucorum* (1108/10 g) and *Carabodes labyrinthicus* (394/10 g). With the exception of *A. lineatus*, these were also the oribatids which occurred most frequently. *A. maculatus* was present in nineteen samples totalling eleven species of lichen and at all four sites (79·2% occurrence), *P. lucorum*, present in eighteen samples of nine lichen species, also at four sites (75%) and *C. labyrinthicus*, present in eight samples of eight lichen species, at three sites (33·3%). The seven species with the lowest occurrence were *Carabodes willmanni*, *Ceratoppia bipilis*, *Hermannia reticulata*, *H. scabra*, *Camisia spinifer* and *C. biurus* found only in *Cladonia portentosa* at the Castle.

The lichen which contained most oribatid species was *Cladonia portentosa* (9 spp.), followed by *Parmelia omphalodes* (7 spp.).

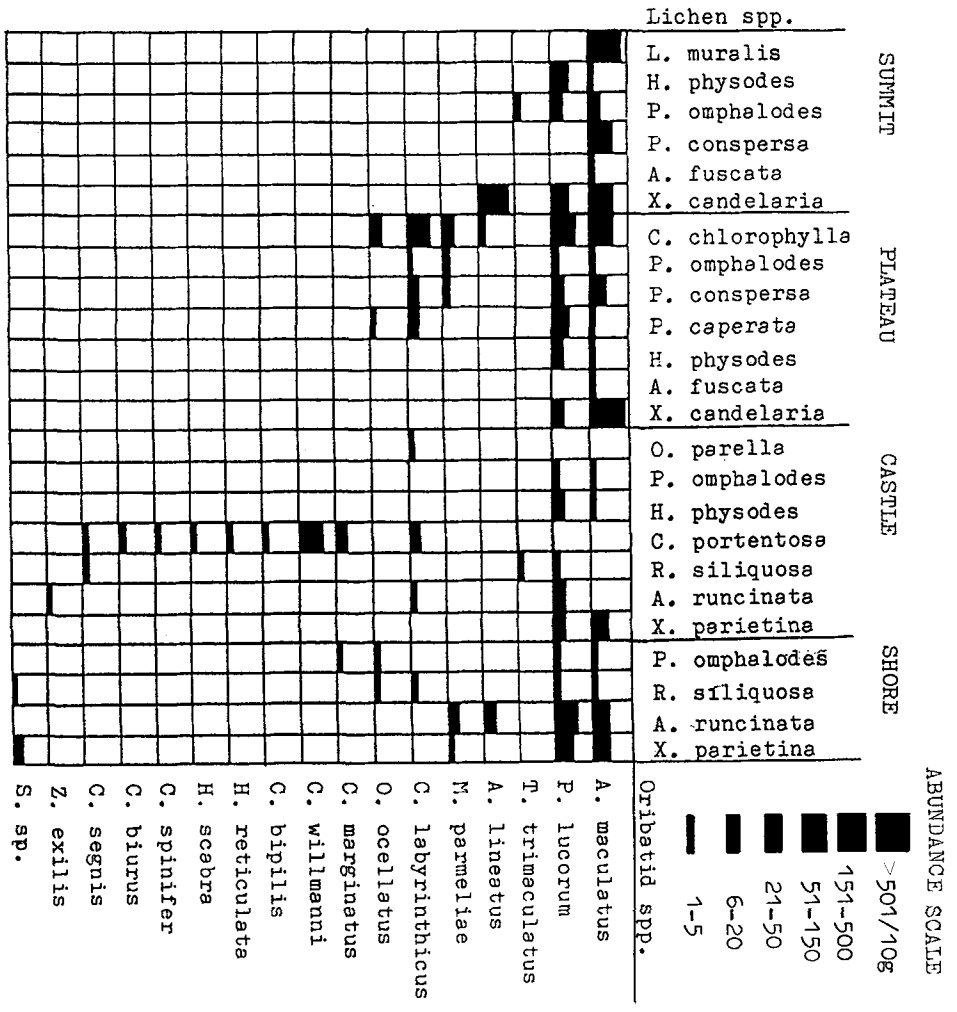

FIG. 2. Diagram showing relative abundance and distribution of oribatid species in lichens.

Effect of thallus morphology (Fig. 3)

The morphology of the thallus has a definite influence on the species diversity of the oribatids. All three crustose lichens contained only one oribatid species each whilst the foliose and fruticose lichens contained means of 4·25 and 7·5 species respectively.

Effect of altitude (Fig. 4)

There was a trend toward a decrease in the number of oribatid species with an increase in altitude although this was not quite statistically significant ($r = -0{\cdot}84$ with 3 degrees of freedom).

Only four were found at the Summit (338 m), compared with six at the Plateau (230 m), thirteen at the Castle (98 m) and nine at the Shore (1 m). By contrast there was an increase in the total number of individual mites/10 g of lichen with increase in altitude although again this was not statistically significant ($r = 0{\cdot}68$ with 3 degrees of freedom).

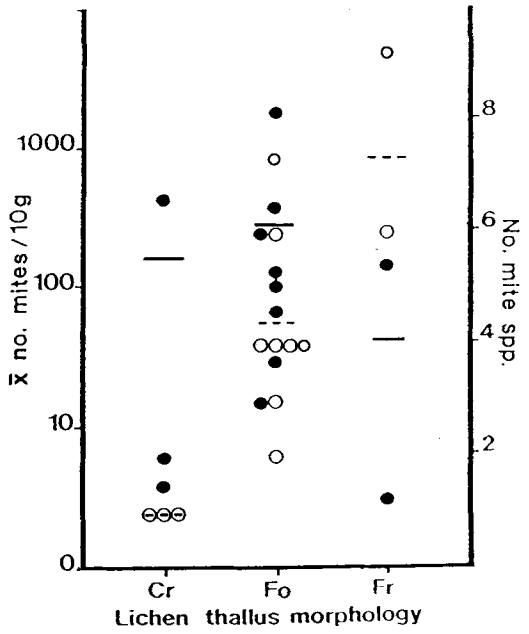

FIG. 3. Relationship between numbers of species and individual oribatids and the morphology of the lichen thallus. Dots = mean number of mites/10 g of lichen, solid lines = arithmetic means. Circles = number of oribatid species present in each lichen species, dashed lines = arithmetic means.

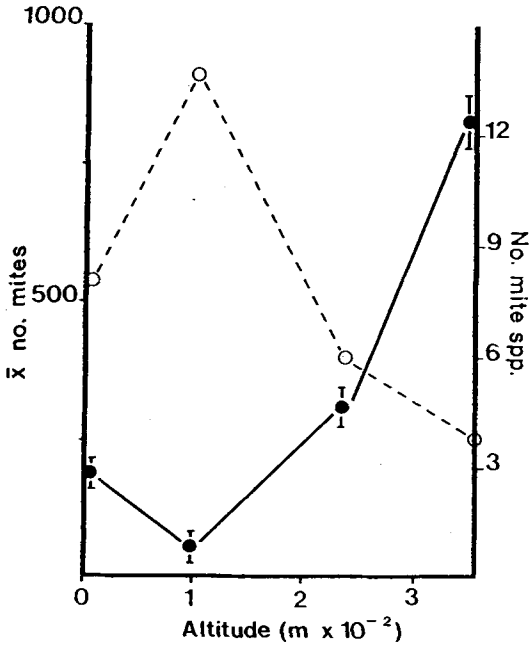

FIG. 4. Relationship between numbers of species (circles, dashed lines) and mean number of individuals (dots, solid lines. Vertical lines = standard error) and altitude.

Oribatid species associations

Two major oribatid species associations were discernible.

(1) An *Ameronothrus maculatus* association containing *A. maculatus*, *P. lucorum* and *A. lineatus*. It was present in *Xanthoria candelaria*, *Cetraria chlorophylla* and *Anaptychia runcinata*. (= *A. fusca*). The impoverished version of this community did not contain *A. lineatus* and was found in *P. omphalodes*, *X. candelaria* and *Hypnogymnia physodes*. *P. lucorum* and *A. maculatus* were the only two oribatids present at all three sites at which *H. physodes* was found. The species-rich version of the community contained a number of subsidiary species including *Mycobates parmeliae*, *Carabodes labyrinthicus* and *Ommatocepheus ocellatus*, and was particularly evident in *Cetraria chlorophylla* and *Parmelia caperata*.

(2) A *Carabodes willmanni* association, exclusive to *Cladonia portentosa* (from which *M. parmeliae*, *Ameronothrus* spp. and *P. lucorum* were absent), containing the *Carabodes* spp., *Camisia* spp., and *Hermannia* spp.

Relationship between Seyd & Seaward's (1984) classification and the number of lichens inhabited by each oribatid species (Fig. 5)

The oribatids in groups 'A' and 'B' were found in more lichen species (means = 7 and 4·6 respectively) than those of group 'C' and unclassified species (means = 2 and 1 respectively).

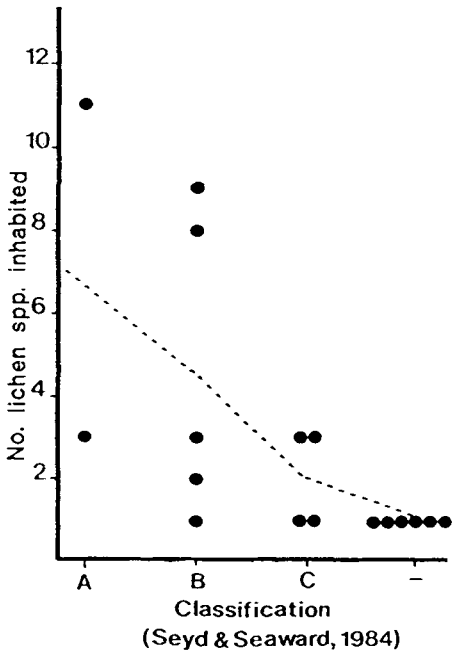

FIG. 5. Relationship between Seyd and Seaward's classification of each species and the number of lichen species in which it was found. Dotted line passes through arithmetic mean of the number of lichen species inhabited by oribatid species in each category. (– = spp. not assigned to any of the three groups).

Discussion

The two species associations are identical in distribution to those found on Great Cumbrae (Colloff, 1983) although their components differ slightly. The '*Ameronothrus*

maculatus' association is characteristic of saxicolous foliose lichens close to the sea whilst the '*Carabodes willmanni*' association is characteristic of terricolous cladoniaceous lichens found on acid heathland and is probably derived from the acarofauna of the underlying soil. Its high species-diversity is probably due to migration of mites from the upper layers of soil and litter (Seyd & Seaward, 1984).

The effect of thallus morphology on abundance of oribatids is equivocal because of probable seasonal variations in numbers of mites. Foliose lichens contained a greater mean number of mites than crustose or fruticose species but there was considerable range around these means. Species diversity is clearly influenced. The crustose lichens, especially *Ochrolechia parella*, tend to have a very dense medulla, hard when dry, which is closely associated with the substrate. Only low numbers of mites inhabit the lichen, burrowing into the medulla via cracks between the areolae. Foliose lichens have a far greater surface area/volume ratio than crustose species and tend to be less adpressed to the substrate. The thalli of many species becomes very soft when wet and oribatids have access through and between the lobes as well as gaps between the underside of the medulla and the substrate. The fruticose species, *Ramalina siliquosa* and *Cladonia portentosa* contained high numbers of species. In *C. portentosa*, as mentioned above, this was probably due to invasion by soil-inhabiting oribatids. The thallus of *R. siliquosa* has the bases of the branches collected into a 'holdfast' in which plant and mineral debris accumulates acting as a water reservoir and microhabitat in which most of the oribatids are found. Gjelstrup & Søchting (1979) reported that the oribatid mite *Phauloppia coineau* bores into the lobes of *R. siliquosa* in preference to *R. cuspidata* at Bornholm in the Baltic. They concluded this preference was due to the looser medullary structure of *R. siliquosa*. Burrowing in *R. siliquosa* from Ailsa Craig was not detected and numbers of mites present were low. From the data on vegetation cover and biomass given by Søchting & Gjelstrup (1985) it seems that *X. parietina* and *A. runcinata* were far more common at the shore site on Ailsa Craig than at Bornholm. Consequently mites inhabited them in preference to *R. siliquosa*.

There is a tendency toward decrease in species diversity with increase in altitude. This may well reflect the more desiccating conditions which prevail at and around the summit of the island since this area receives more insolation and wind-desiccation than the lower areas to the east. Several of the lichen thalli sampled at the Summit were dry and brittle whilst those lower down were damp with sea spray.

Oribatid species having a higher affinity with lichens under Seyd & Seaward's (1984) classification showed a tendency to inhabit more lichen species on Ailsa Craig than those oribatids with a lower affinity. However, only two of the oribatids found were group 'A' species. Further investigation with a more extensive range of lichens over a greater geographical area would help to establish if this trend was genuine. If so, the implication is that oribatid species with a high affinity for lichens tend not to be species-specific and thus must possess adaptations to lichen microhabitats in general.

Acknowledgements

I thank Mr E. L. Seyd (Oxford) for reviewing the manuscript, also Professor D. L. Hawksworth (Commonwealth Institute of Mycology) and Mr D. Macfarlane (Commonwealth Institute of Entomology) for checking the identities of *Acarospora fuscata* and *Ameronothrus lineatus* respectively.

References

COLLOFF, M. J., 1983. Oribatid mites associated with marine and maritime lichens on the island of Great Cumbrae. *Glasgow Naturalist* **20,** (4), 347–359.

COLLOFF, M. J., 1984. Notes on two lichenophagous oribatid mites from Ailsa Craig (Acari: Cryptostigmata). *Glasgow Naturalist* **20,** (5), 451–457.

GJELSTRUP, P. and SØCHTING, U., 1979. Cryptostigmatid mites (Acarina) associated with *Ramalina siliquosa* (Lichenes) on Bornholm in the Baltic. *Pedobiologia* **19,** 237–245.

GJELSTRUP, P. and SØCHTING, U., 1984. Oribatid mites (Acarina) dominant in some lichen and moss species of maritime rocks on Bornholm in the Baltic. In D. A. Griffiths and C. E. Bowman (Eds). *Acarology VI.* Chichester (Ellis Horwood), vol. 1, pp. 528–533.

SCHULTE, G., 1976. Zur Nahrungsbiologie der terrestrischen und marinen Milbenfamilie Ameronothridae (Acari, Oribatei). *Pedobiologia* **16,** 332–352.

SEYD, E. L. and SEAWARD, M. R. D., 1984. The association of oribatid mites with lichens. *Zoological Journal of the Linnean Society* **80,** 369–420.

SØCHTING, U., and GJELSTRUP, P., 1985. Lichen communities and the associated fauna on a rocky shore on Bornholm in the Baltic. *Holarctic Ecology* **8,** 66–75.

TRAVÉ, J., 1963. Ecologie et biologie des Oribates (Acariens) saxicoles et arboricoles. *Vie et Milieu,* supplement no. 14, 267 pp.

VEVERS, H. G., 1936. The land vegetation of Ailsa Craig. *Journal of Ecology* **24,** 424–445.